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## Title 29 — Labor

### Subtitle B — Regulations Relating to Labor

#### Chapter XVII — Occupational Safety and Health Administration, Department of Labor

#### Part 1915 — Occupational Safety and Health Standards for Shipyard Employment

**Authority:** 33 U.S.C. 941; 29 U.S.C. 653, 655, 657; Secretary of Labor's Order No. 12–71 (36 FR 8754); 8–76 (41 FR 25059), 9–83 (48 FR 35736), 1–90 (55 FR 9033), 6–96 (62 FR 111), 3–2000 (65 FR 50017), 5–2002 (67 FR 65008), 5–2007 (72 FR 31160), 4–2010 (75 FR 55355), 1–2012 (77 FR 3912), or 8–2020 (85 FR 58393); 29 CFR part 1911; and 5 U.S.C. 553, as applicable.

**Source:** 47 FR 16986, Apr. 20, 1982, unless otherwise noted.

#### Subpart Z Toxic and Hazardous Substances

- § 1915.1000 Air contaminants.
- § 1915.1001 Asbestos.
- § 1915.1002 Coal tar pitch volatiles; interpretation of term.
- § 1915.1003 13 carcinogens (4–Nitrobiphenyl, etc.).
- § 1915.1004 alpha-Naphthylamine.
- § 1915.1005 *[Reserved]*
- § 1915.1006 Methyl chloromethyl ether.
- § 1915.1007 3,3'-Dichlorobenzidene (and its salts).
- § 1915.1008 bis-Chloromethyl ether.
- § 1915.1009 beta-Naphthylamine.
- § 1915.1010 Benzidine.
- § 1915.1011 4-Aminodiphenyl.
- § 1915.1012 Ethyleneimine.
- § 1915.1013 beta-Propiolactone.
- § 1915.1014 2-Acetylaminofluorene.
- § 1915.1015 4-Dimethylaminoazobenzene.
- § 1915.1016 N-Nitrosodimethylamine.
- § 1915.1017 Vinyl chloride.
- § 1915.1018 Inorganic arsenic.
- § 1915.1020 Access to employee exposure and medical records.
- § 1915.1024 Beryllium.
- § 1915.1025 Lead.
- § 1915.1026 Chromium (VI).
- § 1915.1027 Cadmium.
- § 1915.1028 Benzene.
- § 1915.1030 Bloodborne pathogens.
- § 1915.1044 1,2-dibromo-3-chloropropane.
- § 1915.1045 Acrylonitrile.

- § 1915.1047 Ethylene oxide.
- § 1915.1048 Formaldehyde.
- § 1915.1050 Methylenedianiline.
- § 1915.1052 Methylene chloride.
- § 1915.1053 Respirable crystalline silica.
- § 1915.1200 Hazard communication.
- § 1915.1450 Occupational exposure to hazardous chemicals in laboratories.
- § 1915.1501 COVID-19.

## Subpart Z—Toxic and Hazardous Substances

**Source:** 58 FR 35514, July 1, 1993, unless otherwise noted.

### § 1915.1000 Air contaminants.

Wherever this section applies, an employee's exposure to any substance listed in Table Z—Shipyards of this section shall be limited in accordance with the requirements of the following paragraphs of this section.

(a)

- (1) **Substances with limits preceded by "C"—Ceiling values.** An employee's exposure to any substance in Table Z—Shipyards, the exposure limit of which is preceded by a "C," shall at no time exceed the exposure limit given for that substance. If instantaneous monitoring is not feasible, then the ceiling shall be assessed as a 15-minute time weighted average exposure which shall not be exceeded at any time over a working day.
- (2) **Other Substances—8-hour Time Weighted Averages.** An employee's exposure to any substance in Table Z—Shipyards, the exposure limit of which is not preceded by a "C," shall not exceed the 8-hour Time Weighted Average given for that substance in any 8-hour work shift of a 40-hour work week.

(b)–(c) [Reserved]

- (d) **Computation formula.** The computation formula which shall apply to employee exposure to more than one substance for which 8-hour time weighted averages are listed in subpart Z of 29 CFR part 1915 in order to determine whether an employee is exposed over the regulatory limit is as follows:

(1)

- (i) The cumulative exposure for an 8-hour work shift shall be computed as follows:

$$E = (C_a T_a + C_b T_b + \dots C_n T_n) \div 8$$

Where:

E is the equivalent exposure for the working shift.

C is the concentration during any period of time T where the concentration remains constant.

T is the duration in hours of the exposure at the concentration C.

The value of E shall not exceed the 8-hour time weighted average specified in subpart Z of 29 CFR part 1915 for the material involved.

- (ii) To illustrate the formula prescribed in paragraph (d)(1)(i) of this section, assume that Substance A has an 8-hour time weighted average limit of 100 ppm noted in Table Z—Shipyards. Assume that an employee is subject to the following exposure:

Two hours exposure at 150 ppm

Two hours exposure at 75 ppm

Four hours exposure at 50 ppm

Substituting this information in the formula, we have

$$(2 \times 150 + 2 \times 75 + 4 \times 50) \div 8 = 81.25 \text{ ppm}$$

Since 81.25 ppm is less than 100 ppm, the 8-hour time weighted average limit, the exposure is acceptable.

(2)

- (i) in case of a mixture of air contaminants an employer shall compute the equivalent exposure as follows:

$$E_m = (C_1 \div L_1 + C_2 \div L_2) + \dots (C_n \div L_n)$$

Where:

$E_m$  is the equivalent exposure for the mixture.

C is the concentration of a particular contaminant.

L is the exposure limit for that substance specified in subpart Z of 29 CFR part 1915.

The value of  $E_m$  shall not exceed unity (1).

- (ii) To illustrate the formula prescribed in paragraph (d)(2)(i) of this section, consider the following exposures:

Substance	Actual concentration of 8 hour exposure (ppm)	8 hr. TWA PEL (ppm)
B	500	1000
C	45	200
D	40	200

Substituting in the formula, we have:

$$Em = 500 \div 1,000 + 45 \div 200 + 40 \div 200$$

$$Em = 0.500 + 0.225 + 0.200$$

$$Em = 0.925$$

Since Em is less than unity (1), the exposure combination is within acceptable limits.

Table Z—Shipyards

Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
Abate; see Temephos				
Acetaldehyde	75-07-0	200	360	—
Acetic acid	64-19-7	10	25	—
Acetic anhydride	108-24-7	5	20	—
Acetone	67-64-1	1000	2400	—
Acetonitrile	75-05-8	40	70	—
2-Acetylaminofluorine; see § 1915.1014	53-96-3			
Acetylene	74-86-2	E		
Acetylene dichloride; see 1,2-Dichloroethylene				
Acetylene tetrabromide	79-27-6	1	14	—
Acrolein	107-02-8	0.1	0.25	—
Acrylamide	79-06-1	—	0.3	X
Acrylonitrile; see § 1915.1045	107-13-1			
Aldrin	309-00-2	—	0.25	X
Allyl alcohol	107-18-6	2	5	X
Allyl chloride	107-05-1	1	3	—
Allyl glycidyl ether (AGE)	106-92-3	(C)10	(C)45	—
Allyl propyl disulfide	2179-59-1	2	12	—
alpha-Alumina	1344-28-1			
Total dust		—	15	—
Respirable fraction		—	5	—
Aluminum, (as Al) Metal	7429-90-5			
Total dust		—	15	—
Respirable fraction		—	5	—
Alundum; see alpha-Alumina				
4-Aminodiphenyl; see § 1915.1011	92-67-1			
2-Aminoethanol; see Ethanolamine				
2-Aminopyridine	504-29-0	0.5	2	—
Ammonia	7664-41-7	50	35	—
Ammonium sulfamate	7773-06-0			

Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
Total dust		—	15	—
Respirable fraction		—	5	—
n-Amyl acetate	628-63-7	100	525	—
sec-Amyl acetate	626-38-0	125	650	—
Aniline and homologs	62-53-3	5	19	X
Anisidine (o-, p-isomers)	29191-52-4	—	0.5	X
Antimony and compounds (as Sb)	7440-36-0	—	0.5	—
ANTU (alpha Naphthylthiourea)	86-88-4	—	0.3	—
Argon	7440-37-1	E		
Arsenic, inorganic compounds (as As); see § 1915.1018	7440-38-2	—	—	—
Arsenic, organic compounds (as As)	7440-38-2	—	0.5	—
Arsine	7784-42-1	0.05	0.2	—
Asbestos; see 1915.1001				
Azinphos-methyl	86-50-0	—	0.2	X
Barium, soluble compounds (as Ba)	7440-39-3	—	0.5	—
Barium sulfate	7727-43-7			
Total dust		—	15	—
Respirable fraction		—	5	—
Benomyl	17804-35-2			
Total dust		—	15	—
Respirable fraction		—	5	—
Benzene <sup>g</sup> ; see § 1915.1028	71-43-2			
Benzidine; see § 1915.1010	92-87-5			
p-Benzoquinone; see Quinone				
Benzo(a)pyrene; see Coal tar pitch volatiles				
Benzoyl peroxide	94-36-0	—	5	—
Benzyl chloride	100-44-7	1	5	—
Beryllium and beryllium compounds (as Be); see 1915.1024 <sup>(q)</sup>	7440-41-7		0.002	
Biphenyl; see Diphenyl				
Bismuth telluride, Undoped	1304-82-1			
Total dust		—	15	—
Respirable fraction		—	5	—
Bisphenol A; see Diglycidyl ether				
Boron oxide	1303-86-2			
Total dust		—	15	—
Boron tribromide	10294-33-4	1	10	—
Boron trifluoride	7637-07-2	(C)1	(C)3	—
Bromine	7726-95-6	0.1	0.7	—

Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
Bromine pentafluoride	7789-30-2	0.1	0.7	—
Bromoform	75-25-2	0.5	5	X
Butadiene (1,3-Butadiene); see 29 CFR 1910.1051; 29 CFR 1910.19(l)	106-99-0	1 ppm/5 ppm STEL	—	—
Butanethiol; see Butyl mercaptan				
2-Butanone (Methyl ethyl ketone)	78-93-3	200	590	—
2-Butoxyethanol	111-76-2	50	240	X
n-Butyl-acetate	123-86-4	150	710	—
sec-Butyl acetate	105-46-4	200	950	—
tert-Butyl acetate	540-88-5	200	950	—
n-Butyl alcohol	71-36-3	100	300	—
sec-Butyl alcohol	78-92-2	150	450	—
tert-Butyl alcohol	75-65-0	100	300	—
Butylamine	109-73-9	(C)5	(C)15	X
tert-Butyl chromate (as CrO <sub>3</sub> ); see 1915.1026 <sup>n</sup>	1189-85-1			
n-Butyl glycidyl ether (BGE)	2426-08-6	50	270	—
Butyl mercaptan	109-79-5	0.5	1.5	—
p-tert-Butyltoluene	98-51-1	10	60	—
Cadmium dust fume (as Cd); see 1915.1027	7440-43-9	—	—	—
Calcium carbonate	1317-65-3			
Total dust		—	15	—
Respirable fraction		—	5	—
Calcium hydroxide	1305-62-0	—	—	—
Calcium hydroxide				
Total dust		—	15	—
Respirable fraction		—	5	—
Calcium oxide	1305-78-8	—	5	—
Calcium silicate	1344-95-2			
Total dust		—	15	—
Respirable fraction		—	5	—
Calcium sulfate	7778-18-9			
Total dust		—	15	—
Respirable fraction		—	5	—
Camphor, synthetic	76-22-2	—	2	—
Carbaryl (Sevin)	63-25-2	—	5	—
Carbon black	1333-86-4	—	3.5	—
Carbon dioxide	124-38-9	5000	9000	—
Carbon disulfide	75-15-0	20	60	X

Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
Carbon monoxide	630-08-0	50	55	—
Carbon tetrachloride	56-23-5	10	65	X
Cellulose	9004-34-6			
Total dust		—	15	—
Respirable fraction		—	5	—
Chlordane	57-74-9	—	0.5	X
Chlorinated camphene	8001-35-2	—	0.5	X
Chlorinated diphenyl oxide	55720-99-5	—	0.5	—
Chlorine	7782-50-5	1	3	—
Chlorine trifluoride	7790-91-2	(C)0.1	(C)0.4	—
Chloroacetaldehyde	107-20-0	(C)1	(C)3	—
a-Chloroacetophenone (Phenacyl chloride)	532-27-4	0.05	0.3	—
Chlorobenzene	108-90-7	75	350	—
o-Chlorobenzylidene malononitrile	2698-41-1	0.05	0.4	—
Chlorobromomethane	74-97-5	200	1050	—
2-Chloro-1,3-butadiene; see beta-Chloroprene				
Chlorodiphenyl (42% Chlorine) (PCB)	53469-21-9	—	1	X
Chlorodiphenyl (54% Chlorine) (PCB)	11097-69-1	—	0.5	X
1-Chloro,2,3-epoxypropane; see Epichlorohydrin				
2-Chloroethanol; see Ethylene chlorohydrin				
Chloroethylene; see Vinyl chloride				
Chloroform (Trichloromethane)	67-66-3	50	240	—
bis(Chloromethyl) ether; see § 1915.1008	542-88-1			
Chloromethyl methyl ether; see § 1915.1006	107-30-2			
1-Chloro-1-nitropropane	600-25-9	20	100	—
Chloropicrin	76-06-2	0.1	0.7	
beta-Chloroprene	126-99-8	25	90	X
2-Chloro-6-(trichloromethyl) pyridine	1929-82-4			
Total dust		—	15	—
Respirable fraction		—	5	—
Chromium (II) compounds				
(as Cr)	7440-47-3	—	0.5	—
Chromium (III) compounds				
(as Cr)	7440-47-3	—	0.5	—
Chromium (VI) compounds; see 1915.1026 <sup>o</sup>				
Chromium metal and insol. salts (as Cr)	7440-47-3	—	1	—
Chrysene; see Coal tar pitch volatiles				
Clopidol	2971-90-6			
Total dust		—	15	—



Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
Respirable fraction		—	5	—
Coal tar pitch volatiles (benzene soluble fraction), anthracene, BaP, phenanthrene, acridine, chrysene, pyrene	65966-93-2	—	0.2	—
Cobalt metal, dust, and fume (as Co)	7440-48-4	—	0.1	—
Copper	7440-50-8			
Fume (as Cu)		—	0.1	—
Dusts and mists (as Cu)		—	1	—
Corundum; see Emery				
Cotton dust (raw)		—	1	
Crag herbicide (Sesone)	136-78-7			
Total dust		—	15	—
Respirable fraction		—	5	—
Cresol, all isomers	1319-77-3	5	22	X
Crotonaldehyde	123-73-9;	2	6	
	4170-30-3			
Cumene	98-82-8	50	245	X
Cyanides (as CN)	Varies with Compound	—	5	—
Cyanogen	460-19-5	10	—	—
Cyclohexane	110-82-7	300	1050	—
Cyclohexanol	108-93-0	50	200	—
Cyclohexanone	108-94-1	50	200	—
Cyclohexene	110-83-8	300	1015	—
Cyclonite	121-82-4	—	1.5	X
Cyclopentadiene	542-92-7	75	200	—
2,4-D (Dichlorophenoxyacetic acid)	94-75-7	—	10	—
Decaborane	17702-41-9	0.05	0.3	X
Demeton (Systox)	8065-48-3	—	0.1	X
Diacetone alcohol (4-Hydroxy-4-methyl-2-pentanone)	123-42-2	50	240	—
1,2-Diaminoethane; see Ethylenediamine				
Diazomethane	334-88-3	0.2	0.4	—
Diborane	19287-45-7	0.1	0.1	—
1,2-Dibromo-3-chloropropane (CBCP); see § 1915.1044	96-12-8		—	
1,2-Dibromoethane; see Ethylene dibromide				
Dibutyl phosphate	107-66-4	1	5	—
Dibutyl phthalate	84-74-2	—	5	—
Dichloroacetylene	7572-29-4	(C)0.1	(C)0.4	—
o-Dichlorobenzene	95-50-1	(C)50	(C)300	—
p-Dichlorobenzene	106-46-7	75	450	—

Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
3,3'-Dichlorobenzidine; see § 1915.1007	91-94-1			
Dichlorodifluoromethane	75-71-8	1000	4950	—
1,3-Dichloro-5,5-dimethyl hydantoin	118-52-5	—	0.2	—
Dichlorodiphenyltrichloroethane (DDT)	50-29-3	—	1	X
1,1-Dichloroethane	75-34-3	100	400	—
1,2-Dichloroethane; see Ethylene dichloride				
1,2-Dichloroethylene	540-59-0	200	790	—
Dichloroethyl ether	111-44-4	(C)15	(C)90	X
Dichloromethane; see Methylene chloride				
Dichloromonofluoromethane	75-43-4	1000	4200	—
1,1-Dichloro-1-nitroethane	594-72-9	(C)10	(C)60	—
1,2-Dichloropropane; see Propylene dichloride				
Dichlorotetrafluoroethane	76-14-2	1000	7000	—
Dichlorvos (DDVP)	62-73-7	—	1	X
Dicyclopentadienyl iron	102-54-5			
Total dust		—	15	—
Respirable fraction		—	5	—
Dieldrin	60-57-1	—	0.25	X
Diethylamine	109-89-7	25	75	—
2-Diethylaminoethanol	100-37-8	10	50	—
Diethylene triamine	111-40-0	(C)10	(C)42	X
Diethyl ether; see Ethyl ether				
Difluorodibromomethane	75-61-6	100	860	—
Diglycidyl ether (DGE)	2238-07-5	(C)0.5	(C)2.8	—
Dihydroxybenzene; see Hydroquinone				
Diisobutyl ketone	108-83-8	50	290	—
Diisopropylamine	108-18-9	5	20	X
4-Dimethylaminoazobenzene; see § 1915.1015	60-11-7			
Dimethoxymethane; see Methylal				
Dimethyl acetamide	127-19-5	10	35	X
Dimethylamine	124-40-3	10	18	—
Dimethylaminobenzene; see Xylidine				
Dimethylaniline (N,N-Dimethylaniline)	121-69-7	5	25	X
Dimethylbenzene; see Xylene				
Dimethyl-1,2-dibromo- 2,2-dichloroethyl phosphate	300-76-5	—	3	—
Dimethylformamide	68-12-2	10	30	X
2,6-Dimethyl-4-heptanone; see Diisobutyl ketone				
1,1-Dimethylhydrazine	57-14-7	0.5	1	X
Dimethylphthalate	131-11-3	—	5	—

Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
Dimethyl sulfate	77-78-3	1	5	X
Dinitrobenzene (all isomers)			1	X
(ortho)	528-29-0			
(meta)	99-65-0			
(para)	100-25-4			
Dinitro-o-cresol	534-52-1	—	0.2	X
Dinitrotoluene	25321-14-6	—	1.5	X
Dioxane (Diethylene dioxide)	123-91-1	100	360	X
Diphenyl (Biphenyl)	92-52-4	0.2	1	—
Diphenylamine	122-39-4	—	10	—
Diphenylmethane diisocyanate; see Methylene bisphenyl isocyanate				
Dipropylene glycol methyl ether	34590-94-8	100	600	X
Di-sec octyl phthalate (Di-(2-ethylhexyl) phthalate)	117-81-7	—	5	—
Emery	12415-34-8			
Total dust		—	15	—
Respirable fraction		—	5	—
Endosulfan	115-29-7	—	0.1	X
Endrin	72-20-8	—	0.1	X
Epichlorohydrin	106-89-8	5	19	X
EPN	2104-64-5	—	0.5	X
1,2-Epoxypropane; see Propylene oxide				
2,3-Epoxy-1-propanol; see Glycidol				
Ethane	74-84-0	E		
Ethanethiol; see Ethyl mercaptan				
Ethanolamine	141-43-5	3	6	—
2-Ethoxyethanol (Cellosolve)	110-80-5	200	740	X
2-Ethoxyethyl acetate (Cellosolve acetate)	111-15-9	100	540	X
Ethyl acetate	141-78-6	400	1400	—
Ethyl acrylate	140-88-5	25	100	X
Ethyl alcohol (Ethanol)	64-17-5	1000	1900	—
Ethylamine	75-04-7	10	18	—
Ethyl amyl ketone (5-Methyl-3-heptanone)	541-85-5	25	130	—
Ethyl benzene	100-41-4	100	435	—
Ethyl bromide	74-96-4	200	890	—
Ethyl butyl ketone (3-Heptanone)	106-35-4	50	230	—
Ethyl chloride	75-00-3	1000	2600	—
Ethyl ether	60-29-7	400	1200	—
Ethyl formate	109-94-4	100	300	—

Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
Ethyl mercaptan	75-08-1	0.5	1	—
Ethyl silicate	78-10-4	100	850	—
Ethylene	74-85-1	E		
Ethylene chlorohydrin	107-07-3	5	16	X
Ethylenediamine	107-15-3	10	25	—
Ethylene dibromide	106-93-4	(C)25	(C)190	X
Ethylene dichloride (1,2-Dichloroethane)	107-06-2	50	200	—
Ethylene glycol dinitrate	628-96-6	(C)0.2	(C)1	X
Ethylene glycol methyl acetate; see Methyl cellosolve acetate				
Ethyleneimine; see § 1915.1012	151-56-4			
Ethylene oxide; see § 1915.1047	75-21-8			
Ethylidene chloride; see 1,1-Dichloroethane				
N-Ethylmorpholine	100-74-3	20	94	X
Ferbam	14484-64-1			
Total dust		—	15	—
Ferrovandium dust	12604-58-9	—	1	—
Fibrous Glass				
Total dust			15	—
Respirable fraction		—	5	—
Fluorides (as F)	Varies with compound	—	2.5	—
Fluorine	7782-41-4	0.1	0.2	—
Fluorotrichloromethane (Trichlorofluoromethane)	75-69-4	1000	5600	—
Formaldehyde; see § 1915.1048	50-00-0			
Formic acid	64-18-6	5	9	—
Furfural	98-01-1	5	20	X
Furfuryl alcohol	98-00-0	50	200	—
Gasoline	8006-61-9		A <sup>3</sup>	—
Glycerin (mist)	56-81-5			
Total dust		—	15	—
Respirable fraction		—	5	—
Glycidol	556-52-5	50	150	—
Glycol monoethyl ether; see 2-Ethoxyethanol				
Graphite, natural, respirable dust	7782-42-5	( <sup>2</sup> )	( <sup>2</sup> )	( <sup>2</sup> )
Graphite, synthetic				
Total dust		—	15	—
Respirable fraction		—	5	—
Guthion; see Azinphos methyl				
Gypsum	13397-24-5			

Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
Total dust		—	15	—
Respirable fraction		—	5	—
Hafnium	7440-58-6	—	0.5	—
Helium	7440-59-7	E		
Heptachlor	76-44-8	—	0.5	X
Heptane (n-Heptane)	142-82-5	500	2000	—
Hexachloroethane	67-72-1	1	10	X
Hexachloronaphthalene	1335-87-1	—	0.2	X
n-Hexane	110-54-3	500	1800	—
2-Hexanone (Methyl n-butyl ketone)	591-78-6	100	410	—
Hexone (Methyl isobutyl ketone)	108-10-1	100	410	—
sec-Hexyl acetate	108-84-9	50	300	—
Hydrazine	302-01-2	1	1.3	X
Hydrogen	1333-74-0	E		
Hydrogen bromide	10035-10-6	3	10	—
Hydrogen chloride	7647-01-0	(C)5	(C)7	—
Hydrogen cyanide	74-90-8	10	11	X
Hydrogen fluoride (as F)	7664-39-3	3	2	—
Hydrogen peroxide	7722-84-1	1	1.4	—
Hydrogen selenide (as Se)	7783-07-5	0.05		
Hydrogen sulfide	7783-06-4	10	15	—
Hydroquinone	123-31-9	—	2	—
Indene	95-13-6	10	45	—
Indium and compounds (as In)	7440-74-6	—	0.1	—
Iodine	7553-56-2	(C)0.1	(C)1	—
Iron oxide fume	1309-37-1	—	10	—
Iron salts (soluble) (as Fe)	Varies with compound	—	1	—
Isoamyl acetate	123-92-2	100	525	—
Isoamyl alcohol (primary and secondary)	123-51-3	100	360	—
Isobutyl acetate	110-19-0	150	700	—
Isobutyl alcohol	78-83-1	100	300	—
Isophorone	78-59-1	25	140	—
Isopropyl acetate	108-21-4	250	950	—
Isopropyl alcohol	67-63-0	400	980	—
Isopropylamine	75-31-0	5	12	—
Isopropyl ether	108-20-3	500	2100	—
Isopropyl glycidyl ether (IGE)	4016-14-2	50	240	—
Kaolin	1332-58-7			

Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
Total dust		—	15	—
Respirable fraction		—	5	—
Ketene	463-51-4	0.5	0.9	—
Lead, inorganic (as Pb); see § 1915.1025	7439-92-1	—	—	—
Limestone	1317-65-3			
Total dust		—	15	—
Respirable fraction		—	5	—
Lindane	58-89-9	—	0.5	X
Lithium hydride	7580-67-8	—	0.025	—
L.P.G. (Liquefied petroleum gas)	68476-85-7	1000	1800	
Magnesite	546-93-0			
Total dust		—	15	—
Respirable fraction		—	5	—
Magnesium oxide fume	1309-48-4			
Total particulate		15	—	—
Malathion	121-75-5			
Total dust		—	15	X
Maleic anhydride	108-31-6	0.25		
Manganese compounds (as Mn)	7439-96-5	—	(C)5	—
Manganese fume (as Mn)	7439-96-5	—	(C)5	—
Marble	1317-65-3			
Total dust		—	15	—
Respirable fraction		—	5	—
Mercury (aryl and inorganic)(as Hg)	7439-97-6		0.1	X
Mercury (organo) alkyl compounds (as Hg)	7439-97-6	—	0.01	X
Mercury (vapor) (as Hg)	7439-97-6	—	0.1	X
Mesityl oxide	141-79-7	25	100	—
Methane	74-82-8	E		
Methanethiol; see Methyl mercaptan				
Methoxychlor	72-43-5			
Total dust		—	15	—
2-Methoxyethanol (Methyl cellosolve)	109-86-4	25	80	X
2-Methoxyethyl acetate (Methyl cellosolve acetate)	110-49-6	25	120	X
Methyl acetate	79-20-9	200	610	—
Methyl acetylene (Propyne)	74-99-7	1000	1650	—
Methyl acetylene-propadiene mixture (MAPP)		1000	1800	—
Methyl acrylate	96-33-3	10	35	X
Methylal (Dimethoxy-methane)	109-87-5	1000	3100	—
Methyl alcohol	67-56-1	200	260	—

Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
Methylamine	74-89-5	10	12	—
Methyl amyl alcohol; see Methyl isobutyl carbinol				
Methyl n-amyl ketone	110-43-0	100	465	—
Methyl bromide	74-83-9	(C)20	(C)80	X
Methyl butyl ketone; see 2-Hexanone				
Methyl cellosolve; see 2-Methoxyethanol				
Methyl cellosolve acetate; see 2-Methoxyethyl acetate				
Methyl chloride	74-87-3	100	210	—
Methyl chloroform (1,1,1-Trichloroethane)	71-55-6	350	1900	—
Methylcyclohexane	108-87-2	500	2000	—
Methylcyclohexanol	25639-42-3	100	470	—
o-Methylcyclohexanone	583-60-8	100	460	X
Methylene chloride; see § 1910.1052				
Methyl ethyl ketone (MEK); see 2-Butanone				
Methyl formate	107-31-3	100	250	—
Methyl hydrazine (Monomethyl hydrazine)	60-34-4	(C)0.2	(C)0.35	X
Methyl iodide	74-88-4	5	28	X
Methyl isoamyl ketone	110-12-3	100	475	—
Methyl isobutyl carbinol	108-11-2	25	100	X
Methyl isobutyl ketone; see Hexone				
Methyl isocyanate	624-83-9	0.02	0.05	X
Methyl mercaptan	74-93-1	0.5	1	—
Methyl methacrylate	80-62-6	100	410	100
Methyl propyl ketone; see 2-Pentanone				
Methyl silicate	681-84-5	5	30	—
alpha-Methyl styrene	98-83-9	(C)100	(C)480	—
Methylene bisphenyl isocyanate (MDI)	101-68-8	(C)0.02	(C)0.2	—
Mica; see Silicates				
Mineral wool				
Total dust		—	15	—
Respirable dust		—	5	—
Molybdenum (as Mo)	7439-98-7			
Soluble compounds		—	5	—
Insoluble compounds				
Total dust		—	15	—
Monomethyl aniline	100-61-8	2	9	X
Monomethyl hydrazine; see Methyl hydrazine				
Morpholine	110-91-8	20	70	X
Naphtha (Coal tar)	8030-30-6	100	400	—

Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
Naphthalene	91-20-3	10	50	—
alpha-Naphthylamine; see § 1915.1004	134-32-7			
beta-Naphthylamine; see § 1915.1009	91-59-8			—
Neon	7440-01-9			
Nickel carbonyl (as Ni)	13463-39-3	0.001	0.007	—
Nickel, metal and insoluble compounds (as Ni)	7440-02-0	—	1	—
Nickel, soluble compounds (as Ni)	7440-02-0	—	1	—
Nicotine	54-11-5	—	0.5	X
Nitric acid	7697-37-2	2	5	—
Nitric oxide	10102-43-9	25	30	—
p-Nitroaniline	100-01-6	1	6	X
Nitrobenzene	98-95-3	1	5	X
p-Nitrochlorobenzene	100-00-5	—	1	X
4-Nitrodiphenyl; see § 1915.1003	92-93-3			
Nitroethane	79-24-3	100	310	—
Nitrogen	7727-37-9	E		
Nitrogen dioxide	10102-44-0	(C)5	(C)9	—
Nitrogen trifluoride	7783-54-2	10	29	—
Nitroglycerin	55-63-0	(C)0.2	(C)2	X
Nitromethane	75-52-5	100	250	—
1-Nitropropane	108-03-2	25	90	—
2-Nitropropane	79-46-9	25	90	—
N-Nitrosodimethylamine; see § 1915.1016	62-79-9			—
Nitrotoluene (all isomers)		5	30	X
o-isomer	88-72-2;			
m-isomer	99-08-1;			
p-isomer	99-99-0			
Nitrotrichloromethane; see Chloropicrin				
Nitrous oxide	10024-97-2	E		
Octachloronaphthalene	2234-13-1	—	0.1	X
Octane	111-65-9	400	1900	—
Oil mist, mineral	8012-95-1	—	5	—
Osmium tetroxide (as Os)	20816-12-0	—	0.002	—
Oxalic acid	144-62-7	—	1	—
Oxygen difluoride	7783-41-7	0.05	0.1	—
Ozone	10028-15-6	0.1	0.2	—
Paraquat, respirable dust	4685-14-7;	—	0.5	X
	1910-42-5;			
	2074-50-2			



Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
Parathion	56-38-2	—	0.1	—
Particulates not otherwise regulated				
Total dust organic and inorganic		—	15	—
PCB; see Chlorodiphenyl (42% and 54% chlorine)				
Pentaborane	19624-22-7	0.005	0.01	—
Pentachloronaphthalene	1321-64-8	—	0.5	X
Pentachlorophenol	87-86-5	—	0.5	X
Pentaerythritol	115-77-5			
Total dust		—	15	—
Respirable fraction		—	5	—
Pentane	109-66-0	500	1500	—
2-Pentanone (Methyl propyl ketone)	107-87-9	200	700	—
Perchloroethylene (Tetrachloroethylene)	127-18-4	100	670	—
Perchloromethyl mercaptan	594-42-3	0.1	0.8	—
Perchloryl fluoride	7616-94-6	3	13.5	—
Perlite	93763-70-3			
Total dust		—	15	—
Respirable fraction		—	5	—
Petroleum distillates (Naphtha)(Rubber Solvent)			A <sup>3</sup>	—
Phenol	108-95-2	5	19	X
p-Phenylene diamine	106-50-3	—	0.1	X
Phenyl ether, vapor	101-84-8	1	7	—
Phenyl ether-biphenyl mixture, vapor		1	7	—
Phenylethylene; see Styrene				
Phenyl glycidyl ether (PGE)	122-60-1	10	60	—
Phenylhydrazine	100-63-0	5	22	X
Phosdrin (Mevinphos)	7786-34-7	—	0.1	X
Phosgene (Carbonyl chloride)	75-44-5	0.1	0.4	—
Phosphine	7803-51-2	0.3	0.4	—
Phosphoric acid	7664-38-2	—	1	—
Phosphorus (yellow)	7723-14-0	—	0.1	—
Phosphorus pentachloride	10026-13-8	—	1	—
Phosphorus pentasulfide	1314-80-3	—	1	—
Phosphorus trichloride	7719-12-2	0.5	3	—
Phthalic anhydride	85-44-9	2	12	—
Picloram	1918-02-1			
Total dust		—	15	—
Respirable fraction		—	5	—
Picric acid	88-89-1	—	0.1	—

Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
Piperazine dihydrochloride	142-64-3	—	—	X
Pindone (2-Pivalyl-1,3-indandione)	83-26-1	—	0.1	—
Plaster of Paris	26499-65-0			
Total dust		—	15	—
Respirable fraction		—	5	—
Platinum (as Pt)	7440-06-4			
Metal		—	—	—
Soluble salts		—	0.002	—
Polytetrafluoroethylene decomposition products			A <sup>2</sup>	
Portland cement	65997-15-1			
Total dust		15	—	10
Respirable fraction		5	—	—
Propargyl alcohol	107-19-7	1	—	X
beta-Propiolactone; see § 1915.1013	57-57-8			
Propionic acid	79-09-4	—	—	—
n-Propyl acetate	109-60-4	200	840	—
n-Propyl alcohol	71-23-8	200	500	—
n-Propyl nitrate	627-13-4	25	110	—
Propylene dichloride	78-87-5	75	350	—
Propylene imine	75-55-8	2	5	X
Propylene oxide	75-56-9	100	240	—
Propyne; see Methyl acetylene				
Pyrethrum	8003-34-7	—	5	—
Pyridine	110-86-1	5	15	—
Quinone	106-51-4	0.1	0.4	—
RDX; see Cyclonite				
Rhodium (as Rh), metal fume and insoluble compounds	7440-16-6	—	0.1	—
Rhodium (as Rh), soluble compounds	7440-16-6	—	0.001	—
Ronnel	299-84-3	—	10	—
Rotenone	83-79-4	—	5	—
Rouge		—		
Total dust		—	15	—
Respirable fraction		—	5	—
Selenium compounds (as Se)	7782-49-2	—	0.2	—
Selenium hexafluoride (as Se)	7783-79-1	0.05	0.4	—
Silica, amorphous, precipitated and gel	112926-00-8	( <sup>2</sup> )	( <sup>2</sup> )	( <sup>2</sup> )
Silica, amorphous, diatomaceous earth, containing less than 1% crystalline silica	61790-53-2	( <sup>2</sup> )	( <sup>2</sup> )	( <sup>2</sup> )
Silica, crystalline, respirable dust				

Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
Cristobalite; see 1915.1053	14464-46-1			
Quartz; see 1915.1053 <sup>5</sup>	14808-60-7			
Tripoli (as quartz); see 1915.1053 <sup>5</sup>	1317-95-9			
Tridymite; see 1915.1053	15468-32-3			
Silica, fused, respirable dust	60676-86-0	( <sup>2</sup> )	( <sup>2</sup> )	( <sup>2</sup> )
Silicates (less than 1% crystalline silica)				
Mica (respirable dust)	12001-26-2	( <sup>2</sup> )	( <sup>2</sup> )	( <sup>2</sup> )
Soapstone, total dust	—	( <sup>2</sup> )	( <sup>2</sup> )	( <sup>2</sup> )
Soapstone, respirable dust	—	( <sup>2</sup> )	( <sup>2</sup> )	( <sup>2</sup> )
Talc (containing asbestos)	—	( <sup>3</sup> )	( <sup>3</sup> )	( <sup>3</sup> )
Talc (containing no asbestos), respirable dust	14807-96-6	( <sup>2</sup> )	( <sup>2</sup> )	( <sup>2</sup> )
Tremolite, asbestiform		( <sup>3</sup> )	( <sup>3</sup> )	( <sup>3</sup> )
Silicon	7440-21-3			
Total dust		—	15	—
Respirable fraction		—	5	—
Silicon carbide	409-21-2			
Total dust		—	15	—
Respirable fraction		—	5	—
Silver, metal and soluble compounds (as Ag)	7440-22-4	—	0.01	—
Soapstone; see Silicates				
Sodium fluoroacetate	62-74-8	—	0.05	X
Sodium hydroxide	1310-73-2	—	2	—
Starch	9005-25-8			
Total dust		—	15	—
Respirable fraction		—	5	—
Stibine	7803-52-3	0.1	0.5	—
Stoddard solvent	8052-41-3	200	1150	—
Strychnine	57-24-9	—	0.15	—
Styrene	100-42-5	100	420	50
Sucrose	57-50-1			
Total dust		—	15	—
Respirable fraction		—	5	—
Sulfur dioxide	7446-09-5	5	13	—
Sulfur hexafluoride	2551-62-4	1000	6000	—
Sulfuric acid	7664-93-9	—	1	—
Sulfur monochloride	10025-67-9	1	6	—
Sulfur pentafluoride	5714-22-7	0.025	0.25	—
Sulfuryl fluoride	2699-79-8	5	20	—
Systox, see Demeton				

Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
2,4,5-T (2,4,5-trichlorophenoxyacetic acid)	93-76-5	—	10	—
Talc; see Silicates—				
Tantalum, metal and oxide dust	7440-25-7	—	5	—
TEDP (Sulfotep)	3689-24-5	—	0.2	X
Teflon decomposition products			A2	
Tellurium and compounds (as Te)	13494-80-9	—	0.1	—
Tellurium hexafluoride (as Te)	7783-80-4	0.02	0.2	—
Temephos	3383-96-8			
Total dust		—	15	—
Respirable fraction		—	5	—
TEPP (Tetraethyl pyrophosphate)	107-49-3	—	0.05	X
Terphenyls	26140-60-3	(C)1	(C)9	—
1,1,1,2-Tetrachloro-2,2-difluoroethane	76-11-9	500	4170	—
1,1,2,2-Tetrachloro-1,2-difluoroethane	76-12-0	500	4170	—
1,1,2,2-Tetrachloroethane	79-34-5	5	35	X
Tetrachloroethylene; see Perchloroethylene				
Tetrachloromethane; see Carbon tetrachloride				
Tetrachloronaphthalene	1335-88-2	—	2	X
Tetraethyl lead (as Pb)	78-00-2	—	0.1	X
Tetrahydrofuran	109-99-9	200	590	—
Tetramethyl lead, (as Pb)	75-74-1	—	0.15	X
Tetramethyl succinonitrile	3333-52-6	0.5	3	X
Tetranitromethane	509-14-8	1	8	—
Tetryl (2,4,6-Trinitrophenylmethylnitramine)	479-45-8	—	1.5	X
Thallium, soluble compounds (as Tl)	7440-28-0	—	0.1	X
4,4'-Thiobis (6-tert, Butyl-m-cresol)	96-69-5			
Total dust		—	15	—
Respirable fraction		—	5	—
Thiram	137-26-8	—	5	—
Tin, inorganic compounds (except oxides) (as Sn)	7440-31-5	—	2	—
Tin, organic compounds (as Sn)	7440-31-5	—	0.1	—
Tin oxide (as Sn)	21651-19-4	—	—	—
Total dust		—	15	—
Respirable fraction		—	5	—
Titanium dioxide	13463-67-7			
Total dust		—	15	—
Toluene	108-88-3	200	750	100
Toluene-2,4-diisocyanate (TDI)	584-84-9	(C)0.02	(C)0.14	—
o-Toluidine	95-53-4	5	22	X

Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
Toxaphene; see Chlorinated camphene				
Tremolite; see Silicates				
Tributyl phosphate	126-73-8	—	5	—
1,1,1-Trichloroethane; see Methyl chloroform				
1,1,2-Trichloroethane	79-00-5	10	45	X
Trichloroethylene	79-01-6	100	535	—
Trichloromethane; see Chloroform				
Trichloronaphthalene	1321-65-9	—	5	X
1,2,3-Trichloropropane	96-18-4	50	300	—
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	1000	7600	—
Triethylamine	121-44-8	25	100	—
Trifluorobromomethane	75-63-8	1000	6100	—
Trimethyl benzene	25551-13-7	25	120	—
2,4,6-Trinitrophenyl; see Picric acid				
2,4,6-Trinitrophenylmethylnitramine; see Tetryl				
2,4,6-Trinitrotoluene (TNT)	118-96-7	—	1.5	X
Triorthocresyl phosphate	78-30-8	—	0.1	—
Triphenyl phosphate	115-86-6	—	3	—
Tungsten (as W)	7440-33-7			
Insoluble compounds		—	5	—
Soluble compounds		—	1	—
Turpentine	8006-64-2	100	560	—
Uranium (as U)	7440-61-1			
Soluble compounds		—	0.2	—
Insoluble compounds		—	0.2	—
Vanadium	1314-62-1			
Respirable dust (as V <sub>2</sub> O <sub>5</sub> )		—	(C)0.5	—
Fume (as V <sub>2</sub> O <sub>5</sub> )		—	(C)0.1	—
Vegetable oil mist				
Total dust		—	15	—
Respirable fraction		—	5	—
Vinyl benzene; see Styrene				
Vinyl chloride; see § 1915.1017	75-01-4			
Vinyl cyanide; see Acrylonitrile				
Vinyl toluene	25013-15-4	100	480	—
Warfarin	81-81-2	—	0.1	—
Xylenes (o-, m-, p-isomers)	1330-20-7	100	435	—
Xylidine	1300-73-8	5	25	X
Yttrium	7440-65-5	—	1	—

Substance	CAS No. <sup>d</sup>	ppm <sup>a *</sup>	mg/m <sup>3</sup> <sub>b *</sub>	Skin Designation
Zinc chloride fume	7646-85-7	—	1	—
Zinc oxide fume	1314-13-2	—	5	—
Zinc oxide	1314-13-2			
Total dust		—	15	—
Respirable fraction		—	5	—
Zinc stearate	557-05-1			
Total dust		—	15	—
Respirable fraction		—	5	—
Zirconium compounds (as Zr)	7440-67-7	—	5	

### Mineral Dusts

Substance	mppcf <sup>(i)</sup>
SILICA:	
Crystalline	250 <sup>(k)</sup>
Quartz. Threshold Limit calculated from the formula <sup>(p)</sup>	% SiO <sub>2</sub> + 5
Cristobalite	
Amorphous, including natural diatomaceous earth	20
SILICATES (less than 1% crystalline silica)	
Mica	20
Portland cement	50
Soapstone	20
Talc (non-asbestiform)	20
Talc (fibrous), use asbestos limit	—
Graphite (natural)	15
Inert or Nuisance Particulates: <sup>(m)</sup>	50 (or 15 mg/m <sup>3</sup> whichever is the smaller) of total dust <1% SiO <sub>2</sub>
Conversion factors	
mppcf × 35.3 = million particles per cubic meter = particles per c.c.	

Footnotes to Table Z—Shipyards:

<sup>1</sup> [Reserved]

<sup>2</sup> See Mineral Dusts Table.

<sup>3</sup> Use Asbestos Limit § 1915.1001.

<sup>4</sup> See 1915.1001.

<sup>5</sup> See Mineral Dusts table for the exposure limit for any operations or sectors where the exposure limit in § 1915.1053 is stayed or is otherwise not in effect.

\* The PELs are 8-hour TWAs unless otherwise noted; a (C) designation denotes a ceiling limit. They are to be determined from breathing-zone air samples.

<sup>a</sup> Parts of vapor or gas per million parts of contaminated air by volume at 25 °C and 760 torr.

<sup>b</sup> Milligrams of substance per cubic meter of air. When entry is in this column only, the value is exact; when listed with a ppm entry, it is approximate.

<sup>c</sup> [Reserved]

<sup>d</sup> The CAS number is for information only. Enforcement is based on the substance name. For an entry covering more than one metal compound, measured as the metal, the CAS number for the metal is given—not CAS numbers for the individual compounds.

<sup>e-f</sup> [Reserved]

<sup>g</sup> For sectors excluded from § 1915.1028 the limit is 10 ppm TWA.

<sup>h</sup> Where OSHA has published a proposal for a substance but has not issued a final rule, the proposal is referenced and the existing limit is published.

<sup>i</sup> [Reserved]

<sup>j</sup> Millions of particles per cubic foot of air, based on impinger samples counted by light-field techniques.

<sup>k</sup> The percentage of crystalline silica in the formula is the amount determined from airborne samples, except in those instances in which other methods have been shown to be applicable.

<sup>m</sup> Covers all organic and inorganic particulates not otherwise regulated. Same as Particulates Not Otherwise Regulated.

<sup>n</sup> If the exposure limit in § 1915.1026 is stayed or is otherwise not in effect, the exposure limit is a ceiling of 0.1 mg/m<sup>3</sup>.

<sup>o</sup> If the exposure limit in § 1915.1026 is stayed or is otherwise not in effect, the exposure limit is 0.1 mg/m<sup>3</sup> (as CrO<sub>3</sub>) as an 8-hour TWA.

<sup>p</sup> This standard applies to any operations or sectors for which the respirable crystalline silica standard, 1915.1053, is stayed or otherwise is not in effect.

<sup>q</sup> This standard applies to any operations or sectors for which the beryllium standard, 1915.1024, is stayed or otherwise is not in effect.

The 1970 TLV uses letter designations instead of a numerical value as follows:

A<sup>1</sup> [Reserved]

A<sup>2</sup> Polytetrafluoroethylene decomposition products. Because these products decompose in part by hydrolysis in alkaline solution, they can be quantitatively determined in air as fluoride to provide an index of exposure. No TLV is recommended pending determination of the toxicity of the products, but air concentrations should be minimal.

A<sup>3</sup> Gasoline and/or Petroleum Distillates. The composition of these materials varies greatly and thus a single TLV for all types of these materials is no longer applicable. The content of benzene, other aromatics and additives should be determined to arrive at the appropriate TLV.

E Simple asphyxiants. The limiting factor is the available oxygen which shall be at least 18% and be within the requirement addressing explosion in subpart B of part 1915.

[58 FR 35514, July 1, 1993, as amended at 61 FR 56856, Nov. 4, 1996; 62 FR 1619, Jan. 10, 1997; 67 FR 44545, July 3, 2002; 71 FR 10377, Feb. 28, 2006; 71 FR 36009, June 23, 2006; 76 FR 80740, Dec. 27, 2011; 81 FR 16874, Mar. 2 2016; 81 FR 31167, May 19, 2016; 81 FR 60273, Sept. 2, 2016; 82 FR 2744, Jan. 9, 2017]

## § 1915.1001 Asbestos.

- (a) **Scope and application.** This section regulates asbestos exposure in all shipyard employment work as defined in 29 CFR part 1915, including but not limited to the following:
- (1) Demolition or salvage of structures, vessels, and vessel sections where asbestos is present;
  - (2) Removal or encapsulation of materials containing asbestos;
  - (3) Construction, alteration, repair, maintenance, or renovation of vessels, vessel sections, structures, substrates, or portions thereof, that contain asbestos;
  - (4) Installation of products containing asbestos;
  - (5) Asbestos spill/emergency cleanup; and
  - (6) Transportation, disposal, storage, containment of and housekeeping activities involving asbestos or products containing asbestos, on the site or location at which construction activities are performed.
  - (7) Coverage under this standard shall be based on the nature of the work operation involving asbestos exposure.
  - (8) This section does not apply to asbestos-containing asphalt roof cements, coatings and mastics.
- (b) **Definitions.** **Aggressive method** means removal or disturbance of building/vessel materials by sanding, abrading, grinding, or other method that breaks, crumbles, or otherwise disintegrates intact ACM.

**Amended water** means water to which surfactant (wetting agent) has been added to increase the ability of the liquid to penetrate ACM.



**Asbestos** includes chrysotile, amosite, crocidolite, tremolite asbestos, anthophyllite asbestos, actinolite asbestos, and any of these minerals that has been chemically treated and/or altered. For purposes of this standard, asbestos includes PACM, as defined below.

**Asbestos-containing material**, (ACM) means any material containing more than one percent asbestos.

**Assistant Secretary** means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.

**Authorized person** means any person authorized by the employer and required by work duties to be present in regulated areas.

**Building/facility/vessel owner** is the legal entity, including a lessee, which exercises control over management and record keeping functions relating to a building, facility, and/or vessel in which activities covered by this standard take place.

**Certified Industrial Hygienist** (CIH) means one certified in the practice of industrial hygiene by the American Board of Industrial Hygiene.

**Class I asbestos work** means activities involving the removal of thermal system insulation or surfacing ACM/PACM.

**Class II asbestos work** means activities involving the removal of ACM which is neither TSI or surfacing ACM. This includes, but is not limited to, the removal of asbestos-containing wallboard, floor tile and sheeting, roofing and siding shingles, and construction mastics.

**Class III asbestos work** means repair and maintenance operations, where "ACM", including TSI and surfacing ACM and PACM, is likely to be disturbed.

**Class IV asbestos work** means maintenance and custodial activities during which employees contact but do not disturb ACM or PACM and activities to clean up dust, waste and debris resulting from Class I, II, and III activities.

**Clean room** means an uncontaminated room having facilities for the storage of employees' street clothing and uncontaminated materials and equipment.

**Closely resemble** means that the major workplace conditions which have contributed to the levels of historic asbestos exposure, are no more protective than conditions of the current workplace.

**Competent person** see *qualified person*.

**Critical barrier** means one or more layers of plastic sealed over all openings into a work area or any other physical barrier sufficient to prevent airborne asbestos in a work area from migrating to an adjacent area.

**Decontamination area** means an enclosed area adjacent and connected to the regulated area and consisting of an equipment room, shower area, and clean room, which is used for the decontamination of workers, materials, and equipment that are contaminated with asbestos.

**Demolition** means the wrecking or taking out of any load-supporting structural member and any related razing, removing, or stripping of asbestos products.

**Director** means the Director, National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, or designee.

**Disturbance** means activities that disrupt the matrix of ACM or PACM, crumble or pulverize ACM or PACM, or generate visible debris from ACM or PACM. Disturbance includes cutting away small amounts of ACM and PACM, no greater than the amount which can be contained in one standard sized glove bag or waste bag, in order to access a building or vessel component. In no event shall the amount of ACM or PACM so disturbed exceed that which can be contained in one glove bag or waste bag which shall not exceed 60 inches in length and width.

**Employee exposure** means that exposure to airborne asbestos that would occur if the employee were not using respiratory protective equipment.

**Equipment room** (change room) means a contaminated room located within the decontamination area that is supplied with impermeable bags or containers for the disposal of contaminated protective clothing and equipment.

**Fiber** means a particulate form of asbestos, 5 micrometers or longer, with a length-to-diameter ratio of at least 3 to 1.

**Glovebag** means not more than a 60 × 60 inch impervious plastic bag-like enclosure affixed around an asbestos-containing material, with glove-like appendages through which material and tools may be handled.

**High-efficiency particulate air (HEPA) filter** means a filter capable of trapping and retaining at least 99.97 percent of all mono-dispersed particles of 0.3 micrometers in diameter.

**Homogeneous area** means an area of surfacing material or thermal system insulation that is uniform in color and texture.

**Industrial hygienist** means a professional qualified by education, training, and experience to anticipate, recognize, evaluate and develop controls for occupational health hazards.

**Intact** means that the ACM has not crumbled, been pulverized, or otherwise deteriorated so that the asbestos is no longer likely to be bound with its matrix.

**Modification** for purposes of paragraph (g)(6)(ii) of this section means a changed or altered procedure, material or component of a control system, which replaces a procedure, material or component of a required system. Omitting a procedure or component, or reducing or diminishing the stringency or strength of a material or component of the control system is not a "modification" for purposes of paragraph (g)(6) of this section.

**Negative Initial Exposure Assessment** means a demonstration by the employer, which complies with the criteria in paragraph (f)(2)(iii) of this section, that employee exposure during an operation is expected to be consistently below the PELs.

**PACM** means *presumed asbestos containing material*.

**Presumed asbestos containing material** means thermal system insulation and surfacing material found in buildings, vessels, and vessel sections constructed no later than 1980. The designation of a material as "PACM" may be rebutted pursuant to paragraph (k)(5) of this section.

**Project Designer** means a person who has successfully completed the training requirements for an abatement project designer established by 40 U.S.C. § 763.90(g).

**Qualified person** means, in addition to the definition in 29 CFR 1926.32(f), one who is capable of identifying existing asbestos hazards in the workplace and selecting the appropriate control strategy for asbestos exposure, who has the authority to take prompt corrective measures to eliminate them, as specified in 29 CFR 1926.32(f); in addition, for Class I and Class II work who is specially trained in a training course which meets the criteria of EPA's Model Accreditation Plan (40 CFR part 763) for supervisor, or its equivalent, and for Class III and Class IV work, who is trained in a manner consistent with EPA requirements for training of local education agency maintenance and custodial staff as set forth at 40 CFR 763.92(a)(2).

**Regulated area** means an area established by the employer to demarcate areas where Class I, II, and III asbestos work is conducted, and any adjoining area where debris and waste from such asbestos work accumulate; and a work area within which airborne concentrations of asbestos, exceed or can reasonably be expected to exceed the permissible exposure limit. Requirements for regulated areas are set out in paragraph (e) of this section.

**Removal** means all operations where ACM and/or PACM is taken out or stripped from structures or substrates, and includes demolition operations.

**Renovation** means the modifying of any existing vessel, vessel section, structure, or portion thereof.

**Repair** means overhauling, rebuilding, reconstructing, or reconditioning of vessels, vessel sections, structures or substrates, including encapsulation or other repair of ACM or PACM attached to structures or substrates.

**Surfacing material** means material that is sprayed, troweled-on or otherwise applied to surfaces (such as acoustical plaster on ceilings and fireproofing materials on structural members, or other materials on surfaces for acoustical, fireproofing, and other purposes).

**Surfacing ACM** means surfacing material which contains more than 1% asbestos.

**Thermal system insulation (TSI)** means ACM applied to pipes, fittings, boilers, breeching, tanks, ducts or other structural components to prevent heat loss or gain.

**Thermal system insulation ACM** is thermal system insulation which contains more than 1% asbestos.

(c) **Permissible exposure limits (PELS) –**

- (1) **Time-weighted average limit (TWA).** The employer shall ensure that no employee is exposed to an airborne concentration of asbestos in excess of 0.1 fiber per cubic centimeter of air as an eight (8) hour time-weighted average (TWA), as determined by the method prescribed in appendix A to this section, or by an equivalent method.
- (2) **Excursion limit.** The employer shall ensure that no employee is exposed to an airborne concentration of asbestos in excess of 1.0 fiber per cubic centimeter of air (1 f/cc) as averaged over a sampling period of thirty (30) minutes, as determined by the method prescribed in appendix A to this section, or by an equivalent method.

(d) **Multi-employer worksites.**

- (1) On multi-employer worksites, an employer performing work requiring the establishment of a regulated area shall inform other employers on the site of the nature of the employer's work with asbestos and/or PACM, of the existence of and requirements pertaining to regulated areas, and the measures taken to ensure that employees of such other employers are not exposed to asbestos.

- (2) Asbestos hazards at a multi-employer worksite shall be abated by the contractor who created or controls the source of asbestos contamination. For example, if there is a significant breach of an enclosure containing Class I work, the employer responsible for erecting the enclosure shall repair the breach immediately.
- (3) In addition, all employers of employees exposed to asbestos hazards shall comply with applicable protective provisions to protect their employees. For example, if employees working immediately adjacent to a Class I asbestos job are exposed to asbestos due to the inadequate containment of such job, their employer shall either remove the employees from the area until the enclosure breach is repaired; or perform an initial exposure assessment pursuant to paragraph (f) of this section.
- (4) All employers of employees working adjacent to regulated areas established by another employer on a multi-employer worksite shall take steps on a daily basis to ascertain the integrity of the enclosure and/or the effectiveness of the control method relied on by the primary asbestos contractor to assure that asbestos fibers do not migrate to such adjacent areas.
- (5) All general contractors on a shipyard project which includes work covered by this standard shall be deemed to exercise general supervisory authority over the work covered by this standard, even though the general contractor is not qualified to serve as the asbestos "qualified person" as defined by paragraph (b) of this section. As supervisor of the entire project, the general contractor shall ascertain whether the asbestos contractor is in compliance with this standard, and shall require such contractor to come into compliance with this standard when necessary.

(e) **Regulated areas.**

- (1) All Class I, II and III asbestos work shall be conducted within regulated areas. All other operations covered by this standard shall be conducted within a regulated area where airborne concentrations of asbestos exceed, or there is a reasonable possibility they may exceed a PEL. Regulated areas shall comply with the requirements of paragraphs (e) (2), (3), (4) and (5) of this section.
- (2) **Demarcation.** The regulated area shall be demarcated in any manner that minimizes the number of persons within the area and protects persons outside the area from exposure to airborne asbestos. Where critical barriers or negative pressure enclosures are used, they may demarcate the regulated area. Signs shall be provided and displayed pursuant to the requirements of paragraph (k)(7) of this section.
- (3) **Access.** Access to regulated areas shall be limited to authorized persons and to persons authorized by the Act or regulations issued pursuant thereto.
- (4) **Respirators.** All persons entering a regulated area where employees are required pursuant to paragraph (h)(1) of this section to wear respirators shall be supplied with a respirator selected in accordance with paragraph (h)(2) of this section.
- (5) **Prohibited activities.** The employer shall ensure that employees do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in the regulated area.
- (6) **Qualified persons.** The employer shall ensure that all asbestos work performed within regulated areas is supervised by a qualified person, as defined in paragraph (b) of this section. The duties of the qualified person are set out in paragraph (o) of this section.

(f) **Exposure assessments and monitoring –**

- (1) **General monitoring criteria.**

- (i) Each employer who has a workplace or work operation where exposure monitoring is required under this section shall perform monitoring to determine accurately the airborne concentrations of asbestos to which employees may be exposed.
- (ii) Determinations of employee exposure shall be made from breathing zone air samples that are representative of the 8-hour TWA and 30-minute short-term exposures of each employee.
- (iii) Representative 8-hour TWA employee exposure shall be determined on the basis of one or more samples representing full-shift exposure for employees in each work area. Representative 30-minute short-term employee exposures shall be determined on the basis of one or more samples representing 30 minute exposures associated with operations that are most likely to produce exposures above the excursion limit for employees in each work area.

(2) **Initial exposure assessment.**

- (i) Each employer who has a workplace or work operation covered by this standard shall ensure that a “qualified person” conducts an exposure assessment immediately before or at the initiation of the operation to ascertain expected exposures during that operation or workplace. The assessment must be completed in time to comply with requirements which are triggered by exposure data or the lack of a “negative exposure assessment,” and to provide information necessary to assure that all control systems planned are appropriate for that operation and will work properly.
- (ii) **Basis of initial exposure assessment.** Unless a negative exposure assessment has been made pursuant to paragraph (f)(2)(iii) of this section, the initial exposure assessment shall, if feasible, be based on monitoring conducted pursuant to paragraph (f)(1)(iii) of this section. The assessment shall take into consideration both the monitoring results and all observations, information or calculations which indicate employee exposure to asbestos, including any previous monitoring conducted in the workplace, or of the operations of the employer which indicate the levels of airborne asbestos likely to be encountered on the job. For Class I asbestos work, until the employer conducts exposure monitoring and documents that employees on that job will not be exposed in excess of the PELs, or otherwise makes a negative exposure assessment pursuant to paragraph (f)(2)(iii) of this section, the employer shall presume that employees are exposed in excess of the TWA and excursion limit.
- (iii) **Negative initial exposure assessment.** For any one specific asbestos job which will be performed by employees who have been trained in compliance with the standard, the employer may demonstrate that employee exposures will be below the PELs by data which conform to the following criteria:
  - (A) Objective data demonstrating that the product or material containing asbestos minerals or the activity involving such product or material cannot release airborne fibers in concentrations exceeding the TWA and excursion limit under those work conditions having the greatest potential for releasing asbestos; or
  - (B) Where the employer has monitored prior asbestos jobs for the PEL and the excursion limit within 12 months of the current or projected job, the monitoring and analysis were performed in compliance with the asbestos standard in effect; and the data were obtained during work operations conducted under workplace conditions “closely resembling” the processes, type of material, control methods, work practices, and environmental conditions used and prevailing in the employer’s current operations, the operations were conducted by employees whose training and experience are no more extensive than that

of employees performing the current job, and these data show that under the conditions prevailing and which will prevail in the current workplace there is a high degree of certainty that employee exposures will not exceed the TWA and excursion limit; or

- (C) The results of initial exposure monitoring of the current job made from breathing zone air samples that are representative of the 8-hour TWA and 30-minute short-term exposures of each employee covering operations which are most likely during the performance of the entire asbestos job to result in exposures over the PELs.

(3) **Periodic monitoring** —

- (i) **Class I and II operations.** The employer shall conduct daily monitoring that is representative of the exposure of each employee who is assigned to work within a regulated area who is performing Class I or II work, unless the employer pursuant to paragraph (f)(2)(iii) of this section, has made a negative exposure assessment for the entire operation.
- (ii) **All operations under the standard other than Class I and II operations.** The employer shall conduct periodic monitoring of all work where exposures are expected to exceed a PEL, at intervals sufficient to document the validity of the exposure prediction.
- (iii) **Exception.** When all employees required to be monitored daily are equipped with supplied-air respirators operated in the pressure demand mode, or other positive pressure mode respirator, the employer may dispense with the daily monitoring required by this paragraph. However, employees performing Class I work using a control method which is not listed in paragraph (g)(4) (i), (ii), or (iii) of this section or using a modification of a listed control method, shall continue to be monitored daily even if they are equipped with supplied-air respirators.

(4) **Termination of monitoring.**

- (i) If the periodic monitoring required by paragraph (f)(3) of this section reveals that employee exposures, as indicated by statistically reliable measurements, are below the permissible exposure limit and excursion limit the employer may discontinue monitoring for those employees whose exposures are represented by such monitoring.
- (ii) **Additional monitoring.** Notwithstanding the provisions of paragraph (f) (2) and (3), and (f)(4) of this section, the employer shall institute the exposure monitoring required under paragraph (f)(3) of this section whenever there has been a change in process, control equipment, personnel or work practices that may result in new or additional exposures above the permissible exposure limit and/or excursion limit or when the employer has any reason to suspect that a change may result in new or additional exposures above the permissible exposure limit and/or excursion limit. Such additional monitoring is required regardless of whether a “negative exposure assessment” was previously produced for a specific job.

(5) **Employee notification of monitoring results.** The employer must, as soon as possible but no later than 5 days after the receipt of the results of any monitoring performed under this section, notify each affected employee of these results either individually in writing or by posting the results in an appropriate location that is accessible to employees.

(6) **Observation of monitoring.**

- (i) The employer shall provide affected employees and their designated representatives an opportunity to observe any monitoring of employee exposure to asbestos conducted in accordance with this section.

- (ii) When observation of the monitoring of employee exposure to asbestos requires entry into an area where the use of protective clothing or equipment is required, the observer shall be provided with and be required to use such clothing and equipment and shall comply with all other applicable safety and health procedures.

(g) **Methods of compliance** —

- (1) **Engineering controls and work practices for all operations covered by this section.** The employer shall use the following engineering controls and work practices in all operations covered by this section, regardless of the levels of exposure:
  - (i) Vacuum cleaners equipped with HEPA filters to collect all debris and dust containing ACM and PACM, except as provided in paragraph (g)(8)(ii) of this section in the case of roofing material;
  - (ii) Wet methods, or wetting agents, to control employee exposures during asbestos handling, mixing, removal, cutting, application, and cleanup, except where employers demonstrate that the use of wet methods is infeasible due to for example, the creation of electrical hazards, equipment malfunction, and, in roofing, except as provided in paragraph (g)(8)(ii) of this section; and
  - (iii) Prompt clean-up and disposal of wastes and debris contaminated with asbestos in leak-tight containers except in roofing operations, where the procedures specified in paragraph (g)(8)(ii) of this section apply.
- (2) In addition to the requirements of paragraph (g)(1) of this section above, the employer shall use the following control methods to achieve compliance with the TWA permissible exposure limit and excursion limit prescribed by paragraph (c) of this section;
  - (i) Local exhaust ventilation equipped with HEPA filter dust collection systems;
  - (ii) Enclosure or isolation of processes producing asbestos dust;
  - (iii) Ventilation of the regulated area to move contaminated air away from the breathing zone of employees and toward a filtration or collection device equipped with a HEPA filter;
  - (iv) Use of other work practices and engineering controls that the Assistant Secretary can show to be feasible.
  - (v) Wherever the feasible engineering and work practice controls described above are not sufficient to reduce employee exposure to or below the permissible exposure limit and/or excursion limit prescribed in paragraph (c) of this section, the employer shall use them to reduce employee exposure to the lowest levels attainable by these controls and shall supplement them by the use of respiratory protection that complies with the requirements of paragraph (h) of this section.
- (3) **Prohibitions.** The following work practices and engineering controls shall not be used for work related to asbestos or for work which disturbs ACM or PACM, regardless of measured levels of asbestos exposure or the results of initial exposure assessments:
  - (i) High-speed abrasive disc saws that are not equipped with point of cut ventilator or enclosures with HEPA filtered exhaust air.

- (ii) Compressed air used to remove asbestos, or materials containing asbestos, unless the compressed air is used in conjunction with an enclosed ventilation system designed to capture the dust cloud created by the compressed air.
  - (iii) Dry sweeping, shoveling or other dry clean-up of dust and debris containing ACM and PACM.
  - (iv) Employee rotation as a means of reducing employee exposure to asbestos.
- (4) **Class I requirements.** In addition to the provisions of paragraphs (g) (1) and (2) of this section, the following engineering controls and work practices and procedures shall be used.
- (i) All Class I work, including the installation and operation of the control system shall be supervised by a qualified person as defined in paragraph (b) of this section;
  - (ii) For all Class I jobs involving the removal of more than 25 linear or 10 square feet of TSI or surfacing ACM or PACM; for all other Class I jobs, where the employer cannot produce a negative exposure assessment pursuant to paragraph (f)(2)(iii) of this section, or where employees are working in areas adjacent to the regulated area, while the Class I work is being performed, the employer shall use one of the following methods to ensure that airborne asbestos does not migrate from the regulated area:
    - (A) Critical barriers shall be placed over all the openings to the regulated area, except where activities are performed outdoors; or
    - (B) The employer shall use another barrier or isolation method which prevents the migration of airborne asbestos from the regulated area, as verified by perimeter area surveillance during each work shift at each boundary of the regulated area, showing no visible asbestos dust; and perimeter area monitoring showing that clearance levels contained in 40 CFR part 763, subpart E of the EPA Asbestos in Schools Rule are met, or that perimeter area levels, measured by Phase Contrast Microscopy (PCM) are no more than background levels representing the same area before the asbestos work began. The results of such monitoring shall be made known to the employer no later than 24 hours from the end of the work shift represented by such monitoring. Exception: For work completed outdoors where employees are not working in areas adjacent to the regulated areas, this paragraph (g)(4)(ii) is satisfied when the specific control methods in paragraph (g)(5) of this section are used.
  - (iii) For all Class I jobs, HVAC systems shall be isolated in the regulated area by sealing with a double layer of 6 mil plastic or the equivalent;
  - (iv) For all Class I jobs, impermeable dropcloths shall be placed on surfaces beneath all removal activity;
  - (v) For all Class I jobs, all objects within the regulated area shall be covered with impermeable dropcloths or plastic sheeting which is secured by duct tape or an equivalent.
  - (vi) For all Class I jobs where the employer cannot produce a negative exposure assessment or where exposure monitoring shows the PELs are exceeded, the employer shall ventilate the regulated area to move contaminated air away from the breathing zone of employees toward a HEPA filtration or collection device.
- (5) **Specific control systems for Class I work.** In addition, Class I asbestos work shall be performed using one or more of the following control methods pursuant to the limitations stated below:



- (i) **Negative pressure enclosure (NPE) systems.** NPE systems may be used where the configuration of the work area does not make the erection of the enclosure infeasible, with the following specifications and work practices.

(A) **Specifications –**

- (1) The negative pressure enclosure (NPE) may be of any configuration,
- (2) At least 4 air changes per hour shall be maintained in the NPE,
- (3) A minimum of -0.02 column inches of water pressure differential, relative to outside pressure, shall be maintained within the NPE as evidenced by manometric measurements,
- (4) The NPE shall be kept under negative pressure throughout the period of its use, and
- (5) Air movement shall be directed away from employees performing asbestos work within the enclosure, and toward a HEPA filtration or a collection device.

(B) **Work practices –**

- (1) Before beginning work within the enclosure and at the beginning of each shift, the NPE shall be inspected for breaches and smoke-tested for leaks, and any leaks sealed.
- (2) Electrical circuits in the enclosure shall be deactivated, unless equipped with ground-fault circuit interrupters.

- (ii) Glove bag systems may be used to remove PACM and/or ACM from straight runs of piping and elbows and other connections with the following specifications and work practices:

(A) **Specifications –**

- (1) Glovebags shall be made of 6 mil thick plastic and shall be seamless at the bottom.
- (2) Glovebags used on elbows and other connections must be designed for that purpose and used without modifications.

(B) **Work practices–**

- (1) Each glovebag shall be installed so that it completely covers the circumference of pipes or other structures where the work is to be done.
- (2) Glovebags shall be smoke-tested for leaks and any leaks sealed prior to use.
- (3) Glovebags may be used only once and may not be moved.
- (4) Glovebags shall not be used on surfaces whose temperature exceeds 150 °F.
- (5) Prior to disposal, glovebags shall be collapsed by removing air within them using a HEPA vacuum.
- (6) Before beginning the operation, loose and friable material adjacent to the glovebag/box operation shall be wrapped and sealed in two layers of six mil plastic or otherwise rendered intact.

- (7) Where a system uses an attached waste bag, such bag shall be connected to a collection bag using hose or other material which shall withstand the pressure of ACM waste and water without losing its integrity.
  - (8) A sliding valve or other device shall separate the waste bag from the hose to ensure no exposure when the waste bag is disconnected.
  - (9) At least two persons shall perform Class I glovebag removal operations.
- (iii) **Negative pressure glove bag systems.** Negative pressure glove bag systems may be used to remove ACM or PACM from piping.
  - (A) **Specifications:** In addition to the specifications for glove bag systems above, negative pressure glove bag systems shall attach the HEPA vacuum system or other device to the bag to prevent collapse during removal.
  - (B) **Work practices –**
    - (1) The employer shall comply with the work practices for glove bag systems in paragraph (g)(5)(ii)(B)(4) of this section,
    - (2) The HEPA vacuum cleaner or other device used to prevent collapse of bag during removal shall run continually during the operation until it is completed at which time the bag shall be collapsed prior to removal of the bag from the pipe.
    - (3) Where a separate waste bag is used along with a collection bag and discarded after one use, the collection bag may be reused if rinsed clean with amended water before reuse.
- (iv) **Negative pressure glove box systems.** Negative pressure glove boxes may be used to remove ACM or PACM from pipe runs with the following specifications and work practices.
  - (A) **Specifications –**
    - (1) Glove boxes shall be constructed with rigid sides and made from metal or other material which can withstand the weight of the ACM and PACM and water used during removal:
    - (2) A negative pressure generator shall be used to create negative pressure in the system:
    - (3) An air filtration unit shall be attached to the box:
    - (4) The box shall be fitted with gloved apertures:
    - (5) An aperture at the base of the box shall serve as a bagging outlet for waste ACM and water:
    - (6) A back-up generator shall be present on site:
    - (7) Waste bags shall consist of 6 mil thick plastic double-bagged before they are filled or plastic thicker than 6 mil.
  - (B) **Work practices –**
    - (1) At least two persons shall perform the removal:

- (2) The box shall be smoke-tested for leaks and any leaks sealed prior to each use.
  - (3) Loose or damaged ACM adjacent to the box shall be wrapped and sealed in two layers of 6 mil plastic prior to the job, or otherwise made intact prior to the job.
  - (4) A HEPA filtration system shall be used to maintain pressure barrier in box.
- (v) **Water spray process system.** A water spray process system may be used for removal of ACM and PACM from cold line piping if, employees carrying out such process have completed a 40-hour separate training course in its use, in addition to training required for employees performing Class I work. The system shall meet the following specifications and shall be performed by employees using the following work practices.
  - (A) **Specifications —**
    - (1) Piping from which insulation will be removed shall be surrounded on 3 sides by rigid framing,
    - (2) A 360 degree water spray, delivered through nozzles supplied by a high pressure separate water line, shall be formed around the piping.
    - (3) The spray shall collide to form a fine aerosol which provides a liquid barrier between workers and the ACM and PACM.
  - (B) **Work practices —**
    - (1) The system shall be run for at least 10 minutes before removal begins.
    - (2) All removal shall take place within the barrier.
    - (3) The system shall be operated by at least three persons, one of whom shall not perform removal but shall check equipment, and ensure proper operation of the system.
    - (4) After removal, the ACM and PACM shall be bagged while still inside the water barrier.
- (vi) A small walk-in enclosure which accommodates no more than two persons (mini-enclosure) may be used if the disturbance or removal can be completely contained by the enclosure, with the following specifications and work practices.
  - (A) **Specifications —**
    - (1) The fabricated or job-made enclosure shall be constructed of 6 mil plastic or equivalent:
    - (2) The enclosure shall be placed under negative pressure by means of a HEPA filtered vacuum or similar ventilation unit:
  - (B) **Work practices —**
    - (1) Before use, the mini-enclosure shall be inspected for leaks and smoketested to detect breaches, and any breaches sealed.
    - (2) Before reuse, the interior shall be completely washed with amended water and HEPA-vacuumed.

- (3) During use, air movement shall be directed away from the employee's breathing zone within the mini-enclosure.
- (6) **Alternative control methods for Class I work.** Class I work may be performed using a control method which is not referenced in paragraph (g)(5) of this section, or which modifies a control method referenced in paragraph (g)(5) of this section, if the following provisions are complied with:
  - (i) The control method shall enclose, contain or isolate the processes or source of airborne asbestos dust, or otherwise capture or redirect such dust before it enters the breathing zone of employees.
  - (ii) A certified industrial hygienist or licensed professional engineer who is also qualified as a project designer as defined in paragraph (b) of this section, shall evaluate the work area, the projected work practices and the engineering controls and shall certify in writing that: the planned control method is adequate to reduce direct and indirect employee exposure to below the PELs under worst-case conditions of use, and that the planned control method will prevent asbestos contamination outside the regulated area, as measured by clearance sampling which meets the requirements of EPA's Asbestos in Schools Rule issued under AHERA, or perimeter monitoring which meets the criteria in paragraph (g)(4)(ii)(B) of this section.
    - (A) Where the TSI or surfacing material to be removed is 25 linear or 10 square feet or less , the evaluation required in paragraph (g)(6) of this section may be performed by a "qualified person", and may omit consideration of perimeter or clearance monitoring otherwise required.
    - (B) The evaluation of employee exposure required in paragraph (g)(6) of this section, shall include and be based on sampling and analytical data representing employee exposure during the use of such method under worst-case conditions and by employees whose training and experience are equivalent to employees who are to perform the current job.
- (7) **Work practices and engineering controls for Class II work.**
  - (i) All Class II work shall be supervised by a qualified person as defined in paragraph (b) of this section.
  - (ii) For all indoor Class II jobs, where the employer has not produced a negative exposure assessment pursuant to paragraph (f)(2)(iii) of this section, or where during the job, changed conditions indicate there may be exposure above the PEL or where the employer does not remove the ACM in a substantially intact state, the employer shall use one of the following methods to ensure that airborne asbestos does not migrate from the regulated area;
    - (A) Critical barriers shall be placed over all openings to the regulated area; or,
    - (B) The employer shall use another barrier or isolation method which prevents the migration of airborne asbestos from the regulated area, as verified by perimeter area monitoring or clearance monitoring which meets the criteria set out in paragraph (g)(4)(ii)(B) of this section.
    - (C) Impermeable dropcloths shall be placed on surfaces beneath all removal activity;
  - (iii) [Reserved]
  - (iv) All Class II asbestos work shall be performed using the work practices and requirements set out above in paragraph (g)(1)(i) through (g)(1)(iii) of this section.

- (8) ***Additional controls for Class II work.*** Class II asbestos work shall also be performed by complying with the work practices and controls designated for each type of asbestos work to be performed, set out in this paragraph. Where more than one control method may be used for a type of asbestos work, the employer may choose one or a combination of designated control methods. Class II work also may be performed using a method allowed for Class I work, except that glove bags and glove boxes are allowed if they fully enclose the Class II material to be removed.
- (i) For removing vinyl and asphalt flooring/deck materials which contain ACM or for which in buildings constructed not later than 1980, the employer has not verified the absence of ACM pursuant to paragraph (g)(8)(i)(I): the employer shall ensure that employees comply with the following work practices and that employees are trained in these practices pursuant to paragraph (k)(9) of this section:
- (A) Flooring/deck materials or its backing shall not be sanded.
  - (B) Vacuums equipped with HEPA filter, disposable dust bag, and metal floor tool (no brush) shall be used to clean floors.
  - (C) Resilient sheeting shall be removed by cutting with wetting of the snip point and wetting during delamination. Rip-up of resilient sheet floor material is prohibited.
  - (D) All scraping of residual adhesive and/or backing shall be performed using wet methods.
  - (E) Dry sweeping is prohibited.
  - (F) Mechanical chipping is prohibited unless performed in a negative pressure enclosure which meets the requirements of paragraph (g)(5)(i) of this section.
  - (G) Tiles shall be removed intact, unless the employer demonstrates that intact removal is not possible.
  - (H) When tiles are heated and can be removed intact, wetting may be omitted.
  - (I) Resilient flooring/deck material in buildings/vessels constructed no later than 1980, including associated mastic and backing shall be assumed to be asbestos-containing unless an industrial hygienist determines that it is asbestos-free using recognized analytical techniques.
- (ii) For removing roofing material which contains ACM the employer shall ensure that the following work practices are followed:
- (A) Roofing material shall be removed in an intact state to the extent feasible.
  - (B) Wet methods shall be used to remove roofing materials that are not intact, or that will be rendered not intact during removal, unless such wet methods are not feasible or will create safety hazards.
  - (C) Cutting machines shall be continuously misted during use, unless a competent person determines that misting substantially decreases worker safety.
  - (D) When removing built-up roofs with asbestos-containing roofing felts and an aggregate surface using a power roof cutter, all dust resulting from the cutting operation shall be collected by a HEPA dust collector, or shall be HEPA vacuumed by vacuuming along the cut line. When removing built-up roofs with asbestos-containing roofing felts and a smooth surface using a power roof cutter, the dust resulting from the cutting operation

shall be collected either by a HEPA dust collector or HEPA vacuuming along the cut line, or by gently sweeping and then carefully and completely wiping up the still-wet dust and debris left along the cut line. The dust and debris shall be immediately bagged or placed in covered containers.

- (E) Asbestos-containing material that has been removed from a roof shall not be dropped or thrown to the ground. Unless the material is carried or passed to the ground by hand, it shall be lowered to the ground via covered, dust-tight chute, crane or hoist:
  - (1) Any ACM that is not intact shall be lowered to the ground as soon as is practicable, but in any event no later than the end of the work shift. While the material remains on the roof it shall either be kept wet, placed in an impermeable waste bag, or wrapped in plastic sheeting.
  - (2) Intact ACM shall be lowered to the ground as soon as is practicable, but in any event no later than the end of the work shift.
- (F) Upon being lowered, unwrapped material shall be transferred to a closed receptacle in such manner so as to preclude the dispersion of dust.
- (G) Roof level heating and ventilation air intake sources shall be isolated or the ventilation system shall be shut down.
- (H) Notwithstanding any other provision of this section, removal or repair of sections of intact roofing less than 25 square feet in area does not require use of wet methods or HEPA vacuuming as long as manual methods which do not render the material non-intact are used to remove the material and no visible dust is created by the removal method used. In determining whether a job involves less than 25 square feet, the employer shall include all removal and repair work performed on the same roof on the same day.
- (iii) When removing cementitious asbestos-containing siding and shingles or transite panels containing ACM on building exteriors (other than roofs, where paragraph (g)(8)(ii) of this section applies) the employer shall ensure that the following work practices are followed:
  - (A) Cutting, abrading or breaking siding, shingles, or transite panels shall be prohibited unless the employer can demonstrate that methods less likely to result in asbestos fiber release cannot be used.
  - (B) Each panel or shingle shall be sprayed with amended water prior to removal.
  - (C) Unwrapped or unbagged panels or shingles shall be immediately lowered to the ground via a covered dust-tight chute, crane or hoist, or be placed in an impervious waste bag or wrapped in plastic sheeting and lowered to the ground no later than the end of the work shift.
  - (D) Nails shall be cut with flat, sharp instruments.
- (iv) When removing gaskets containing ACM, the employer shall ensure that the following work practices are followed:
  - (A) If a gasket is visibly deteriorated and unlikely to be removed intact, removal shall be undertaken within a glovebag as described in paragraph (g)(5)(ii) of this section.
  - (B) [Reserved]

- (C) The gasket shall be immediately placed in a disposal container.
- (D) Any scraping to remove residue must be performed wet.
- (v) When performing any other Class II removal of asbestos containing material for which specific controls have not been listed in paragraph (g)(8)(iv) (A) through (D) of this section, the employer shall ensure that the following work practices are complied with.
  - (A) The material shall be thoroughly wetted with amended water prior to and during its removal.
  - (B) The material shall be removed in an intact state unless the employer demonstrates that intact removal is not possible.
  - (C) Cutting, abrading or breaking the material shall be prohibited unless the employer can demonstrate that methods less likely to result in asbestos fiber release are not feasible.
  - (D) Asbestos-containing material removed, shall be immediately bagged or wrapped, or kept wetted until transferred to a closed receptacle, no later than the end of the work shift.
- (vi) **Alternative work practices and controls.** Instead of the work practices and controls listed in paragraphs (g)(8) (i) through (v) of this section, the employer may use different or modified engineering and work practice controls if the following provisions are complied with.
  - (A) The employer shall demonstrate by data representing employee exposure during the use of such method under conditions which closely resemble the conditions under which the method is to be used, that employee exposure will not exceed the PELs under any anticipated circumstances.
  - (B) A qualified person shall evaluate the work area, the projected work practices and the engineering controls, and shall certify in writing, that the different or modified controls are adequate to reduce direct and indirect employee exposure to below the PELs under all expected conditions of use and that the method meets the requirements of this standard. The evaluation shall include and be based on data representing employee exposure during the use of such method under conditions which closely resemble the conditions under which the method is to be used for the current job, and by employees whose training and experience are equivalent to employees who are to perform the current job.
- (9) **Work practices and engineering controls for Class III asbestos work.** Class III asbestos work shall be conducted using engineering and work practice controls which minimize the exposure to employees performing the asbestos work and to bystander employees.
  - (i) The work shall be performed using wet methods.
  - (ii) To the extent feasible, the work shall be performed using local exhaust ventilation.
  - (iii) Where the disturbance involves drilling, cutting, abrading, sanding, chipping, breaking, or sawing of thermal system insulation or surfacing material, the employer shall use impermeable dropcloths and shall isolate the operation using mini-enclosures or glove bag systems pursuant to paragraph (g)(5) of this section or another isolation method.

- (iv) Where the employer does not demonstrate by a negative exposure assessment performed in compliance with paragraph (f)(2)(iii) of this section that the PELs will not be exceeded, or where monitoring results show exceedances of a PEL, the employer shall contain the area using impermeable dropcloths and plastic barriers or their equivalent, or shall isolate the operation using mini-enclosure or glove bag systems pursuant to paragraph (g)(5) of this section.
  - (v) Employees performing Class III jobs which involve the disturbance of TSI or surfacing ACM or PACM or where the employer does not demonstrate by a “negative exposure assessment” in compliance with paragraph (f)(2)(iii) of this section that the PELs will not be exceeded or where monitoring results show exceedances of the PEL, shall wear respirators which are selected, used and fitted pursuant to provisions of paragraph (h) of this section.
- (10) **Class IV asbestos work.** Class IV asbestos jobs shall be conducted by employees trained pursuant to the asbestos awareness training program set out in paragraph (k)(9) of this section. In addition, all Class IV jobs shall be conducted in conformity with the requirements set out in paragraph (g)(1) of this section, mandating wet methods, HEPA vacuums, and prompt clean up of debris containing ACM or PACM.
- (i) Employees cleaning up debris and waste in a regulated area where respirators are required shall wear respirators which are selected, used and fitted pursuant to provisions of paragraph (h) of this section.
  - (ii) Employers of employees cleaning up waste and debris in an area where friable TSI or surfacing ACM/PACM is accessible, shall assume that such waste and debris contain asbestos.
- (11) **Specific compliance methods for brake and clutch repair –**
- (i) **Engineering controls and work practices for brake and clutch repair and service.** During automotive brake and clutch inspection, disassembly, repair and assembly operations, the employer shall institute engineering controls and work practices to reduce employee exposure to materials containing asbestos using a negative pressure enclosure/HEPA vacuum system method or low pressure/wet cleaning method, which meets the detailed requirements set out in appendix L to this section. The employer may also comply using an equivalent method which follows written procedures which the employer demonstrates can achieve results equivalent to Method A. For facilities in which no more than 5 pair of brakes or 5 clutches are inspected, disassembled, repaired, or assembled per week, the method set for in paragraph [D] of appendix L to this section may be used.
  - (ii) The employer may also comply by using an equivalent method which follows written procedures, which the employer demonstrates can achieve equivalent exposure reductions as do the two “preferred methods.” Such demonstration must include monitoring data conducted under workplace conditions closely resembling the process, type of asbestos containing materials, control method, work practices and environmental conditions which the equivalent method will be used, or objective data, which document that under all reasonably foreseeable conditions of brake and clutch repair applications, the method results in exposures which are equivalent to the methods set out in appendix L to this section.
- (12) **Alternative methods of compliance for installation, removal, repair, and maintenance of certain roofing and pipeline coating materials.** Notwithstanding any other provision of this section, an employer who complies with all provisions of this paragraph (g)(12) when installing, removing, repairing, or maintaining intact pipeline asphaltic wrap, or roof flashings which contain asbestos fibers encapsulated or coated by bituminous or resinous compounds shall be deemed to be in



compliance with this section. If an employer does not comply with all provisions of this paragraph (g)(12) or if during the course of the job the material does not remain intact, the provisions of paragraph (g)(8) of this section apply instead of this paragraph (g)(12).

- (i) Before work begins and as needed during the job, a qualified person who is capable of identifying asbestos hazards in the workplace and selecting the appropriate control strategy for asbestos exposure, and who has the authority to take prompt corrective measures to eliminate such hazards, shall conduct an inspection of the worksite and determine that the roofing material is intact and will likely remain intact.
- (ii) All employees performing work covered by this paragraph (g)(12) shall be trained in a training program that meets the requirements of paragraph (k)(9)(viii) of this section.
- (iii) The material shall not be sanded, abraded, or ground. Manual methods which do not render the material non-intact shall be used.
- (iv) Material that has been removed from a roof shall not be dropped or thrown to the ground. Unless the material is carried or passed to the ground by hand, it shall be lowered to the ground via covered, dust-tight chute, crane or hoist. All such material shall be removed from the roof as soon as is practicable, but in any event no later than the end of the work shift.
- (v) Where roofing products which have been labeled as containing asbestos pursuant to paragraph (k)(8) of this section are installed on non-residential roofs during operations covered by this paragraph (g)(12), the employer shall notify the building owner of the presence and location of such materials no later than the end of the job.
- (vi) All removal or disturbance of pipeline asphaltic wrap shall be performed using wet methods.

(h) **Respiratory protection** —(1) *General*. For employees who use respirators required by this section, the employer must provide each employee an appropriate respirator that complies with the requirements of this paragraph. Respirators must be used in the following circumstances:

- (i) During all Class I asbestos jobs.
- (ii) During all Class II work where the ACM is not removed in a substantially intact state.
- (iii) During all Class II and III work which is not performed using wet methods, provided, however, that respirators need not be worn during removal of ACM from sloped roofs when a negative exposure assessment has been made and the ACM is removed in an intact state.
- (iv) During all Class II and III asbestos jobs where the employer does not produce a “negative exposure assessment.”
- (v) During all Class III jobs where TSI or surfacing ACM or PACM is being disturbed.
- (vi) During all Class IV work performed within regulated areas where employees performing other work are required to wear respirators.
- (vii) During all work covered by this section where employees are exposed above the TWA or excursion limit.
- (viii) In emergencies.

(2) **Respirator selection.**

- (i) Employers must select, and provide to employees at no cost, the appropriate respirators specified in paragraph (d)(3)(i)(A) of 29 CFR 1910.134; however, employers must not select or use filtering facepiece respirators for use against asbestos fibers.
- (ii) Employers are to provide HEPA filters for powered and non-powered air-purifying respirators.
- (iii) Employers must:
  - (A) Inform employees that they may require the employer to provide a tight-fitting, powered air-purifying respirator (PAPR) permitted for use under paragraph (h)(2)(i) of this standard instead of a negative pressure respirator.
  - (B) Provide employees with a tight-fitting PAPR instead of a negative pressure respirator when the employees choose to use a tight-fitting PAPR and it provides them with the required protection against asbestos.
- (iv) Employers must provide employees with an air-purifying, half mask respirator, other than a filtering facepiece respirator, whenever the employees perform:
  - (A) Class II or Class III asbestos work for which no negative exposure assessment is available.
  - (B) Class III asbestos work involving disturbance of TSI or surfacing ACM or PACM.
- (v) Employers must provide employees with:
  - (A) A tight-fitting, powered air-purifying respirator or a full facepiece, supplied-air respirator operated in the pressure-demand mode and equipped with either HEPA egress cartridges or an auxiliary positive-pressure, self-contained breathing apparatus (SCBA) whenever the employees are in a regulated area performing Class I asbestos work for which a negative exposure assessment is not available and the exposure assessment indicates that the exposure level will be at or below 1 f/cc as an 8-hour time-weighted average (TWA).
  - (B) A full facepiece, supplied-air respirator operated in the pressure-demand mode and equipped with an auxiliary positive-pressure SCBA whenever the employees are in a regulated area performing Class I asbestos work for which a negative exposure assessment is not available and the exposure assessment indicates that the exposure level will be above 1 f/cc as an 8-hour TWA.

**(3) Respirator program.**

- (i) When respiratory protection is used, the employer shall institute a respiratory protection program in accordance with 29 CFR 1910.134(b) through (d) (except paragraph (d)(1)(iii)), and (f) through (m) which covers each employee required by this section to use a respirator.
- (ii) No employee shall be assigned to tasks requiring the use of respirators if, based on his or her most recent examination, an examining physician determines that the employee will be unable to function normally wearing a respirator, or that the safety or health of the employee or of other employees will be impaired by the use of a respirator. Such employees shall be assigned to another job or given the opportunity to transfer to a different position, the duties of which he or she is able to perform with the same employer, in the same geographical area, and with the same seniority, status, and rate of pay and other job benefits he or she had just prior to such transfer, if such a different position is available.

(i) **Protective clothing –**

(1) **General.** The employer shall provide and require the use of protective clothing, such as coveralls or similar whole-body clothing, head coverings, gloves, and foot coverings for any employee exposed to airborne concentrations of asbestos that exceed the TWA and/or excursion limit prescribed in paragraph (c) of this section, or for which a required negative exposure assessment is not produced, or for any employee performing Class I operations which involve the removal of over 25 linear or 10 square feet of TSI or surfacing ACM or PACM.

(2) **Laundering.**

(i) The employer shall ensure that laundering of contaminated clothing is done so as to prevent the release of airborne asbestos in excess of the TWA or excursion limit prescribed in paragraph (c) of this section.

(ii) Any employer who gives contaminated clothing to another person for laundering shall inform such person of the requirement in paragraph (i)(2)(i) of this section to effectively prevent the release of airborne asbestos in excess of the TWA excursion limit prescribed in paragraph (c) of this section.

(3) The employer shall ensure that contaminated clothing is transported in sealed impermeable bags, or other closed, impermeable containers, and labeled in accordance with paragraph (k) of this section.

(4) **Inspection of protective clothing.**

(i) The qualified person shall examine worksuits worn by employees at least once per workshift for rips or tears that may occur during the performance of work.

(ii) When rips or tears are detected while an employee is working, rips and tears shall be immediately mended, or the worksuit shall be immediately replaced.

(j) **Hygiene facilities and practices for employees.**

(1) Requirements for employees performing Class I asbestos jobs involving over 25 linear or 10 square feet of TSI or surfacing ACM and PACM.

(i) **Decontamination areas.** For all Class I jobs involving over 25 linear or 10 square feet of TSI or surfacing ACM or PACM, the employer shall establish a decontamination area that is adjacent and connected to the regulated area for the decontamination of such employees. The decontamination area shall consist of an equipment room, shower area, and clean room in series. The employer shall ensure that employees enter and exit the regulated area through the decontamination area.

(A) **Equipment room.** The equipment room shall be supplied with impermeable, labeled bags and containers for the containment and disposal of contaminated protective equipment.

(B) **Shower area.** Shower facilities shall be provided which comply with 29 CFR 1910.141(d)(3), unless the employer can demonstrate that they are not feasible. The showers shall be adjacent both to the equipment room and the clean room, unless the employer can demonstrate that this location is not feasible. Where the employer can demonstrate that it is not feasible to locate the shower between the equipment room and the clean room, or where the work is performed outdoors, or when the work involving asbestos exposure takes place on board a ship, the employers shall ensure that employees:

- (1) Remove asbestos contamination from their worksuits in the equipment room using a HEPA vacuum before proceeding to a shower that is not adjacent to the work area; or
    - (2) Remove their contaminated worksuits in the equipment room, then don clean worksuits, and proceed to a shower that is not adjacent to the work area.
  - (C) **Clean change room.** The clean room shall be equipped with a locker or appropriate storage container for each employee's use. When the employer can demonstrate that it is not feasible to provide a clean change area adjacent to the work area, or where the work is performed outdoors, or when the work takes place aboard a ship, the employer may permit employees engaged in Class I asbestos jobs to clean their protective clothing with a portable HEPA-equipped vacuum before such employees leave the regulated area. Following showering, such employees however must then change into street clothing in clean change areas provided by the employer which otherwise meet the requirements of this section.
  - (ii) **Decontamination area entry procedures.** The employer shall ensure that employees:
    - (A) Enter the decontamination area through the clean room;
    - (B) Remove and deposit street clothing within a locker provided for their use; and
    - (C) Put on protective clothing and respiratory protection before leaving the clean room.
    - (D) Before entering the regulated area, the employer shall ensure that employees pass through the equipment room.
  - (iii) **Decontamination area exit procedures.** The employer shall ensure that:
    - (A) Before leaving the regulated area, employees shall remove all gross contamination and debris from their protective clothing.
    - (B) Employees shall remove their protective clothing in the equipment room and deposit the clothing in labeled impermeable bags or containers.
    - (C) Employees shall not remove their respirators in the equipment room.
    - (D) Employees shall shower prior to entering the clean room.
    - (E) After showering, employees shall enter the clean room before changing into street clothes.
  - (iv) **Lunch areas.** Whenever food or beverages are consumed at the worksite where employees are performing Class I asbestos work, the employer shall provide lunch areas in which the airborne concentrations of asbestos are below the permissible exposure limit and/or excursion limit.
- (2) **Requirements for Class I work involving less than 25 linear or 10 square feet of TSI or surfacing and PACM, and for Class II and Class III asbestos work operations where exposures exceed a PEL or where there is no negative exposure assessment produced before the operation.**
- (i) The employer shall establish an equipment room or area that is adjacent to the regulated area for the decontamination of employees and their equipment which is contaminated with asbestos which shall consist of an area covered by an impermeable drop cloth on the floor/ deck or horizontal working surface.

- (ii) The area must be of sufficient size as to accommodate cleaning of equipment and removing personal protective equipment without spreading contamination beyond the area (as determined by visible accumulations).
- (iii) Work clothing must be cleaned with a HEPA vacuum before it is removed.
- (iv) All equipment and surfaces of containers filled with ACM must be cleaned prior to removing them from the equipment room or area.
- (v) The employer shall ensure that employees enter and exit the regulated area through the equipment room or area.

- (3) **Requirements for Class IV work.** Employers shall ensure that employees performing Class IV work within a regulated area comply with the hygiene practice required of employees performing work which has a higher classification within that regulated area. Otherwise employers of employees cleaning up debris and material which is TSI or surfacing ACM or identified as PACM shall provide decontamination facilities for such employees which are required by paragraph (j)(2) of this section.
- (4) **Smoking in work areas.** The employer shall ensure that employees do not smoke in work areas where they are occupationally exposed to asbestos because of activities in that work area.

(k) **Communication of hazards.**

- (1) This section applies to the communication of information concerning asbestos hazards in shipyard employment activities to facilitate compliance with this standard. Most asbestos-related shipyard activities involve previously installed building materials. Building/vessel owners often are the only and/or best sources of information concerning them. Therefore, they, along with employers of potentially exposed employees, are assigned specific information conveying and retention duties under this section. Installed Asbestos Containing Building/Vessel Material: Employers and building/vessel owners shall identify TSI and sprayed or troweled on surfacing materials as asbestos-containing unless the employer, by complying with paragraph (k)(5) of this section determines that the material is not asbestos-containing. Asphalt or vinyl flooring/decking material installed in buildings or vessels no later than 1980 must also be considered as asbestos containing unless the employer/owner, pursuant to paragraph (g)(8)(i)(I) of this section, determines it is not asbestos containing. If the employer or building/vessel owner has actual knowledge or should have known, through the exercise of due diligence, that materials other than TSI and sprayed-on or troweled-on surfacing materials are asbestos-containing, they must be treated as such. When communicating information to employees pursuant to this standard, owners and employers shall identify "PACM" as ACM. Additional requirements relating to communication of asbestos work on multi- employer worksites are set out in paragraph (d) of this standard.

(2) **Duties of building/vessel and facility owners.**

- (i) Before work subject to this standard is begun, building/vessel and facility owners shall determine the presence, location, and quantity of ACM and/or PACM at the work site pursuant to paragraph (k)(1) of this section.
- (ii) Building/vessel and/or facility owners shall notify the following persons of the presence, location and quantity of ACM or PACM, at work sites in their buildings/facilities/vessels. Notification either shall be in writing or shall consist of a personal communication between the owner and the person to whom notification must be given or their authorized representatives:

- (A) Prospective employers applying or bidding for work whose employees reasonably can be expected to work in or adjacent to areas containing such material;
  - (B) Employees of the owner who will work in or adjacent to areas containing such material;
  - (C) On multi-employer worksites, all employers of employees who will be performing work within or adjacent to areas containing such materials;
  - (D) Tenants who will occupy areas containing such materials.
- (3) ***Duties of employers whose employees perform work subject to this standard in or adjacent to areas containing ACM and PACM.*** Building/vessel and facility owners whose employees perform such work shall comply with these provisions to the extent applicable.
  - (i) Before work in areas containing ACM and PACM is begun, employers shall identify the presence, location, and quantity of ACM, and/or PACM therein pursuant to paragraph (k)(1) of this section.
  - (ii) Before work under this standard is performed employers of employees who will perform such work shall inform the following persons of the location and quantity of ACM and/or PACM present at the worksite and the precautions to be taken to ensure that airborne asbestos is confined to the area.
  - (iii) Within 10 days of the completion of such work, the employer whose employees have performed work subject to this standard, shall inform the building/vessel or facility owner and employers of employees who will be working in the area of the current location and quantity of PACM and/or ACM remaining in the former regulated area and final monitoring results, if any.
- (4) In addition to the above requirements, all employers who discover ACM and/or PACM on a work site shall convey information concerning the presence, location and quantity of such newly discovered ACM and/or PACM to the owner and to other employers of employees working at the work site, within 24 hours of the discovery.
- (5) Criteria to rebut the designation of installed material as PACM.
  - (i) At any time, an employer and/or building/vessel owner may demonstrate, for purposes of this standard, that PACM does not contain asbestos. Building/vessel owners and/or employers are not required to communicate information about the presence of building material for which such a demonstration pursuant to the requirements of paragraph (k)(5)(ii) of this section has been made. However, in all such cases, the information, data and analysis supporting the determination that PACM does not contain asbestos, shall be retained pursuant to paragraph (n) of this section.
  - (ii) An employer or owner may demonstrate that PACM does not contain more than 1% asbestos by the following:
    - (A) Having completed an inspection conducted pursuant to the requirements of AHERA (40 CFR part 763, subpart E) which demonstrates that the material is not ACM; or
    - (B) Performing tests of the material containing PACM which demonstrate that no ACM is present in the material. Such tests shall include analysis of bulk samples collected in the manner described in 40 CFR 763.86. The tests, evaluation and sample collection shall be conducted by an accredited inspector or by a CIH. Analysis of samples shall be performed by persons or laboratories with proficiency demonstrated by current successful

participation in a nationally recognized testing program such as the National Voluntary Laboratory Accreditation Program (NVLAP) or the National Institute for Standards and Technology (NIST) or the Round Robin for bulk samples administered by the American Industrial Hygiene Association (AIHA), or an equivalent nationally-recognized round robin testing program.

- (iii) The employer and/or building/vessel owner may demonstrate that flooring material including associated mastic and backing does not contain asbestos, by a determination of an industrial hygienist based upon recognized analytical techniques showing that the material is not ACM.
- (6) At the entrance to mechanical rooms/areas in which employees reasonably can be expected to enter and which contain ACM and/or PACM, the building/vessel owner shall post signs which identify the material which is present, its location, and appropriate work practices which, if followed, will ensure that ACM and/or PACM will not be disturbed. The employer shall ensure, to the extent feasible, that employees who come in contact with these signs can comprehend them. Means to ensure employee comprehension may include the use of foreign languages, pictographs, graphics, and awareness training.

(7) **Hazard communication.**

- (i) Labels shall be affixed to all products containing asbestos and to all containers containing such products, including waste containers. Where feasible, installed asbestos products shall contain a visible label.
- (ii) **General.** The employer shall include asbestos in the program established to comply with the Hazard Communication Standard (HCS) (§ 1910.1200). The employer shall ensure that each employee has access to labels on containers of asbestos and safety data sheets, and is trained in accordance with the provisions of the HCS and paragraph (k)(9) of this section. The employer shall ensure that at least the following hazards are addressed: Cancer and lung effects.

(iii) **Labels.**

- (A) The employer shall ensure that labels of bags or containers of protective clothing and equipment, scrap, waste, and debris containing asbestos fibers bear the following information:

DANGER

CONTAINS ASBESTOS FIBERS

MAY CAUSE CANCER

CAUSES DAMAGE TO LUNGS

DO NOT BREATHE DUST

AVOID CREATING DUST

(B)

- (1) Prior to June 1, 2015, employers may include the following information on raw materials, mixtures or labels of bags or containers of protective clothing and equipment, scrap, waste, and debris containing asbestos fibers in lieu of the labeling requirements in paragraphs (k)(7)(ii) and (k)(7)(iii)(A) of this section:

DANGER

CONTAINS ASBESTOS FIBERS

AVOID CREATING DUST

CANCER AND LUNG DISEASE HAZARD

- (2) Labels shall also contain a warning statement against breathing asbestos fibers.

- (iv) The provisions for labels required in paragraph (k)(7) of this section do not apply where:

- (A) Asbestos fibers have been modified by a bonding agent, coating, binder, or other material, provided that the manufacturer can demonstrate that, during any reasonably foreseeable use, handling, storage, disposal, processing, or transportation, no airborne concentrations of asbestos fibers in excess of the permissible exposure limit and/or excursion limit will be released, or

- (B) Asbestos is present in a product in concentrations less than 1.0 percent.

(8) **Signs.**

- (i) Warning signs that demarcate the regulated area shall be provided and displayed at each location where a regulated area is required to be established by paragraph (e) of this section. Signs shall be posted at such a distance from such a location that an employee may read the signs and take necessary protective steps before entering the area marked by the signs.

- (ii) The warning signs required by this paragraph (k)(8) shall bear the following legend:

DANGER

ASBESTOS

MAY CAUSE CANCER

CAUSES DAMAGE TO LUNGS

AUTHORIZED PERSONNEL ONLY

- (iii) In addition, where the use of respirators and protective clothing is required in the regulated area under this section, the warning signs shall include the following:

WEAR RESPIRATORY PROTECTION

AND PROTECTIVE CLOTHING IN THIS AREA



- (iv) The employer shall ensure that employees working in and contiguous to regulated areas comprehend the warning signs required to be posted by paragraph (k)(8) of this section. Means to ensure employee comprehension may include the use of foreign languages, pictographs, and graphics.
- (v) When a building/vessel owner or employer identifies previously installed PACM and/or ACM, labels or signs shall be affixed or posted so that employees will be notified of what materials contain PACM and/or ACM. The employer shall attach such labels in areas where they will clearly be noticed by employees who are likely to be exposed, such as at the entrance to mechanical room/areas. Signs required by paragraph (k)(6) of this section may be posted in lieu of labels, so long as they contain information required for labeling. The employer shall ensure, to the extent feasible, that employees who come in contact with these signs or labels can comprehend them. Means to ensure employee comprehension may include the use of foreign languages, pictographs, graphics, and awareness training.
- (vi) Prior to June 1, 2016, employers may use the following legend in lieu of that specified in paragraph (k)(8)(ii) of this section:

DANGER

ASBESTOS

CANCER AND LUNG DISEASE HAZARD

AUTHORIZED PERSONNEL ONLY

- (vii) Prior to June 1, 2016, employers may use the following legend in lieu of that specified in paragraph (k)(8)(iii) of this section:

RESPIRATORS AND PROTECTIVE CLOTHING ARE REQUIRED IN THIS AREA

(9) ***Employee information and training.***

- (i) The employer shall train each employee who is likely to be exposed in excess of a PEL and each employee who performs Class I through IV asbestos operations in accordance with the requirements of this section. Training shall be provided at no cost to the employee. The employer shall institute a training program and ensure employee participation in the program.
- (ii) Training shall be provided prior to or at the time of initial assignment and at least annually thereafter.
- (iii) Training for Class I operations and for Class II operations that require the use of critical barriers (or equivalent isolation methods) and/or negative pressure enclosures under this section shall be the equivalent in curriculum, training method and length to the EPA Model Accreditation Plan (MAP) asbestos abatement workers training (40 CFR part 763, subpart E, appendix C).
- (iv) Training for other Class II work.

- (A) For work with asbestos containing roofing materials, flooring materials, siding materials, ceiling tiles, or transite panels, training shall include at a minimum all the elements included in paragraph (k)(9)(viii) of this section and in addition, the specific work practices and engineering controls set forth in paragraph (g) of this section which specifically relate to that category. Such course shall include "hands-on" training and shall take at least 8 hours.
- (B) An employee who works with more than one of the categories of material specified in paragraph (k)(9)(iv)(A) of this section shall receive training in the work practices applicable to each category of material that the employee removes and each removal method that the employee uses.
- (C) For Class II operations not involving the categories of material specified in paragraph (k)(9)(iv)(A) of this section, training shall be provided which shall include at a minimum all the elements included in paragraph (k)(9)(viii) of this section and in addition, the specific work practices and engineering controls set forth in paragraph (g) of this section which specifically relate to the category of material being removed, and shall include "hands-on" training in the work practices applicable to each category of material that the employee removes and each removal method that the employee uses.
- (v) Training for Class III employees shall be consistent with EPA requirements for training of local education agency maintenance and custodial staff as set forth at 40 CFR 763.92(a)(2). Such a course shall also include "hands-on" training and shall take at least 16 hours. Exception: For Class III operations for which the competent person determines that the EPA curriculum does not adequately cover the training needed to perform that activity, training shall include as a minimum all the elements included in paragraph (k)(9)(viii) of this section and in addition, the specific work practices and engineering controls set forth in paragraph (g) of this section which specifically relate to that activity, and shall include "hands-on" training in the work practices applicable to each category of material that the employee disturbs.
- (vi) Training for employees performing Class IV operations shall be consistent with EPA requirements for training of local education agency maintenance and custodial staff as set forth at 40 CFR 763.92(a)(1). Such a course shall include available information concerning the locations of thermal system insulation and surfacing ACM/PACM, and asbestos-containing flooring material, or flooring material where the absence of asbestos has not yet been certified; and instruction in the recognition of damage, deterioration, and delamination of asbestos containing building materials. Such a course shall take at least 2 hours.
- (vii) Training for employees who are likely to be exposed in excess of the PEL and who are not otherwise required to be trained under paragraph (k)(9) (iii) through (vi) of this section, shall meet the requirements of paragraph (k)(9)(viii) of this section.
- (viii) The training program shall be conducted in a manner that the employee is able to understand. In addition to the content required by the provisions in paragraphs (k)(9)(iii) through (vi) of this section, the employer shall ensure that each such employee is informed of the following:
  - (A) Methods of recognizing asbestos, including the requirement in paragraph (k)(1) of this section to presume that certain building materials contain asbestos;
  - (B) The health effects associated with asbestos exposure;
  - (C) The relationship between smoking and asbestos in producing lung cancer;

- (D) The nature of operations that could result in exposure to asbestos, the importance of necessary protective controls to minimize exposure including, as applicable, engineering controls, work practices, respirators, housekeeping procedures, hygiene facilities, protective clothing, decontamination procedures, emergency procedures, and waste disposal procedures, and any necessary instruction in the use of these controls and procedures; where Class III and IV work will be or is performed, the contents of EPA 20T-2003, "Managing Asbestos In-Place" July 1990 or its equivalent in content;
  - (E) The purpose, proper use, fitting instructions, and limitations of respirators as required by 29 CFR 1910.134;
  - (F) The appropriate work practices for performing the asbestos job;
  - (G) Medical surveillance program requirements;
  - (H) The content of this standard including appendices;
  - (I) The names, addresses and phone numbers of public health organizations which provide information, materials and/or conduct programs concerning smoking cessation. The employer may distribute the list of such organizations contained in appendix J to this section, to comply with this requirement; and
  - (J) The requirements for posting signs and affixing labels and the meaning of the required legends for such signs and labels.
- (10) Access to training materials.
- (i) The employer shall make readily available to affected employees without cost, written materials relating to the employee training program, including a copy of this regulation.
  - (ii) The employer shall provide to the Assistant Secretary and the Director, upon request, all information and training materials relating to the employee information and training program.
  - (iii) The employer shall inform all employees concerning the availability of self-help smoking cessation program material. Upon employee request, the employer shall distribute such material, consisting of NIH Publication No. 89-1647, or equivalent self-help material, which is approved or published by a public health organization listed in appendix J to this section.

(I) **Housekeeping** –

- (1) **Vacuuming.** Where vacuuming methods are selected, HEPA filtered vacuuming equipment must be used. The equipment shall be used and emptied in a manner that minimizes the reentry of asbestos into the workplace.
- (2) **Waste disposal.** Asbestos waste, scrap, debris, bags, containers, equipment, and contaminated clothing consigned for disposal shall be collected and disposed of in sealed, labeled, impermeable bags or other closed, labeled, impermeable containers except in roofing operations, where the procedures specified in paragraph (g)(8)(ii) of this section apply.
- (3) **Care of asbestos-containing flooring/deck material.**
  - (i) All vinyl and asphalt flooring/deck material shall be maintained in accordance with this paragraph unless the building/facility owner demonstrates, pursuant to paragraph (g)(8)(i)(I) of this section that the flooring/deck does not contain asbestos.

- (ii) Sanding of flooring/deck material is prohibited.
- (iii) Stripping of finishes shall be conducted using low abrasion pads at speeds lower than 300 rpm and wet methods.
- (iv) Burnishing or dry buffing may be performed only on flooring/deck which has sufficient finish so that the pad cannot contact the flooring/deck material.

(4) Waste and debris and accompanying dust in an area containing accessible thermal system insulation or surfacing ACM/PACM or visibly deteriorated ACM:

- (i) Shall not be dusted or swept dry, or vacuumed without using a HEPA filter;
- (ii) Shall be promptly cleaned up and disposed of in leak tight containers.

(m) **Medical surveillance** —

(1) **General** —

(i) **Employees covered.**

- (A) The employer shall institute a medical surveillance program for all employees who for a combined total of 30 or more days per year are engaged in Class I, II and III work or are exposed at or above a permissible exposure limit. For purposes of this paragraph, any day in which a worker engages in Class II or Class III operations or a combination thereof on intact material for one hour or less (taking into account the entire time spent on the removal operation, including cleanup) and, while doing so, adheres fully to the work practices specified in this standard, shall not be counted.
- (B) For employees otherwise required by this standard to wear a negative pressure respirator, employers shall ensure employees are physically able to perform the work and use the equipment. This determination shall be made under the supervision of a physician.

(ii) **Examination.**

- (A) The employer shall ensure that all medical examinations and procedures are performed by or under the supervision of a licensed physician, and are provided at no cost to the employee and at a reasonable time and place.
- (B) Persons other than such licensed physicians who administer the pulmonary function testing required by this section shall complete a training course in spirometry sponsored by an appropriate academic or professional institution.

(2) **Medical examinations and consultations** —

- (i) **Frequency.** The employer shall make available medical examinations and consultations to each employee covered under paragraph (m)(1)(i) of this section on the following schedules:
  - (A) Prior to assignment of the employee to an area where negative-pressure respirators are worn;
  - (B) When the employee is assigned to an area where exposure to asbestos may be at or above the permissible exposure limit for 30 or more days per year, or engage in Class I, II, or III work for a combined total of 30 or more days per year, a medical examination must be given within 10 working days following the thirtieth day of exposure;

- (C) And at least annually thereafter.
  - (D) If the examining physician determines that any of the examinations should be provided more frequently than specified, the employer shall provide such examinations to affected employees at the frequencies specified by the physician.
  - (E) Exception: No medical examination is required of any employee if adequate records show that the employee has been examined in accordance with this paragraph within the past 1-year period.
- (ii) **Content.** Medical examinations made available pursuant to paragraphs (m)(2)(i) (A) through (m)(2)(i) (C) of this section shall include:
- (A) A medical and work history with special emphasis directed to the pulmonary, cardiovascular, and gastrointestinal systems.
  - (B) On initial examination, the standardized questionnaire contained in part 1 of appendix D to this section and, on annual examination, the abbreviated standardized questionnaire contained in part 2 of appendix D to this section.
  - (C) A physical examination directed to the pulmonary and gastrointestinal systems, including a 14- by 17-inch or other reasonably-sized standard film or digital posterior-anterior chest X-ray to be administered at the discretion of the physician, and pulmonary function tests of forced vital capacity (FVC) and forced expiratory volume at one second (FEV<sub>1</sub>). Classification of all chest X-rays shall be conducted in accordance with appendix E to this section.
  - (D) Any other examinations or tests deemed necessary by the examining physician.
- (3) **Information provided to the physician.** The employer shall provide the following information to the examining physician:
- (i) A copy of this standard and appendices D, E, and I to this section;
  - (ii) A description of the affected employee's duties as they relate to the employee's exposure;
  - (iii) The employee's representative exposure level or anticipated exposure level;
  - (iv) A description of any personal protective and respiratory equipment used or to be used; and
  - (v) Information from previous medical examinations of the affected employee that is not otherwise available to the examining physician.
- (4) **Physician's written opinion.**
- (i) The employer shall obtain a written opinion from the examining physician. This written opinion shall contain the results of the medical examination and shall include:
    - (A) The physician's opinion as to whether the employee has any detected medical conditions that would place the employee at an increased risk of material health impairment from exposure to asbestos;
    - (B) Any recommended limitations on the employee or on the use of personal protective equipment such as respirators; and

- (C) A statement that the employee has been informed by the physician of the results of the medical examination and of any medical conditions that may result from asbestos exposure.
- (D) A statement that the employee has been informed by the physician of the increased risk of lung cancer attributable to the combined effect of smoking and asbestos exposure.
- (ii) The employer shall instruct the physician not to reveal in the written opinion given to the employer specific findings or diagnoses unrelated to occupational exposure to asbestos.
- (iii) The employer shall provide a copy of the physician's written opinion to the affected employee within 30 days from its receipt.

(n) **Recordkeeping –**

(1) ***Objective data relied on pursuant to paragraph (f) of this section.***

- (i) Where the employer has relied on objective data that demonstrates that products made from or containing asbestos or the activity involving such products or material are not capable of releasing fibers of asbestos in concentrations at or above the permissible exposure limit and/or excursion limit under the expected conditions of processing, use, or handling to satisfy the requirements of paragraph (f) of this section, the employer shall establish and maintain an accurate record of objective data reasonably relied upon in support of the exemption.
- (ii) The record shall include at least the following information:
  - (A) The product qualifying for exemption;
  - (B) The source of the objective data;
  - (C) The testing protocol, results of testing, and/or analysis of the material for the release of asbestos;
  - (D) A description of the operation exempted and how the data support the exemption; and
  - (E) Other data relevant to the operations, materials, processing, or employee exposures covered by the exemption.
- (iii) The employer shall maintain this record for the duration of the employer's reliance upon such objective data.

(2) ***Exposure measurements.***

- (i) The employer shall keep an accurate record of all measurements taken to monitor employee exposure to asbestos as prescribed in paragraph (f) of this section. Note: The employer may utilize the services of qualified organizations such as industry trade associations and employee associations to maintain the records required by this section.
- (ii) This record shall include at least the following information:
  - (A) The date of measurement;
  - (B) The operation involving exposure to asbestos that is being monitored;
  - (C) Sampling and analytical methods used and evidence of their accuracy;
  - (D) Number, duration, and results of samples taken;

- (E) Type of protective devices worn, if any; and
  - (F) Name and exposure of the employees whose exposures are represented.
- (iii) The employer shall maintain this record for at least thirty (30) years, in accordance with 29 CFR 1910.1020.
- (3) **Medical surveillance.**
  - (i) The employer shall establish and maintain an accurate record for each employee subject to medical surveillance by paragraph (m) of this section, in accordance with 29 CFR 1910.1020.
  - (ii) The record shall include at least the following information:
    - (A) The name of the employee;
    - (B) A copy of the employee's medical examination results, including the medical history, questionnaire responses, results of any tests, and physician's recommendations.
    - (C) Physician's written opinions;
    - (D) Any employee medical complaints related to exposure to asbestos; and
    - (E) A copy of the information provided to the physician as required by paragraph (m) of this section.
  - (iii) The employer shall ensure that this record is maintained for the duration of employment plus thirty (30) years, in accordance with 29 CFR 1910.1020.
- (4) **Training records.** The employer shall maintain all employee training records for one (1) year beyond the last date of employment by that employer.
- (5) **Data to rebut PACM.**
  - (i) Where the building owner and employer have relied on data to demonstrate that PACM is not asbestos-containing, such data shall be maintained for as long as they are relied upon to rebut the presumption.
  - (ii) [Reserved]
- (6) **Records of required notification.**
  - (i) Where the building/vessel owner has communicated and received information concerning the identity, location and quantity of ACM and PACM, written records of such notifications and their content shall be maintained by the owner for the duration of ownership and shall be transferred to successive owners of such buildings/facilities/vessels.
  - (ii) [Reserved]
- (7) **Availability.**
  - (i) The employer, upon written request, shall make all records required to be maintained by this section available to the Assistant Secretary and the Director for examination and copying.
  - (ii) The employer, upon request, shall make any exposure records required by paragraphs (f) and (n) of this section available for examination and copying to affected employees, former employees, designated representatives, and the Assistant Secretary, in accordance with 29 CFR 1910.1020(a) through (e) and (g) through (i).

(iii) The employer, upon request, shall make employee medical records required by paragraphs (m) and (n) of this section available for examination and copying to the subject employee, anyone having the specific written consent of the subject employee, and the Assistant Secretary, in accordance with 29 CFR 1910.1020.

(8) **Transfer of records.** The employer shall comply with the requirements concerning transfer of records set forth in 29 CFR 1910.1020(h).

(o) **Qualified person –**

(1) **General.** On all shipyard worksites covered by this standard, the employer shall designate a qualified person, having the qualifications and authority for ensuring worker safety and health required by subpart C, General Safety and Health Provisions for Construction (29 CFR 1926.20 through 1926.32).

(2) **Required inspections by the qualified person.** § 1926.20(b)(2) which requires health and safety prevention programs to provide for frequent and regular inspections of the job sites, materials, and equipment to be made by qualified persons, is incorporated.

(3) **Additional inspections.** In addition, the qualified person shall make frequent and regular inspections of the job sites, in order to perform the duties set out in paragraph (o)(3)(i) of this section. For Class I jobs, on-site inspections shall be made at least once during each work shift, and at any time at employee request. For Class II, III and IV jobs, on-site inspections shall be made at intervals sufficient to assess whether conditions have changed, and at any reasonable time at employee request.

(i) On all worksites where employees are engaged in Class I or II asbestos work, the qualified person designated in accordance with paragraph (e)(6) of this section shall perform or supervise the following duties, as applicable:

(A) Set up the regulated area, enclosure, or other containment;

(B) Ensure (by on-site inspection) the integrity of the enclosure or containment;

(C) Set up procedures to control entry to and exit from the enclosure and/or area;

(D) Supervise all employee exposure monitoring required by this section and ensure that it is conducted as required by paragraph (f) of this section;

(E) Ensure that employees working within the enclosure and/or using glove bags wear respirators and protective clothing as required by paragraphs (h) and (i) of this section;

(F) Ensure through on-site supervision, that employees set up, use, and remove engineering controls, use work practices and personal protective equipment in compliance with all requirements;

(G) Ensure that employees use the hygiene facilities and observe the decontamination procedures specified in paragraph (j) of this section;

(H) Ensure that through on-site inspection, engineering controls are functioning properly and employees are using proper work practices; and

(I) Ensure that notification requirements in paragraph (k) of this section are met.

(4) **Training for the competent person.**



- (i) For Class I and II asbestos work the qualified person shall be trained in all aspects of asbestos removal and handling, including: Abatement, installation, removal and handling; the contents of this standard; the identification of asbestos; removal procedures, where appropriate; and other practices for reducing the hazard. Such training shall be obtained in a comprehensive course for supervisors, that meets the criteria of EPA's Model Accreditation Plan (40 CFR part 763, subpart E, appendix C), such as a course conducted by an EPA-approved or state-approved training provider, certified by EPA or a state, or a course equivalent in stringency, content, and length.
- (ii) For Class III and IV asbestos work, the qualified person shall be trained in aspects of asbestos handling appropriate for the nature of the work, to include procedures for setting up glove bags and mini-enclosures, practices for reducing asbestos exposures, use of wet methods, the contents of this standard, and the identification of asbestos. Such training shall include successful completion of a course that is consistent with EPA requirements for training of local education agency maintenance and custodial staff as set forth at 40 CFR 763.92(a)(2), or its equivalent in stringency, content, and length. Qualified persons for Class III and Class IV work may also be trained pursuant to the requirements of paragraph (o)(4)(i) of this section.

(p) **Appendices.**

- (1) Appendices A, C, D, and E to this section are incorporated as part of this section and the contents of these appendices are mandatory.
- (2) Appendices B, F, H, I, J, and K to this section are informational and are not intended to create any additional obligations not otherwise imposed or to detract from any existing obligations.

## Appendix A to § 1915.1001—OSHA Reference Method (Mandatory)

This mandatory appendix specifies the procedure for analyzing air samples for asbestos, and specifies quality control procedures that must be implemented by laboratories performing the analysis. The sampling and analytical methods described below represent the elements of the available monitoring methods (such as appendix B to this section, the most current version of the OSHA method ID-160, or the most current version of the NIOSH Method 7400) which OSHA considers to be essential to achieve adequate employee exposure monitoring while allowing employers to use methods that are already established within their organizations. All employers who are required to conduct air monitoring under paragraph (f) of this section are required to utilize analytical laboratories that use this procedure, or an equivalent method, for collecting and analyzing samples.

### Sampling and Analytical Procedure

1. The sampling medium for air samples shall be mixed cellulose ester filter membranes. These shall be designated by the manufacturer as suitable for asbestos counting. See below for rejection of blanks.
2. The preferred collection device shall be the 25-mm diameter cassette with an open-faced 50-mm extension cowl. The 37-mm cassette may be used if necessary but only if written justification for the need to use the 37-mm filter cassette accompanies the sample results in the employee's exposure monitoring record. Other cassettes such as the Bell-mouth may be used within the limits of their validation. Do not reuse or reload cassettes for asbestos sample collection.
3. An air flow rate between 0.5 liter/min and 5 liters/min shall be selected for the 25-mm cassette. If the 37-mm cassette is used, an air flow rate between 1 liter/min and 5 liters/min shall be selected.

4. Where possible, a sufficient air volume for each air sample shall be collected to yield between 100 and 1,300 fibers per square millimeter on the membrane filter. If a filter darkens in appearance or if loose dust is seen on the filter, a second sample shall be started.
5. Ship the samples in a rigid container with sufficient packing material to prevent dislodging the collected fibers. Packing material that has a high electrostatic charge on its surface (e.g., expanded polystyrene) cannot be used because such material can cause loss of fibers to the sides of the cassette.
6. Calibrate each personal sampling pump before and after use with a representative filter cassette installed between the pump and the calibration devices.
7. Personal samples shall be taken in the "breathing zone" of the employee (i.e., attached to or near the collar or lapel near the worker's face).
8. Fiber counts shall be made by positive phase contrast using a microscope with an 8 to 10× eyepiece and a 40 to 45× objective for a total magnification of approximately 400× and a numerical aperture of 0.65 to 0.75. The microscope shall also be fitted with a green or blue filter.
9. The microscope shall be fitted with a Walton-Beckett eyepiece graticule calibrated for a field diameter of 100 micrometers ( $\pm 2$  micrometers).
10. The phase-shift detection limit of the microscope shall be about 3 degrees measured using the HSE phase shift test slide as outlined below.
  - a. Place the test slide on the microscope stage and center it under the phase objective.
  - b. Bring the blocks of grooved lines into focus.

Note: The slide consists of seven sets of grooved lines (ca. 20 grooves to each block) in descending order of visibility from sets 1 to 7, seven being the least visible. The requirements for asbestos, tremolite, anthophyllite, and actinolite counting are that the microscope optics must resolve the grooved lines in set 3 completely, although they may appear somewhat faint, and that the grooved lines in sets 6 and 7 must be invisible. Sets 4 and 5 must be at least partially visible but may vary slightly in visibility between microscopes. A microscope that fails to meet these requirements has either too low or too high a resolution to be used for asbestos, tremolite, anthophyllite, and actinolite counting.

- c. If the image deteriorates, clean and adjust the microscope optics. If the problem persists, consult the microscope manufacturer.

11. Each set of samples taken will include 10% field blanks or a minimum of 2 field blanks. These blanks must come from the same lot as the filters used for sample collection. The field blank results shall be averaged and subtracted from the analytical results before reporting. A set consists of any sample or group of samples for which an evaluation for this standard must be made. Any samples represented by a field blank having a fiber count in excess of the detection limit of the method being used shall be rejected.

12. The samples shall be mounted by the acetone/triacetin method or a method with an equivalent index of refraction and similar clarity.
13. Observe the following counting rules.
  - a. Count only fibers equal to or longer than 5 micrometers. Measure the length of curved fibers along the curve.
  - b. In the absence of other information, count all particles as asbestos that have a length-to-width ratio (aspect ratio) of 3 to 1 or greater.
  - c. Fibers lying entirely within the boundary of the Walton-Beckett graticule field shall receive a count of 1. Fibers crossing the boundary once, having one end within the circle, shall receive the count of one half ( $1/2$ ). Do not count any fiber that crosses the graticule boundary more than once. Reject and do not count any other fibers even though they may be visible outside the graticule area.
  - d. Count bundles of fibers as one fiber unless individual fibers can be identified by observing both ends of an individual fiber.
  - e. Count enough graticule fields to yield 100 fibers. Count a minimum of 20 fields; stop counting at 100 fields regardless of fiber count.
14. Blind recounts shall be conducted at the rate of 10 percent.

## Quality Control Procedures

1. Intra-laboratory program. Each laboratory and/or each company with more than one microscopist counting slides shall establish a statistically designed quality assurance program involving blind recounts and comparisons between microscopists to monitor the variability of counting by each microscopist and between microscopists. In a company with more than one laboratory, the program shall include all laboratories and shall also evaluate the laboratory-to-laboratory variability.
2. a. Interlaboratory program. Each laboratory analyzing asbestos, tremolite, anthophyllite, and actinolite samples for compliance determination shall implement an interlaboratory quality assurance program that as a minimum includes participation of at least two other independent laboratories. Each laboratory shall participate in round robin testing at least once every 6 months with at least all the other laboratories in its interlaboratory quality assurance group. Each laboratory shall submit slides typical of its own work load for use in this program. The round robin shall be designed and results analyzed using appropriate statistical methodology.
  - b. All laboratories should participate in a national sample testing scheme such as the Proficiency Analytical Testing Program (PAT), the Asbestos Registry sponsored by the American Industrial Hygiene Association (AIHA).
3. All individuals performing asbestos, tremolite, anthophyllite, and actinolite analysis must have taken the NIOSH course for sampling and evaluating airborne asbestos, tremolite, anthophyllite, and actinolite dust or an equivalent course.

4. When the use of different microscopes contributes to differences between counters and laboratories, the effect of the different microscope shall be evaluated and the microscope shall be replaced, as necessary.
5. Current results of these quality assurance programs shall be posted in each laboratory to keep the microscopists informed.

## Appendix B to § 1915.1001—Detailed Procedures for Asbestos Sampling and Analysis (Non-mandatory)

Matrix:	Air
OSHA Permissible Exposure Limits:	
Time Weighted Average	0.1 fiber/cc
Excursion Level (30 minutes)	1.0 fiber/cc
Collection Procedure:	
A known volume of air is drawn through a 25-mm diameter cassette containing a mixed-cellulose ester filter. The cassette must be equipped with an electrically conductive 50-mm extension cowl. The sampling time and rate are chosen to give a fiber density of between 100 to 1,300 fibers/mm <sup>2</sup> on the filter.	
Recommended Sampling Rate	0.5 to 5.0 liters/minute (L/min)
Recommended Air Volumes:	
Minimum	25 L
Maximum	2,400 L

Analytical Procedure: A portion of the sample filter is cleared and prepared for asbestos fiber counting by Phase Contrast Microscopy (PCM) at 400X.

Commercial manufacturers and products mentioned in this method are for descriptive use only and do not constitute endorsements by USDOL-OSHA. Similar products from other sources can be substituted.

## 1. Introduction

This method describes the collection of airborne asbestos fibers using calibrated sampling pumps with mixed-cellulose ester (MCE) filters and analysis by phase contrast microscopy (PCM). Some terms used are unique to this method and are defined below: *Asbestos*: A term for naturally occurring fibrous minerals. Asbestos includes chrysotile, crocidolite, amosite (cummingtonite-grunerite asbestos), tremolite asbestos, actinolite asbestos, anthophyllite asbestos, and any of these minerals that have been chemically treated and/or altered. The precise chemical formulation of each species will vary with the location from which it was mined. Nominal compositions are listed:

Chrysotile	$\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4$
Crocidolite	$\text{Na}_2\text{Fe}_3\text{Si}_2\text{O}_{10} + \text{Fe}_2\text{SiO}_4 + \text{Si}_2\text{O}_2(\text{OH})_2$
Amosite	$(\text{Mg},\text{Fe})_7\text{Si}_8\text{O}_{22}(\text{OH})_2$
Tremolite-actinolite	$\text{Ca}_2(\text{Mg},\text{Fe})_5\text{Si}_8\text{O}_{22}(\text{OH})_2$
Anthophyllite	$(\text{Mg},\text{Fe})_7\text{Si}_8\text{O}_{22}(\text{OH})_2$

*Asbestos Fiber*: A fiber of asbestos which meets the criteria specified below for a fiber.

*Aspect Ratio*: The ratio of the length of a fiber to its diameter (e.g. 3:1, 5:1 aspect ratios).

*Cleavage Fragments*: Mineral particles formed by comminution of minerals, especially those characterized by parallel sides and a moderate aspect ratio (usually less than 20:1).

*Detection Limit*: The number of fibers necessary to be 95% certain that the result is greater than zero.

*Differential Counting*: The term applied to the practice of excluding certain kinds of fibers from the fiber count because they do not appear to be asbestos.

*Fiber*: A particle that is 5  $\mu\text{m}$  or longer, with a length-to-width ratio of 3 to 1 or longer.

*Field*: The area within the graticule circle that is superimposed on the microscope image.

*Set*: The samples which are taken, submitted to the laboratory, analyzed, and for which, interim or final result reports are generated.

*Tremolite, Anthophyllite, and Actinolite*: The non-asbestos form of these minerals which meet the definition of a fiber. It includes any of these minerals that have been chemically treated and/or altered.

*Walton-Beckett Graticule*: An eyepiece graticule specifically designed for asbestos fiber counting. It consists of a circle with a projected diameter of  $100 \pm 2 \mu\text{m}$  (area of about  $0.00785 \text{ mm}^2$ ) with a crosshair having tic-marks at 3- $\mu\text{m}$  intervals in one direction and 5- $\mu\text{m}$  in the orthogonal direction. There are marks around the periphery of the circle to demonstrate the proper sizes and shapes of fibers. This design is reproduced in figure 1. The disk is placed in one of the microscope eyepieces so that the design is superimposed on the field of view.

### 1.1. HISTORY

Early surveys to determine asbestos exposures were conducted using impinger counts of total dust with the counts expressed as million particles per cubic foot. The British Asbestos Research Council recommended filter membrane counting in 1969. In July 1969, the Bureau of Occupational Safety and Health published a filter membrane method for counting asbestos fibers in the United States. This method was refined by NIOSH and published as P & CAM 239. On May 29, 1971, OSHA specified filter membrane sampling with phase contrast counting for evaluation of asbestos exposures at work sites in the United States. The use of this technique was again required by OSHA in 1986. Phase contrast microscopy has continued to be the method of choice for the measurement of occupational exposure to asbestos.

### 1.2. PRINCIPLE

Air is drawn through a MCE filter to capture airborne asbestos fibers. A wedge shaped portion of the filter is removed, placed on a glass microscope slide and made transparent. A measured area (field) is viewed by PCM. All the fibers meeting defined criteria for asbestos are counted and considered a measure of the airborne asbestos concentration.

### 1.3. ADVANTAGES AND DISADVANTAGES

There are four main advantages of PCM over other methods:

- (1) The technique is specific for fibers. Phase contrast is a fiber counting technique which excludes non-fibrous particles from the analysis.
- (2) The technique is inexpensive and does not require specialized knowledge to carry out the analysis for total fiber counts.
- (3) The analysis is quick and can be performed on-site for rapid determination of air concentrations of asbestos fibers.
- (4) The technique has continuity with historical epidemiological studies so that estimates of expected disease can be inferred from long-term determinations of asbestos exposures.

The main disadvantage of PCM is that it does not positively identify asbestos fibers. Other fibers which are not asbestos may be included in the count unless differential counting is performed. This requires a great deal of experience to adequately differentiate asbestos from non-asbestos fibers. Positive identification of asbestos must be performed by polarized light or electron microscopy techniques. A further disadvantage of PCM is that the smallest visible fibers are about 0.2  $\mu\text{m}$  in diameter while the finest asbestos fibers may be as small as 0.02  $\mu\text{m}$  in diameter. For some exposures, substantially more fibers may be present than are actually counted.

## 1.4. WORKPLACE EXPOSURE

Asbestos is used by the construction industry in such products as shingles, floor tiles, asbestos cement, roofing felts, insulation and acoustical products. Non-construction uses include brakes, clutch facings, paper, paints, plastics, and fabrics. One of the most significant exposures in the workplace is the removal and encapsulation of asbestos in schools, public buildings, and homes. Many workers have the potential to be exposed to asbestos during these operations.

About 95% of the asbestos in commercial use in the United States is chrysotile. Crocidolite and amosite make up most of the remainder. Anthophyllite and tremolite or actinolite are likely to be encountered as contaminants in various industrial products.

## 1.5. PHYSICAL PROPERTIES

Asbestos fiber possesses a high tensile strength along its axis, is chemically inert, non-combustible, and heat resistant. It has a high electrical resistance and good sound absorbing properties. It can be weaved into cables, fabrics or other textiles, and also matted into asbestos papers, felts, or mats.

## 2. Range and Detection Limit

2.1. The ideal counting range on the filter is 100 to 1,300 fibers/mm<sup>2</sup>. With a Walton-Beckett graticule this range is equivalent to 0.8 to 10 fibers/field. Using NIOSH counting statistics, a count of 0.8 fibers/field would give an approximate coefficient of variation (CV) of 0.13.

2.2. The detection limit for this method is 4.0 fibers per 100 fields or 5.5 fibers/mm<sup>2</sup>. This was determined using an equation to estimate the maximum CV possible at a specific concentration (95% confidence) and a Lower Control Limit of zero. The CV value was then used to determine a corresponding concentration from historical CV vs fiber relationships. As an example:

$$\text{Lower Control Limit (95\% Confidence)} = AC - 1.645(CV)(AC)$$

Where:

AC = Estimate of the airborne fiber concentration (fibers/cc) Setting the Lower Control Limit = 0 and solving for CV:

$$0 = AC - 1.645(CV)(AC)$$

$$CV = 0.61$$

This value was compared with CV vs. count curves. The count at which CV = 0.61 for Leidel-Busch counting statistics (8.9.) or for an OSHA Salt Lake Technical Center (OSHA-SLTC) CV curve (see appendix A for further information) was 4.4 fibers or 3.9 fibers per 100 fields, respectively. Although a lower detection limit of 4 fibers per 100 fields is supported by the OSHA-SLTC data, both data sets support the 4.5 fibers per 100 fields value.

### 3. Method Performance—Precision and Accuracy

Precision is dependent upon the total number of fibers counted and the uniformity of the fiber distribution on the filter. A general rule is to count at least 20 and not more than 100 fields. The count is discontinued when 100 fibers are counted, provided that 20 fields have already been counted. Counting more than 100 fibers results in only a small gain in precision. As the total count drops below 10 fibers, an accelerated loss of precision is noted.

At this time, there is no known method to determine the absolute accuracy of the asbestos analysis. Results of samples prepared through the Proficiency Analytical Testing (PAT) Program and analyzed by the OSHA-SLTC showed no significant bias when compared to PAT reference values. The PAT samples were analyzed from 1987 to 1989 (N = 36) and the concentration range was from 120 to 1,300 fibers/mm<sup>2</sup>.

### 4. Interferences

Fibrous substances, if present, may interfere with asbestos analysis.

Some common fibers are:

fiberglass

anhydrate

plant fibers

perlite veins

gypsum

some synthetic fibers

membrane structures

sponge spicules

diatoms

microorganism

wollastonite

The use of electron microscopy or optical tests such as polarized light, and dispersion staining may be used to differentiate these materials from asbestos when necessary.



## 5. Sampling

### 5.1. EQUIPMENT

5.1.1. Sample assembly (The assembly is shown in figure 3). Conductive filter holder consisting of a 25-mm diameter, 3-piece cassette having a 50-mm long electrically conductive extension cowl. Backup pad, 25-mm, cellulose. Membrane filter, mixed-cellulose ester (MCE), 25-mm, plain, white, 0.4 to 1.2- $\mu$ m pore size.

Notes: (a) DO NOT RE-USE CASSETTES.

(b) Fully conductive cassettes are required to reduce fiber loss to the sides of the cassette due to electrostatic attraction.

(c) Purchase filters which have been selected by the manufacturer for asbestos counting or analyze representative filters for fiber background before use. Discard the filter lot if more than 4 fibers/100 fields are found.

(d) To decrease the possibility of contamination, the sampling system (filter-backup pad-cassette) for asbestos is usually preassembled by the manufacturer.

(e) Other cassettes, such as the Bell-mouth, may be used within the limits of their validation.

5.1.2. Gel bands for sealing cassettes.

5.1.3. Sampling pump.

Each pump must be a battery operated, self-contained unit small enough to be placed on the monitored employee and not interfere with the work being performed. The pump must be capable of sampling at the collection rate for the required sampling time.

5.1.4. Flexible tubing, 6-mm bore.

5.1.5. Pump calibration.

Stopwatch and bubble tube/burette or electronic meter.

### 5.2. SAMPLING PROCEDURE

5.2.1. Seal the point where the base and cowl of each cassette meet with a gel band or tape.

5.2.2. Charge the pumps completely before beginning.

5.2.3. Connect each pump to a calibration cassette with an appropriate length of 6-mm bore plastic tubing. Do not use luer connectors—the type of cassette specified above has built-in adapters.

5.2.4. Select an appropriate flow rate for the situation being monitored. The sampling flow rate must be between 0.5 and 5.0 L/min for personal sampling and is commonly set between 1 and 2 L/min. Always choose a flow rate that will not produce overloaded filters.

5.2.5. Calibrate each sampling pump before and after sampling with a calibration cassette in-line (Note: This calibration cassette should be from the same lot of cassettes used for sampling). Use a primary standard (e.g. bubble burette) to calibrate each pump. If possible, calibrate at the sampling site.

Note: If sampling site calibration is not possible, environmental influences may affect the flow rate. The extent is dependent on the type of pump used. Consult with the pump manufacturer to determine dependence on environmental influences. If the pump is affected by temperature and pressure changes, correct the flow rate by using the formula shown in the section "Sampling Pump Flow Rate Corrections" at the end of this appendix.

5.2.6. Connect each pump to the base of each sampling cassette with flexible tubing. Remove the end cap of each cassette and take each air sample open face. Assure that each sample cassette is held open side down in the employee's breathing zone during sampling. The distance from the nose/mouth of the employee to the cassette should be about 10 cm. Secure the cassette on the collar or lapel of the employee using spring clips or other similar devices.

5.2.7. A suggested minimum air volume when sampling to determine TWA compliance is 25 L. For Excursion Limit (30 min sampling time) evaluations, a minimum air volume of 48 L is recommended.

5.2.8. The most significant problem when sampling for asbestos is overloading the filter with non-asbestos dust. Suggested maximum air sample volumes for specific environments are:

Environment	Air vol. (L)
Asbestos removal operations (visible dust)	100
Asbestos removal operations (little dust)	240
Office environments	400 to 2,400

*Caution:* Do not overload the filter with dust. High levels of non-fibrous dust particles may obscure fibers on the filter and lower the count or make counting impossible. If more than about 25 to 30% of the field area is obscured with dust, the result may be biased low. Smaller air volumes may be necessary when there is excessive non-asbestos dust in the air.

While sampling, observe the filter with a small flashlight. If there is a visible layer of dust on the filter, stop sampling, remove and seal the cassette, and replace with a new sampling assembly. The total dust loading should not exceed 1 mg.

5.2.9. Blank samples are used to determine if any contamination has occurred during sample handling. Prepare two blanks for the first 1 to 20 samples. For sets containing greater than 20 samples, prepare blanks as 10% of the samples. Handle blank samples in the same manner as air samples with one exception: Do not draw any air

through the blank samples. Open the blank cassette in the place where the sample cassettes are mounted on the employee. Hold it open for about 30 seconds. Close and seal the cassette appropriately. Store blanks for shipment with the sample cassettes.

5.2.10. Immediately after sampling, close and seal each cassette with the base and plastic plugs. Do not touch or puncture the filter membrane as this will invalidate the analysis.

5.2.11 Attach and secure a sample seal around each sample cassette in such a way as to assure that the end cap and base plugs cannot be removed without destroying the seal. Tape the ends of the seal together since the seal is not long enough to be wrapped end-to-end. Also wrap tape around the cassette at each joint to keep the seal secure.

### 5.3. SAMPLE SHIPMENT

5.3.1. Send the samples to the laboratory with paperwork requesting asbestos analysis. List any known fibrous interferences present during sampling on the paperwork. Also, note the workplace operation(s) sampled.

5.3.2. Secure and handle the samples in such that they will not rattle during shipment nor be exposed to static electricity. Do not ship samples in expanded polystyrene peanuts, vermiculite, paper shreds, or excelsior. Tape sample cassettes to sheet bubbles and place in a container that will cushion the samples in such a manner that they will not rattle.

5.3.3. To avoid the possibility of sample contamination, always ship bulk samples in separate mailing containers.

## 6. Analysis

### 6.1. SAFETY PRECAUTIONS

6.1.1. Acetone is extremely flammable and precautions must be taken not to ignite it. Avoid using large containers or quantities of acetone. Transfer the solvent in a ventilated laboratory hood. Do not use acetone near any open flame. For generation of acetone vapor, use a spark free heat source.

6.1.2. Any asbestos spills should be cleaned up immediately to prevent dispersal of fibers. Prudence should be exercised to avoid contamination of laboratory facilities or exposure of personnel to asbestos. Asbestos spills should be cleaned up with wet methods and/or a High Efficiency Particulate-Air (HEPA) filtered vacuum.

*Caution:* Do not use a vacuum without a HEPA filter—It will disperse fine asbestos fibers in the air.

### 6.2. EQUIPMENT

6.2.1. Phase contrast microscope with binocular or trinocular head.

6.2.2. Widefield or Huygenian 10X eyepieces (NOTE: The eyepiece containing the graticule must be a focusing eyepiece. Use a 40X phase objective with a numerical aperture of 0.65 to 0.75).

6.2.3. Kohler illumination (if possible) with green or blue filter.

6.2.4. Walton-Beckett Graticule, type G-22 with  $100 \pm 2$   $\mu\text{m}$  projected diameter.

6.2.5. Mechanical stage. A rotating mechanical stage is convenient for use with polarized light.

6.2.6. Phase telescope.

6.2.7. Stage micrometer with 0.01-mm subdivisions.

6.2.8. Phase-shift test slide, mark II (Available from PTR optics Ltd., and also McCrone).

6.2.9. Precleaned glass slides, 25 mm  $\times$  75 mm. One end can be frosted for convenience in writing sample numbers, etc., or paste-on labels can be used.

6.2.10. Cover glass #1<sup>1</sup>/<sub>2</sub>.

6.2.11. Scalpel (#10, curved blade).

6.2.12. Fine tipped forceps.

6.2.13. Aluminum block for clearing filter (see appendix D and figure 4).

6.2.14. Automatic adjustable pipette, 100- to 500- $\mu\text{L}$ .

6.2.15. Micropipette, 5  $\mu\text{L}$ .

### 6.3. REAGENTS

6.3.1. Acetone (HPLC grade).

6.3.2. Triacetin (glycerol triacetate).

6.3.3. Lacquer or nail polish.

### 6.4. STANDARD PREPARATION

A way to prepare standard asbestos samples of known concentration has not been developed. It is possible to prepare replicate samples of nearly equal concentration. This has been performed through the PAT program. These asbestos samples are distributed by the AIHA to participating laboratories.

Since only about one-fourth of a 25-mm sample membrane is required for an asbestos count, any PAT sample can serve as a "standard" for replicate counting.

## 6.5. SAMPLE MOUNTING

Note: See Safety Precautions in Section 6.1. before proceeding. The objective is to produce samples with a smooth (non-grainy) background in a medium with a refractive index of approximately 1.46. The technique below collapses the filter for easier focusing and produces permanent mounts which are useful for quality control and interlaboratory comparison.

An aluminum block or similar device is required for sample preparation.

6.5.1. Heat the aluminum block to about 70 °C. The hot block should not be used on any surface that can be damaged by either the heat or from exposure to acetone.

6.5.2. Ensure that the glass slides and cover glasses are free of dust and fibers.

6.5.3. Remove the top plug to prevent a vacuum when the cassette is opened. Clean the outside of the cassette if necessary. Cut the seal and/or tape on the cassette with a razor blade. Very carefully separate the base from the extension cowl, leaving the filter and backup pad in the base.

6.5.4. With a rocking motion cut a triangular wedge from the filter using the scalpel. This wedge should be one-sixth to one-fourth of the filter. Grasp the filter wedge with the forceps on the perimeter of the filter which was clamped between the cassette pieces. DO NOT TOUCH the filter with your finger. Place the filter on the glass slide sample side up. Static electricity will usually keep the filter on the slide until it is cleared.

6.5.5. Place the tip of the micropipette containing about 200 µL acetone into the aluminum block. Insert the glass slide into the receiving slot in the aluminum block. Inject the acetone into the block with slow, steady pressure on the plunger while holding the pipette firmly in place. Wait 3 to 5 seconds for the filter to clear, then remove the pipette and slide from the aluminum block.

6.5.6. Immediately (less than 30 seconds) place 2.5 to 3.5 µL of triacetin on the filter (NOTE: Waiting longer than 30 seconds will result in increased index of refraction and decreased contrast between the fibers and the preparation. This may also lead to separation of the cover slip from the slide).

6.5.7. Lower a cover slip gently onto the filter at a slight angle to reduce the possibility of forming air bubbles. If more than 30 seconds have elapsed between acetone exposure and triacetin application, glue the edges of the cover slip to the slide with lacquer or nail polish.

6.5.8. If clearing is slow, warm the slide for 15 min on a hot plate having a surface temperature of about 50 °C to hasten clearing. The top of the hot block can be used if the slide is not heated too long.

6.5.9. Counting may proceed immediately after clearing and mounting are completed.

## 6.6. SAMPLE ANALYSIS

Completely align the microscope according to the manufacturer's instructions. Then, align the microscope using the following general alignment routine at the beginning of every counting session and more often if necessary.

### 6.6.1. ALIGNMENT

- (1) Clean all optical surfaces. Even a small amount of dirt can significantly degrade the image.
- (2) Rough focus the objective on a sample.
- (3) Close down the field iris so that it is visible in the field of view. Focus the image of the iris with the condenser focus. Center the image of the iris in the field of view.
- (4) Install the phase telescope and focus on the phase rings. Critically center the rings. Misalignment of the rings results in astigmatism which will degrade the image.
- (5) Place the phase-shift test slide on the microscope stage and focus on the lines. The analyst must see line set 3 and should see at least parts of 4 and 5 but, not see line set 6 or 6. A microscope/microscopist combination which does not pass this test may not be used.

### 6.6.2. COUNTING FIBERS

- (1) Place the prepared sample slide on the mechanical stage of the microscope. Position the center of the wedge under the objective lens and focus upon the sample.
- (2) Start counting from one end of the wedge and progress along a radial line to the other end (count in either direction from perimeter to wedge tip). Select fields randomly, without looking into the eyepieces, by slightly advancing the slide in one direction with the mechanical stage control.
- (3) Continually scan over a range of focal planes (generally the upper 10 to 15  $\mu\text{m}$  of the filter surface) with the fine focus control during each field count. Spend at least 5 to 15 seconds per field.
- (4) Most samples will contain asbestos fibers with fiber diameters less than 1  $\mu\text{m}$ . Look carefully for faint fiber images. The small diameter fibers will be very hard to see. However, they are an important contribution to the total count.
- (5) Count only fibers equal to or longer than 5  $\mu\text{m}$ . Measure the length of curved fibers along the curve.
- (6) Count fibers which have a length to width ratio of 3:1 or greater.
- (7) Count all the fibers in at least 20 fields. Continue counting until either 100 fibers are counted or 100 fields have been viewed; whichever occurs first. Count all the fibers in the final field.

(8) Fibers lying entirely within the boundary of the Walton-Beckett graticule field shall receive a count of 1. Fibers crossing the boundary once, having one end within the circle shall receive a count of  $\frac{1}{2}$ . Do not count any fiber that crosses the graticule boundary more than once. Reject and do not count any other fibers even though they may be visible outside the graticule area. If a fiber touches the circle, it is considered to cross the line.

(9) Count bundles of fibers as one fiber unless individual fibers can be clearly identified and each individual fiber is clearly not connected to another counted fiber. See figure 1 for counting conventions.

(10) Record the number of fibers in each field in a consistent way such that filter non-uniformity can be assessed.

(11) Regularly check phase ring alignment.

(12) When an agglomerate (mass of material) covers more than 25% of the field of view, reject the field and select another. Do not include it in the number of fields counted.

(13) Perform a "blind recount" of 1 in every 10 filter wedges (slides). Re-label the slides using a person other than the original counter.

#### 6.7. FIBER IDENTIFICATION

As previously mentioned in Section 1.3., PCM does not provide positive confirmation of asbestos fibers. Alternate differential counting techniques should be used if discrimination is desirable. Differential counting may include primary discrimination based on morphology, polarized light analysis of fibers, or modification of PCM data by Scanning Electron or Transmission Electron Microscopy.

A great deal of experience is required to routinely and correctly perform differential counting. It is discouraged unless it is legally necessary. Then, only if a fiber is obviously not asbestos should it be excluded from the count. Further discussion of this technique can be found in reference 8.10.

If there is a question whether a fiber is asbestos or not, follow the rule:

"WHEN IN DOUBT, COUNT."

#### 6.8. ANALYTICAL RECOMMENDATIONS—QUALITY CONTROL SYSTEM

6.8.1. All individuals performing asbestos analysis must have taken the NIOSH course for sampling and evaluating airborne asbestos or an equivalent course.

6.8.2. Each laboratory engaged in asbestos counting shall set up a slide trading arrangement with at least two other laboratories in order to compare performance and eliminate inbreeding of error. The slide exchange occurs at least semiannually. The round robin results shall be posted where all analysts can view individual analyst's results.

6.8.3. Each laboratory engaged in asbestos counting shall participate in the Proficiency Analytical Testing Program, the Asbestos Analyst Registry or equivalent.

6.8.4. Each analyst shall select and count prepared slides from a "slide bank". These are quality assurance counts. The slide bank shall be prepared using uniformly distributed samples taken from the workload. Fiber densities should cover the entire range routinely analyzed by the laboratory. These slides are counted blind by all counters to establish an original standard deviation. This historical distribution is compared with the quality assurance counts. A counter must have 95% of all quality control samples counted within three standard deviations of the historical mean. This count is then integrated into a new historical mean and standard deviation for the slide.

The analyses done by the counters to establish the slide bank may be used for an interim quality control program if the data are treated in a proper statistical fashion.

## 7. Calculations

7.1. Calculate the estimated airborne asbestos fiber concentration on the filter sample using the following formula:

$$AC = \frac{\left[ \left( \frac{FB}{FL} \right) - \left( \frac{BFB}{BFL} \right) \right] \times ECA}{1000 \times FR \times T \times MFA}$$

Where:

AC = Airborne fiber concentration

FB = Total number of fibers greater than 5 µm counted

FL = Total number of fields counted on the filter

BFB = Total number of fibers greater than 5 µm counted in the blank

BFL = Total number of fields counted on the blank

ECA = Effective collecting area of filter (385 mm<sup>2</sup> nominal for a 25-mm filter.)

FR = Pump flow rate (L/min)

MFA = Microscope count field area (mm<sup>2</sup>). This is 0.00785 mm<sup>2</sup> for a Walton-Beckett Graticule.

T = Sample collection time (min)

1,000 = Conversion of L to cc

Note: The collection area of a filter is seldom equal to 385 mm<sup>2</sup>. It is appropriate for laboratories to routinely monitor the exact diameter using an inside micrometer. The



collection area is calculated according to the formula:

$$\text{Area} = \pi(d/2)^2$$

## 7.2. SHORT-CUT CALCULATION

Since a given analyst always has the same interpupillary distance, the number of fields per filter for a particular analyst will remain constant for a given size filter. The field size for that analyst is constant (i.e. the analyst is using an assigned microscope and is not changing the reticle).

For example, if the exposed area of the filter is always 385 mm<sup>2</sup> and the size of the field is always 0.00785 mm<sup>2</sup>, the number of fields per filter will always be 49,000. In addition it is necessary to convert liters of air to cc. These three constants can then be combined such that  $ECA/(1,000 \times MFA) = 49$ . The previous equation simplifies to:

$$AC = \frac{\left(\frac{FB}{FL}\right) - \left(\frac{BFB}{BFL}\right) \times 49}{FR \times T}$$

## 7.3. RECOUNT CALCULATIONS

As mentioned in step 13 of Section 6.6.2., a “blind recount” of 10% of the slides is performed. In all cases, differences will be observed between the first and second counts of the same filter wedge. Most of these differences will be due to chance alone, that is, due to the random variability (precision) of the count method. Statistical recount criteria enables one to decide whether observed differences can be explained due to chance alone or are probably due to systematic differences between analysts, microscopes, or other biasing factors.

The following recount criterion is for a pair of counts that estimate AC in fibers/cc. The criterion is given at the type-I error level. That is, there is 5% maximum risk that we will reject a pair of counts for the reason that one might be biased, when the large observed difference is really due to chance.

Reject a pair of counts if:

$$\left| \sqrt{AC_2} - \sqrt{AC_1} \right| > 2.78 \times \left( \sqrt{AC_{AVG}} \right) \times CV_{FB}$$

Where:

AC<sub>1</sub> = lower estimated airborne fiber concentration

AC<sub>2</sub> = higher estimated airborne fiber concentration

$AC_{avg}$  = average of the two concentration estimates

$CV_{FB}$  = CV for the average of the two concentration estimates

If a pair of counts are rejected by this criterion then, recount the rest of the filters in the submitted set. Apply the test and reject any other pairs failing the test. Rejection shall include a memo to the industrial hygienist stating that the sample failed a statistical test for homogeneity and the true air concentration may be significantly different than the reported value.

#### 7.4. REPORTING RESULTS

Report results to the industrial hygienist as fibers/cc. Use two significant figures. If multiple analyses are performed on a sample, an average of the results is to be reported unless any of the results can be rejected for cause.

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## Quality Control

The OSHA asbestos regulations require each laboratory to establish a quality control program. The following is presented as an example of how the OSHA-SLTC constructed its internal CV curve as part of meeting this requirement. Data is from 395 samples collected during OSHA compliance inspections and analyzed from October 1980 through April 1986.

Each sample was counted by 2 to 5 different counters independently of one another. The standard deviation and the CV statistic was calculated for each sample. This data was then plotted on a graph of CV vs. fibers/mm<sup>2</sup>. A least squares regression was performed using the following equation:

$$CV = \text{antilog}_{10}[A(\log_{10}(x))^2 + B(\log_{10}(x)) + C]$$

Where:

x = the number of fibers/mm<sup>2</sup>

Application of least squares gave:

$$A = 0.182205$$

$$B = -0.973343$$

$$C = 0.327499$$

Using these values, the equation becomes:

$$CV = \text{antilog}_{10}[0.182205(\log_{10}(x))^2 - 0.973343(\log_{10}(x)) + 0.327499]$$

## SAMPLING PUMP FLOW RATE CORRECTIONS

This correction is used if a difference greater than 5% in ambient temperature and/or pressure is noted between calibration and sampling sites and the pump does not compensate for the differences.

$$Q_{\text{act}} = Q_{\text{cal}} \times \sqrt{\left(\frac{P_{\text{cal}}}{P_{\text{act}}}\right) \times \left(\frac{T_{\text{act}}}{T_{\text{cal}}}\right)}$$

Where:

$Q_{\text{act}}$  = actual flow rate

$Q_{cal}$  = calibrated flow rate (if a rotameter was used, the rotameter value)

$P_{cal}$  = uncorrected air pressure at calibration

$P_{act}$  = uncorrected air pressure at sampling site

$T_{act}$  = temperature at sampling site (K)

$T_{cal}$  = temperature at calibration (K)

## Walton-Beckett Graticule

When ordering the Graticule for asbestos counting, specify the exact disc diameter needed to fit the ocular of the microscope and the diameter (mm) of the circular counting area. Instructions for measuring the dimensions necessary are listed:

(1) Insert any available graticule into the focusing eyepiece and focus so that the graticule lines are sharp and clear.

(2) Align the microscope.

(3) Place a stage micrometer on the microscope object stage and focus the microscope on the graduated lines.

(4) Measure the magnified grid length, PL ( $\mu\text{m}$ ), using the stage micrometer.

(5) Remove the graticule from the microscope and measure its actual grid length, AL (mm). This can be accomplished by using a mechanical stage fitted with verniers, or a jeweler's loupe with a direct reading scale.

(6) Let  $D = 100 \mu\text{m}$ . Calculate the circle diameter,  $d_c$  (mm), for the Walton-Beckett graticule and specify the diameter when making a purchase:

$$d_c = \frac{AL \times D}{PL}$$

Example: If  $PL = 108 \mu\text{m}$ ,  $AL = 2.93 \text{ mm}$  and  $D = 100 \mu\text{m}$ , then,

$$d_c = \frac{2.93 \times 100}{108} = 2.71 \text{ mm}$$

(7) Each eyepiece-objective-reticle combination on the microscope must be calibrated. Should any of the three be changed (by zoom adjustment, disassembly, replacement, etc.), the combination must be recalibrated. Calibration may change if interpupillary distance is changed.

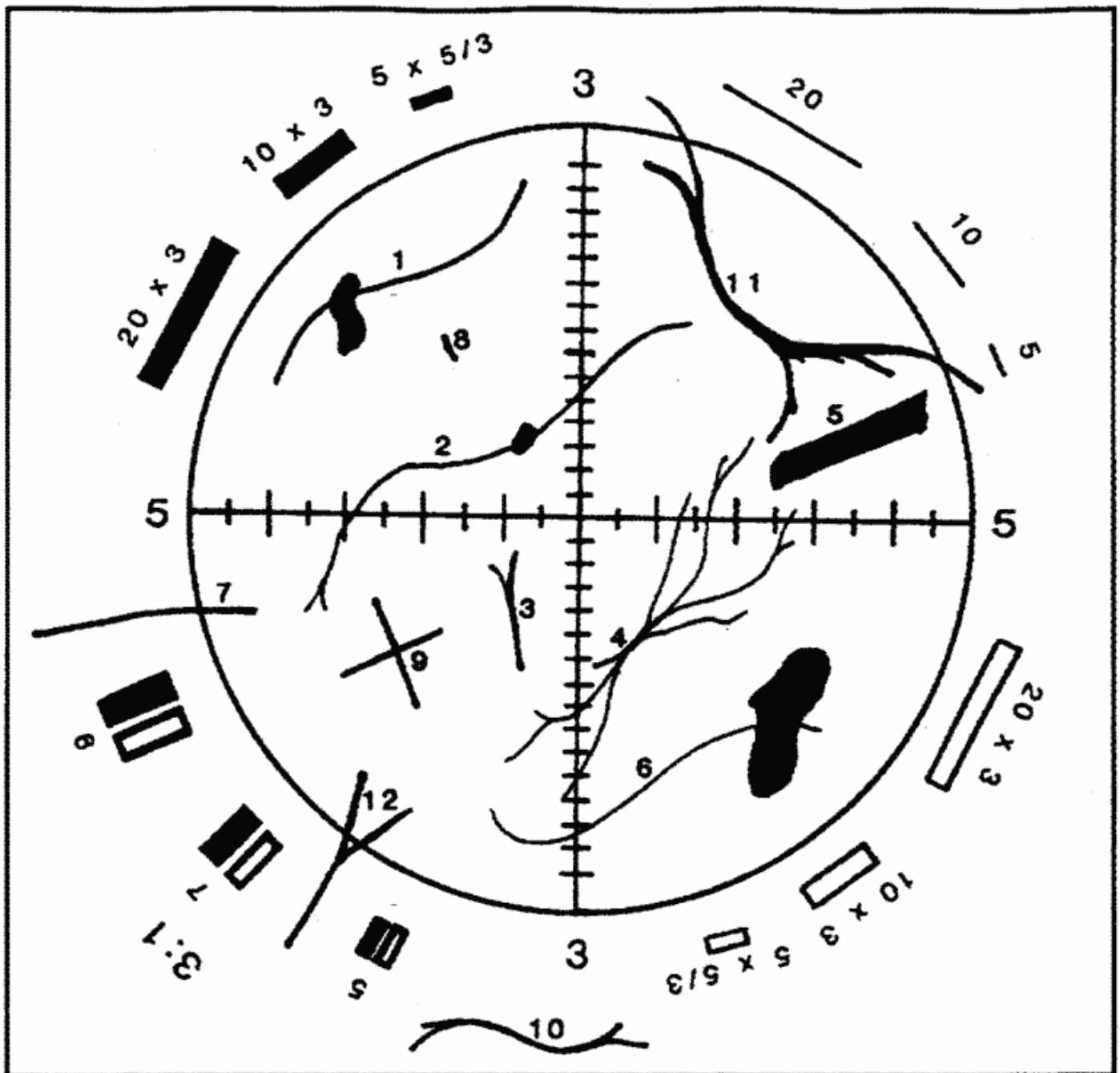
Measure the field diameter,  $D$  (acceptable range:  $100 \pm 2 \mu\text{m}$ ) with a stage micrometer upon receipt of the graticule from the manufacturer. Determine the field area ( $\text{mm}^2$ ).

$$\text{Field Area} = \pi(D/2)^2$$

If  $D = 100 \mu\text{m} = 0.1 \text{ mm}$ , then

$$\text{Field Area} = \pi(0.1 \text{ mm}/2)^2 = 0.00785 \text{ mm}^2$$

The Graticule is available from: Graticules Ltd., Morley Road, Tonbridge TN9 1RN, Kent, England (Telephone 011-44-732-359061). Also available from PTR Optics Ltd., 145 Newton Street, Waltham, MA 02154 [telephone (617) 891-6000] or McCrone Accessories and Components, 2506 S. Michigan Ave., Chicago, IL 60616 [phone (312) 842-7100]. The graticule is custom made for each microscope.



**Figure 1: Walton-Beckett Graticule with some explanatory fibers.**

Counts for the Fibers in the Figure

Structure No.	Count	Explanation
1 to 6	1	Single fibers all contained within the circle.
7	$\frac{1}{2}$	Fiber crosses circle once.
8	0	Fiber too short.
9	2	Two crossing fibers.
10	0	Fiber outside graticule.

Structure No.	Count	Explanation
11	0	Fiber crosses graticule twice.
12	<sup>1</sup> / <sub>2</sub>	Although split, fiber only crosses once.

## Appendix C to § 1915.1001—Qualitative and Quantitative Fit Testing Procedures. Mandatory

Employers must perform fit testing in accordance with the fit-testing requirements of 29 CFR 1910.134(f) and the qualitative and quantitative fit-testing protocols and procedures specified in Appendix A of 29 CFR 1910.134.

## Appendix D to § 1915.1001—Medical Questionnaires. Mandatory

This mandatory appendix contains the medical questionnaires that must be administered to all employees who are exposed to asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals above the permissible exposure limit (0.1 f/cc), and who will therefore be included in their employer's medical surveillance program. Part 1 of the appendix contains the Initial Medical Questionnaire, which must be obtained for all new hires who will be covered by the medical surveillance requirements. Part 2 includes the abbreviated Periodical Medical Questionnaire, which must be administered to all employees who are provided periodic medical examinations under the medical surveillance provisions of the standard.

## APPENDIX D TO § 1915.1001—MEDICAL QUESTIONNAIRES; MANDATORY

This mandatory appendix contains the medical questionnaires that must be administered to all employees who are exposed to asbestos, tremolite, anthophyllite, actinolite, or a combination of these minerals above the permissible exposure limit (0.1 f/cc), and who will therefore be included in their employer's medical surveillance program. Part 1 of this appendix contains the Initial Medical Questionnaire, which must be obtained for all new hires who will be covered by the medical surveillance requirements. Part 2 includes the abbreviated Periodical Medical Questionnaire, which must be administered to all employees who are provided periodic medical examinations under the medical surveillance provisions of the standard in this section.

### Part 1 INITIAL MEDICAL QUESTIONNAIRE

1. NAME \_\_\_\_\_
2. CLOCK NUMBER \_\_\_\_\_
3. PRESENT OCCUPATION \_\_\_\_\_
4. PLANT \_\_\_\_\_
5. ADDRESS \_\_\_\_\_
6. \_\_\_\_\_  
(Zip Code)
7. TELEPHONE NUMBER \_\_\_\_\_
8. INTERVIEWER \_\_\_\_\_
9. DATE \_\_\_\_\_



12. Sex 1. Male \_\_\_\_\_  
2. Female \_\_\_\_\_

13. What is your marital status?      1. Single \_\_\_\_\_      4. Separated/  
2. Married \_\_\_\_\_      Divorced \_\_\_\_\_  
3. Widowed \_\_\_\_\_

14. Race (Check all that apply)

1. White \_\_\_\_\_
2. Black or African American \_\_\_\_\_
3. Asian \_\_\_\_\_
4. Hispanic or Latino \_\_\_\_\_
5. American Indian  
or Alaska Native \_\_\_\_\_
6. Native Hawaiian or  
Other Pacific Islander \_\_\_\_\_

15. What is the highest grade completed in school? \_\_\_\_\_  
(For example 12 years is completion of high school)

## OCCUPATIONAL HISTORY

16A. Have you ever worked full time (30 hours per week or more) for 6 months or more? 1. Yes \_\_\_\_ 2. No \_\_\_\_

IF YES TO 16A:

B. Have you ever worked for a year or more in any dusty job? 1. Yes \_\_\_\_ 2. No \_\_\_\_  
3. Does Not Apply \_\_\_\_

Specify job/industry	Total Years Worked
1. _____	_____
2. _____	_____
3. _____	_____
4. _____	_____
5. _____	_____
6. _____	_____
7. _____	_____
8. _____	_____
9. _____	_____
10. _____	_____
11. _____	_____
12. _____	_____
13. _____	_____
14. _____	_____
15. _____	_____
16. _____	_____
17. _____	_____
18. _____	_____
19. _____	_____
20. _____	_____
21. _____	_____
22. _____	_____
23. _____	_____
24. _____	_____
25. _____	_____
26. _____	_____
27. _____	_____
28. _____	_____
29. _____	_____
30. _____	_____
31. _____	_____
32. _____	_____
33. _____	_____
34. _____	_____
35. _____	_____
36. _____	_____
37. _____	_____
38. _____	_____
39. _____	_____
40. _____	_____
41. _____	_____
42. _____	_____
43. _____	_____
44. _____	_____
45. _____	_____
46. _____	_____
47. _____	_____
48. _____	_____
49. _____	_____
50. _____	_____

Was dust exposure:                      1. Mild              2. Moderate              3. Severe

C. Have you ever been exposed to gas or chemical fumes in your work? 1. Yes \_\_\_\_ 2. No \_\_\_\_

Specify job/industry	Total Years Worked
1. _____	_____
2. _____	_____
3. _____	_____
4. _____	_____
5. _____	_____
6. _____	_____
7. _____	_____
8. _____	_____
9. _____	_____
10. _____	_____
11. _____	_____
12. _____	_____
13. _____	_____
14. _____	_____
15. _____	_____
16. _____	_____
17. _____	_____
18. _____	_____
19. _____	_____
20. _____	_____
21. _____	_____
22. _____	_____
23. _____	_____
24. _____	_____
25. _____	_____
26. _____	_____
27. _____	_____
28. _____	_____
29. _____	_____
30. _____	_____
31. _____	_____
32. _____	_____
33. _____	_____
34. _____	_____
35. _____	_____
36. _____	_____
37. _____	_____
38. _____	_____
39. _____	_____
40. _____	_____
41. _____	_____
42. _____	_____
43. _____	_____
44. _____	_____
45. _____	_____
46. _____	_____
47. _____	_____
48. _____	_____
49. _____	_____
50. _____	_____

D. What has been your usual occupation or job—the one you have worked at the longest?

1. Job occupation \_\_\_\_\_

2. Number of years employed in this occupation \_\_\_\_\_

3. Position/job title \_\_\_\_\_

4. Business, field or industry \_\_\_\_\_

(Record on lines the years in which you have worked in any of these industries, e.g. 1960-1969)

Have you ever worked:	YES	NO
E. In a mine? .....	_____	_____
F. In a quarry? .....	_____	_____
G. In a foundry? .....	_____	_____
H. In a pottery? .....	_____	_____
I. In a cotton, flax or hemp mill?....	_____	_____
J. With asbestos? .....	_____	_____

17. <u>PAST MEDICAL HISTORY</u>	YES	NO
---------------------------------	-----	----

A. Do you consider yourself to be in good health?	_____	_____
---	-------	-------

If "NO" state reason \_\_\_\_\_

B. Have you any defect of vision?	_____	_____
-----------------------------------	-------	-------

If "YES" state nature of defect \_\_\_\_\_

C. Have you any hearing defect?	_____	_____
---------------------------------	-------	-------

If "YES" state nature of defect \_\_\_\_\_

D. Are you suffering from or  
 have you ever suffered  
 from:

YES

NO

a. Epilepsy (or fits, seizures,  
 convulsions)?

\_\_\_\_\_

\_\_\_\_\_

b. Rheumatic fever?

\_\_\_\_\_

\_\_\_\_\_

c. Kidney disease?

\_\_\_\_\_

\_\_\_\_\_

d. Bladder disease?

\_\_\_\_\_

\_\_\_\_\_

e. Diabetes?

\_\_\_\_\_

\_\_\_\_\_

f. Jaundice?

\_\_\_\_\_

\_\_\_\_\_

## 18. CHEST COLDS AND CHEST ILLNESSES

18A. If you get a cold, does it "usually"  
 go to your chest? (Usually means more  
 than 1/2 the time)

1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_

3. Don't get colds \_\_\_\_\_

19A. During the past 3 years, have you  
 had any chest illnesses that have kept you  
 off work, indoors at home, or in bed?

1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_

IF YES TO 19A:

B. Did you produce phlegm with any of  
 these chest illnesses?

1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_

3. Does Not Apply \_\_\_\_\_

C. In the last 3 years, how many such  
 illnesses with (increased) phlegm did you  
 have which lasted a week or more?

Number of illnesses \_\_\_\_\_

No such illnesses \_\_\_\_\_

20. Did you have any lung trouble before the

1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_

21. Have you ever had any of the following?

1A. Attacks of bronchitis?

1. Yes \_\_\_\_ 2. No \_\_\_\_

IF YES TO 1A:

B. Was it confirmed by a doctor?

1. Yes \_\_\_\_ 2. No \_\_\_\_  
3. Does Not Apply \_\_\_\_

C. At what age was your first attack?

Age in Years \_\_\_\_  
Does Not Apply \_\_\_\_

2A. Pneumonia (include  
bronchopneumonia)?

1. Yes \_\_\_\_ 2. No \_\_\_\_

IF YES TO 2A:

B. Was it confirmed by a doctor?

1. Yes \_\_\_\_ 2. No \_\_\_\_  
3. Does Not Apply \_\_\_\_

C. At what age did you first have it?

Age in Years \_\_\_\_  
Does Not Apply \_\_\_\_

3A. Hay Fever?

1. Yes \_\_\_\_ 2. No \_\_\_\_

IF YES TO 3A:

B. Was it confirmed by a doctor?

1. Yes \_\_\_\_ 2. No \_\_\_\_  
3. Does Not Apply \_\_\_\_

C. At what age did it start?

Age in Years \_\_\_\_  
Does Not Apply \_\_\_\_

22A. Have you ever had chronic bronchitis?

1. Yes \_\_\_\_ 2. No \_\_\_\_

IF YES TO 22A:

B. Do you still have it?

1. Yes \_\_\_\_ 2. No \_\_\_\_  
3. Does Not Apply \_\_\_\_

D. At what age did it start?

Age in Years \_\_\_\_\_  
Does Not Apply \_\_\_\_\_

23A. Have you ever had emphysema?

1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_

IF YES TO 23A:

B. Do you still have it?

1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_  
3. Does Not Apply \_\_\_\_\_

C. Was it confirmed by a doctor?

1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_  
3. Does Not Apply \_\_\_\_\_

D. At what age did it start?

Age in Years \_\_\_\_\_  
Does Not Apply \_\_\_\_\_

24A. Have you ever had asthma?

1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_

IF YES TO 24A:

B. Do you still have it?

1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_  
3. Does Not Apply \_\_\_\_\_

C. Was it confirmed by a doctor?

1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_  
3. Does Not Apply \_\_\_\_\_

D. At what age did it start?

Age in Years \_\_\_\_\_  
Does Not Apply \_\_\_\_\_

E. If you no longer have it, at what age did it stop?

Age stopped \_\_\_\_\_  
Does Not Apply \_\_\_\_\_

25. Have you ever had:

A. Any other chest illness?

1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_

B. Any chest operations?

1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_

C. Any chest injuries?

1. Yes \_\_\_\_

2. No \_\_\_\_

If yes, please specify \_\_\_\_\_

26A. Has a doctor ever told  
you that you had heart  
trouble?

1. Yes \_\_\_\_

2. No \_\_\_\_

IF YES TO 26A:

B. Have you ever had  
treatment for heart  
trouble in the past 10  
years?

1. Yes \_\_\_\_

2. No \_\_\_\_

3. Does Not Apply \_\_\_\_

27A. Has a doctor told you  
that you had high blood  
pressure?

1. Yes \_\_\_\_

2. No \_\_\_\_

IF YES TO 27A:

B. Have you had any  
treatment for high  
blood pressure  
(hypertension) in the  
past 10 years?

1. Yes \_\_\_\_

2. No \_\_\_\_

3. Does Not Apply \_\_\_\_

28. When did you last have your chest X-rayed?

(Year) \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_

29. Where did you last have  
your chest X-rayed (if  
known)?

\_\_\_\_\_

What was the outcome?

\_\_\_\_\_

## FAMILY HISTORY

	FATHER			MOTHER		
30. Were either of your natural parents ever told by a doctor that they had a chronic lung condition such as:	1. Yes	2. No	3. Don't know	1. Yes	2. No	3. Don't know
A. Chronic Bronchitis?	_____	_____	_____	_____	_____	_____
B. Emphysema?	_____	_____	_____	_____	_____	_____
C. Asthma?	_____	_____	_____	_____	_____	_____
D. Lung cancer?	_____	_____	_____	_____	_____	_____
E. Other chest conditions?	_____	_____	_____	_____	_____	_____
F. Is parent currently alive?	_____	_____	_____	_____	_____	_____
G. Please Specify	_____ Age if Living			_____ Age if Living		
	_____ Age at Death			_____ Age at Death		
	_____ Don't Know			_____ Don't Know		
H. Please specify cause of death	_____			_____		

## COUGH

31A. Do you usually have a cough? (Count a cough with first smoke or on first going out of doors. Exclude clearing of throat.) (If no, skip to question 31C.)	1. Yes _____	2. No _____
29 CFR 1915.1001(p)(2) (enhanced display)		
B. Do you usually cough as much as 4 to 6 times a day 4 or more days out of the	1. Yes _____	2. No _____

D. Do you usually cough at all during the rest of the day or at night?

1. Yes \_\_\_\_ 2. No \_\_\_\_

IF YES TO ANY OF ABOVE (31A, B, C, OR D), ANSWER THE FOLLOWING. IF NO TO ALL, CHECK "DOES NOT APPLY" AND SKIP TO NEXT PAGE

E. Do you usually cough like this on most days for 3 consecutive months or more during the year?

1. Yes \_\_\_\_ 2. No \_\_\_\_  
3. Does not apply \_\_\_\_

F. For how many years have you had the cough?

Number of years \_\_\_\_  
Does not apply \_\_\_\_

32A. Do you usually bring up phlegm from your chest?  
Count phlegm with the first smoke or on first going out of doors. Exclude phlegm from the nose. Count swallowed phlegm.)  
(If no, skip to 32C)

1. Yes \_\_\_\_ 2. No \_\_\_\_

B. Do you usually bring up phlegm like this as much as twice a day 4 or more days out of the week?

1. Yes \_\_\_\_ 2. No \_\_\_\_

C. Do you usually bring up phlegm at all on getting up or first thing in the morning?

1. Yes \_\_\_\_ 2. No \_\_\_\_

D. Do you usually bring up phlegm at all on during the rest of the day or at night?

1. Yes \_\_\_\_ 2. No \_\_\_\_

IF YES TO ANY OF THE ABOVE (32A, B, C, OR D), ANSWER THE FOLLOWING:

IF NO TO ALL, CHECK "DOES NOT APPLY" AND SKIP TO 33A

E. Do you bring up phlegm like this on most days for 3 consecutive months or more during the year?

1. Yes \_\_\_\_ 2. No \_\_\_\_  
3. Does not apply \_\_\_\_

29 CFR 1915.1001(p)(2) (enhanced display)  
F. For how many years have you had trouble with phlegm?

Number of years \_\_\_\_  
Does not apply \_\_\_\_



## EPISODES OF COUGH AND PHLEGM

33A. Have you had periods or episodes of (increased\*) cough and phlegm lasting for 3 weeks or more each year?

\*(For persons who usually have cough and/or phlegm)

1. Yes \_\_\_\_ 2. No \_\_\_\_

IF YES TO 33A

B. For how long have you had at least 1 such episode per year?

Number of years \_\_\_\_  
Does not apply \_\_\_\_

## WHEEZING

34A. Does your chest ever sound wheezy or whistling

1. When you have a cold?

1. Yes \_\_\_\_ 2. No \_\_\_\_

2. Occasionally apart from colds?

1. Yes \_\_\_\_ 2. No \_\_\_\_

3. Most days or nights?

1. Yes \_\_\_\_ 2. No \_\_\_\_

B. For how many years has this been present?

Number of years \_\_\_\_  
Does not apply \_\_\_\_

35A. Have you ever had an attack of wheezing that has made you feel short of breath?

1. Yes \_\_\_\_ 2. No \_\_\_\_

IF YES TO 35A

B. How old were you when you had your first such attack?

Age in years \_\_\_\_  
Does not apply \_\_\_\_

C. Have you had 2 or more such episodes?

1. Yes \_\_\_\_ 2. No \_\_\_\_  
3. Does not apply \_\_\_\_

## BREATHLESSNESS

36. If disabled from walking by any condition other than heart or lung disease, please describe and proceed to question 38A.

Nature of condition(s)

\_\_\_\_\_  
\_\_\_\_\_

37A. Are you troubled by shortness of breath when hurrying on the level or walking up a slight hill?

1. Yes \_\_\_\_ 2. No \_\_\_\_

IF YES TO 37A

B. Do you have to walk slower than people of your age on the level because of breathlessness?

1. Yes \_\_\_\_ 2. No \_\_\_\_  
3. Does not apply \_\_\_\_

C. Do you ever have to stop for breath when walking at your own pace on the level?

1. Yes \_\_\_\_ 2. No \_\_\_\_  
3. Does not apply \_\_\_\_

D. Do you ever have to stop for breath after walking about 100 yards (or after a few minutes) on the level?

1. Yes \_\_\_\_ 2. No \_\_\_\_  
3. Does not apply \_\_\_\_

E. Are you too breathless to leave the house or breathless on dressing or climbing one flight of stairs?

1. Yes \_\_\_\_ 2. No \_\_\_\_  
3. Does not apply \_\_\_\_

## TOBACCO SMOKING

38A. Have you ever smoked cigarettes?  
(No means less than 20 packs of cigarettes or 12 oz. of tobacco in a lifetime or less than 1 cigarette a day for 1 year.)

1. Yes \_\_\_\_ 2. No \_\_\_\_

IF YES TO 38A

C. How old were you when you first started regular cigarette smoking? Age in years \_\_\_\_  
Does not apply \_\_\_\_

D. If you have stopped smoking cigarettes completely, how old were you when you stopped? Age stopped \_\_\_\_  
Check if still smoking \_\_\_\_  
Does not apply \_\_\_\_

E. How many cigarettes do you smoke per day now? Cigarettes per day \_\_\_\_  
Does not apply \_\_\_\_

F. On the average of the entire time you smoked, how many cigarettes did you smoke per day? Cigarettes per day \_\_\_\_  
Does not apply \_\_\_\_

G. Do or did you inhale the cigarette smoke? 1. Does not apply \_\_\_\_  
2. Not at all \_\_\_\_  
3. Slightly \_\_\_\_  
4. Moderately \_\_\_\_  
5. Deeply \_\_\_\_

39A. Have you ever smoked a pipe regularly? 1. Yes \_\_\_\_ 2. No \_\_\_\_  
(Yes means more than 12 oz. of tobacco in a lifetime.)

IF YES TO 39A

FOR PERSONS WHO HAVE EVER SMOKED A PIPE

B. 1. How old were you when you started to smoke a pipe regularly? Age \_\_\_\_

2. If you have stopped smoking a pipe completely, how old were you when you stopped? Age stopped \_\_\_\_  
Check if still smoking pipe \_\_\_\_  
Does not apply \_\_\_\_

C. On the average over the entire time you smoked a pipe, how much pipe tobacco did you smoke per week? \_\_\_\_\_ oz. per week (a standard pouch of tobacco contains 1 1/2 oz.)  
\_\_\_\_\_ Does not apply

D. How much pipe tobacco are you smoking now? \_\_\_\_\_ oz. per week  
Not currently smoking a pipe \_\_\_\_\_

E. Do you or did you inhale the pipe smoke?  
1. Never smoked \_\_\_\_\_  
2. Not at all \_\_\_\_\_  
3. Slightly \_\_\_\_\_  
4. Moderately \_\_\_\_\_  
5. Deeply \_\_\_\_\_

40A. Have you ever smoked cigars regularly? 1. Yes \_\_\_\_\_ 2. No \_\_\_\_\_

(Yes means more than 1 cigar a week for a year)

IF YES TO 40A

FOR PERSONS WHO HAVE EVER SMOKED A CIGAR

B. 1. How old were you when you started smoking cigars regularly? Age \_\_\_\_\_

2. If you have stopped smoking cigars completely, how old were you when you stopped smoking cigars? Age stopped \_\_\_\_\_  
Check if still \_\_\_\_\_  
Does not apply \_\_\_\_\_

C. On the average over the entire time you smoked cigars, how many cigars did you smoke per week? Cigars per week \_\_\_\_\_  
Does not apply \_\_\_\_\_

D. How many cigars are you Cigars per week \_\_\_\_\_

smoke?

- 2. Not at all \_\_\_\_\_
- 3. Slightly \_\_\_\_\_
- 4. Moderately \_\_\_\_\_
- 5. Deeply \_\_\_\_\_

Signature \_\_\_\_\_ Date \_\_\_\_\_



11F. In the past year,  
what was your:

1. Job/occupation? \_\_\_\_\_  
2. Position/job title? \_\_\_\_\_

## 12. RECENT MEDICAL HISTORY

12A. Do you consider yourself to  
be in good health? Yes \_\_\_\_ No \_\_\_\_

If NO, state reason \_\_\_\_\_

12B. In the past year, have you developed:

	<u>Yes</u>	<u>No</u>
Epilepsy?	____	____
Rheumatic fever?	____	____
Kidney disease?	____	____
Bladder disease?	____	____
Diabetes?	____	____
Jaundice?	____	____
Cancer?	____	____

## 13. CHEST COLDS AND CHEST ILLNESSES

13A. If you get a cold, does it "usually" go to your chest? (usually means more than 1/2 the time)

1. Yes \_\_\_\_ 2. No \_\_\_\_  
3. Don't get colds \_\_\_\_

14A. During the past year, have you had  
any chest illnesses that have kept you  
off work, indoors at home, or in bed?

1. Yes \_\_\_\_ 2. No \_\_\_\_  
3. Does Not Apply \_\_\_\_

IF YES TO 14A:

14B. Did you produce phlegm with any  
of these chest illnesses?

1. Yes \_\_\_\_ 2. No \_\_\_\_  
3. Does Not Apply \_\_\_\_

14C. In the past year, how many such  
illnesses with (increased) phlegm  
did you have which lasted a week  
or more?

Number of illnesses \_\_\_\_  
No such illnesses \_\_\_\_

## 15. RESPIRATORY SYSTEM

In the past year have you had:

	<u>Yes or No</u>	<u>Further Comment on Positive</u> <u>Answers</u>
Asthma	_____	
Bronchitis	_____	
Hay Fever	_____	
Other Allergies	_____	

	<u>Yes or No</u>	<u>Further Comment on Positive</u> <u>Answers</u>
Pneumonia	_____	
Tuberculosis	_____	
Chest Surgery	_____	
Other Lung Problems	_____	
Heart Disease	_____	
Do you have:		

	<u>Yes or No</u>	<u>Further Comment on Positive</u> <u>Answers</u>
Frequent colds	_____	
Chronic cough	_____	
Shortness of breath when walking or climbing one flight or stairs	_____	
Do you:		
Wheeze	_____	
Cough up phlegm	_____	
Smoke cigarettes	_____	Packs per day _____ How many years _____

Date \_\_\_\_\_ Signature \_\_\_\_\_



## Appendix E to § 1915.1001—Classification of Chest X-Rays. Mandatory

- (a) Chest X-rays shall be classified in accordance with the Guidelines for the use of the ILO International Classification of Radiographs of Pneumoconioses (revised edition 2011) (incorporated by reference, see § 1915.5), and recorded on a classification form following the format of the CDC/NIOSH (M) 2.8 form. As a minimum, the content within the bold lines of this form (items 1 through 4) shall be included. This form is not to be submitted to NIOSH.
- (b) All X-rays shall be classified only by a B-Reader, a board eligible/certified radiologist, or an experienced physician with known expertise in pneumoconioses.
- (c) Whenever classifying chest X-ray film, the physician shall have immediately available for reference a complete set of the ILO standard format radiographs provided for use with the Guidelines for the use of the ILO International Classification of Radiographs of Pneumoconioses (revised edition 2011).
- (d) Whenever classifying digitally-acquired chest X-rays, the physician shall have immediately available for reference a complete set of ILO standard digital chest radiographic images provided for use with the Guidelines for the Use of the ILO International Classification of Radiographs of Pneumoconioses (revised edition 2011). Classification of digitally-acquired chest X-rays shall be based on the viewing of images displayed as electronic copies and shall not be based on the viewing of hard copy printed transparencies of images.

## Appendix F to § 1915.1001—Work Practices and Engineering Controls for Class I Asbestos Operations Non-Mandatory

This is a non-mandatory appendix to the asbestos standards for construction and for shipyards. It describes criteria and procedures for erecting and using negative pressure enclosures for Class I Asbestos Work, when NPEs are used as an allowable control method to comply with paragraph (g)(5)(i) of this section. Many small and variable details are involved in the erection of a negative pressure enclosure. OSHA and most participants in the rulemaking agreed that only the major, more performance oriented criteria should be made mandatory. These criteria are set out in paragraph (g) of this section. In addition, this appendix includes these mandatory specifications and procedures in its guidelines in order to make this appendix coherent and helpful. The mandatory nature of the criteria which appear in the regulatory text is not changed because they are included in this “non-mandatory” appendix. Similarly, the additional criteria and procedures included as guidelines in the appendix, do not become mandatory because mandatory criteria are also included in these comprehensive guidelines.

In addition, none of the criteria, both mandatory and recommended, are meant to specify or imply the need for use of patented or licensed methods or equipment. Recommended specifications included in this attachment should not discourage the use of creative alternatives which can be shown to reliably achieve the objectives of negative-pressure enclosures.

Requirements included in this appendix, cover general provisions to be followed in all asbestos jobs, provisions which must be followed for all Class I asbestos jobs, and provisions governing the construction and testing of negative pressure enclosures. The first category includes the requirement for use of wet methods, HEPA vacuums, and immediate bagging of waste; Class I work must conform to the following provisions:

- oversight by competent person

- use of critical barriers over all openings to work area
- isolation of HVAC systems
- use of impermeable dropcloths and coverage of all objects within regulated areas

In addition, more specific requirements for NPEs include:

- maintenance of -0.02 inches water gauge within enclosure
- manometric measurements
- air movement away from employees performing removal work
- smoke testing or equivalent for detection of leaks and air direction
- deactivation of electrical circuits, if not provided with ground-fault circuit interrupters.

## Planning the Project

The standard requires that an exposure assessment be conducted before the asbestos job is begun § 1915.1001(f)(1). Information needed for that assessment, includes data relating to prior similar jobs, as applied to the specific variables of the current job. The information needed to conduct the assessment will be useful in planning the project, and in complying with any reporting requirements under this standard, when significant changes are being made to a control system listed in the standard, [see paragraph (k) of this section], as well as those of USEPA (40 CFR part 61, subpart M). Thus, although the standard does not explicitly require the preparation of a written asbestos removal plan, the usual constituents of such a plan, i.e., a description of the enclosure, the equipment, and the procedures to be used throughout the project, must be determined before the enclosure can be erected. The following information should be included in the planning of the system:

A physical description of the work area;

A description of the approximate amount of material to be removed;

A schedule for turning off and sealing existing ventilation systems;

Personnel hygiene procedures;

A description of personal protective equipment and clothing to worn by employees;

A description of the local exhaust ventilation systems to be used and how they are to be tested;

A description of work practices to be observed by employees;

An air monitoring plan;

A description of the method to be used to transport waste material; and

The location of the dump site.

## Materials and Equipment Necessary for Asbestos Removal

Although individual asbestos removal projects vary in terms of the equipment required to accomplish the removal of the materials, some equipment and materials are common to most asbestos removal operations.

Plastic sheeting used to protect horizontal surfaces, seal HVAC openings or to seal vertical openings and ceilings should have a minimum thickness of 6 mils. Tape or other adhesive used to attach plastic sheeting should be of sufficient adhesive strength to support the weight of the material plus all stresses encountered during the entire duration of the project without becoming detached from the surface.

Other equipment and materials which should be available at the beginning of each project are:

- HEPA Filtered Vacuum is essential for cleaning the work area after the asbestos has been removed. It should have a long hose capable of reaching out-of-the-way places, such as areas above ceiling tiles, behind pipes, etc.

- Portable air ventilation systems installed to provide the negative air pressure and air removal from the enclosure must be equipped with a HEPA filter. The number and capacity of units required to ventilate an enclosure depend on the size of the area to be ventilated. The filters for these systems should be designed in such a manner that they can be replaced when the air flow volume is reduced by the build-up of dust in the filtration material. Pressure monitoring devices with alarms and strip chart recorders attached to each system to indicate the pressure differential and the loss due to dust buildup on the filter are recommended.

- Water sprayers should be used to keep the asbestos material as saturated as possible during removal; the sprayers will provide a fine mist that minimizes the impact of the spray on the material.

- Water used to saturate the asbestos containing material can be amended by adding at least 15 milliliters ( $\frac{1}{4}$  ounce) of wetting agent in 1 liter (1 pint) of water. An example of a wetting agent is a 50/50 mixture of polyoxyethylene ether and polyoxyethylene polyglycol ester.

- Backup power supplies are recommended, especially for ventilation systems.

- Shower and bath water should be with mixed hot and cold water faucets. Water that has been used to clean personnel or equipment should either be filtered or be collected and discarded as asbestos waste. Soap and shampoo should be provided to aid in removing dust from the workers' skin and hair.

- See paragraphs (h) and (i) of this section for appropriate respiratory protection and protective clothing.

- See paragraph (k) of this section for required signs and labels.

## Preparing the Work Area

**Disabling HVAC Systems:** The power to the heating, ventilation, and air conditioning systems that service the restricted area must be deactivated and locked off. All ducts, grills, access ports, windows and vents must be sealed off with two layers of plastic to prevent entrainment of contaminated air.

**Operating HVAC Systems in the Restricted Area:** If components of a HVAC system located in the restricted area are connected to a system that will service another zone during the project, the portion of the duct in the restricted area must be sealed and pressurized. Necessary precautions include caulking the duct joints, covering all cracks and openings with two layers of sheeting, and pressurizing the duct throughout the duration of the project by restricting the return air flow. The power to the fan supplying the positive pressure should be locked "on" to prevent pressure loss.

**Sealing Elevators:** If an elevator shaft is located in the restricted area, it should be either shut down or isolated by sealing with two layers of plastic sheeting. The sheeting should provide enough slack to accommodate the pressure changes in the shaft without breaking the air-tight seal.

**Removing Mobile Objects:** All movable objects should be cleaned and removed from the work area before an enclosure is constructed unless moving the objects creates a hazard. Mobile objects will be assumed to be contaminated and should be either cleaned with amended water and a HEPA vacuum and then removed from the area or wrapped and then disposed of as hazardous waste.

**Cleaning and Sealing Surfaces:** After cleaning with water and a HEPA vacuum, surfaces of stationary objects should be covered with two layers of plastic sheeting. The sheeting should be secured with duct tape or an equivalent method to provide a tight seal around the object.

**Bagging Waste:** In addition to the requirement for immediate bagging of waste for disposal, it is further recommended that the waste material be double-bagged and sealed in plastic bags designed for asbestos disposal. The bags should be stored in a waste storage area that can be controlled by the workers conducting the removal. Filters removed from air handling units and rubbish removed from the area are to be bagged and handled as hazardous waste.

## Constructing the Enclosure

The enclosure should be constructed to provide an air-tight seal around ducts and openings into existing ventilation systems and around penetrations for electrical conduits, telephone wires, water lines, drain pipes, etc. Enclosures should be both airtight and watertight except for those openings designed to provide entry and/or air flow control.

**Size:** An enclosure should be the minimum volume to encompass all of the working surfaces yet allow unencumbered movement by the worker(s), provide unrestricted air flow past the worker(s), and ensure walking surfaces can be kept free of tripping hazards.

**Shape:** The enclosure may be any shape that optimizes the flow of ventilation air past the worker(s).

**Structural Integrity:** The walls, ceilings and floors must be supported in such a manner that portions of the enclosure will not fall down during normal use.

Openings: It is not necessary that the structure be airtight; openings may be designed to direct air flow. Such openings should be located at a distance from active removal operations. They should be designed to draw air into the enclosure under all anticipated circumstances. In the event that negative pressure is lost, they should be fitted with either HEPA filters to trap dust or automatic trap doors that prevent dust from escaping the enclosure. Openings for exits should be controlled by an airlock or a vestibule.

Barrier Supports: Frames should be constructed to support all unsupported spans of sheeting.

Sheeting: Walls, barriers, ceilings, and floors should be lined with two layers of plastic sheeting having a thickness of at least 6 mil.

Seams: Seams in the sheeting material should be minimized to reduce the possibilities of accidental rips and tears in the adhesive or connections. All seams in the sheeting should overlap, be staggered and not be located at corners or wall-to-floor joints. Areas Within an Enclosure: Each enclosure consists of a work area, a decontamination area, and waste storage area. The work area where the asbestos removal operations occur should be separated from both the waste storage area and the contamination control area by physical curtains, doors, and/or airflow patterns that force any airborne contamination back into the work area.

See paragraph (j) of § 1915.1001 for requirements for hygiene facilities.

During egress from the work area, each worker should step into the equipment room, clean tools and equipment, and remove gross contamination from clothing by wet cleaning and HEPA vacuuming. Before entering the shower area, foot coverings, head coverings, hand coverings, and coveralls are removed and placed in impervious bags for disposal or cleaning. Airline connections from airline respirators with HEPA disconnects and power cables from powered air-purifying respirators (PAPRs) will be disconnected just prior to entering the shower room.

## Establishing Negative Pressure Within the Enclosure

Negative Pressure: Air is to be drawn into the enclosure under all anticipated conditions and exhausted through a HEPA filter for 24 hours a day during the entire duration of the project.

Air Flow Tests: Air flow patterns will be checked before removal operations begin, at least once per operating shift and any time there is a question regarding the integrity of the enclosure. The primary test for air flow is to trace air currents with smoke tubes or other visual methods. Flow checks are made at each opening and at each doorway to demonstrate that air is being drawn into the enclosure and at each worker's position to show that air is being drawn away from the breathing zone.

Monitoring Pressure Within the Enclosure: After the initial air flow patterns have been checked, the static pressure must be monitored within the enclosure. Monitoring may be made using manometers, pressure gauges, or combinations of these devices. It is recommended that they be attached to alarms and strip chart recorders at points identified by the design engineer.

Corrective Actions: If the manometers or pressure gauges demonstrate a reduction in pressure differential below the required level, work should cease and the reason for the change investigated and appropriate changes made. The air flow patterns should be retested before work begins again.

**Pressure Differential:** The design parameters for static pressure differentials between the inside and outside of enclosures typically range from 0.02 to 0.10 inches of water gauge, depending on conditions. All zones inside the enclosure must have less pressure than the ambient pressure outside of the enclosure (–0.02 inches water gauge differential). Design specifications for the differential vary according to the size, configuration, and shape of the enclosure as well as ambient and mechanical air pressure conditions around the enclosure.

**Air Flow Patterns:** The flow of air past each worker shall be enhanced by positioning the intakes and exhaust ports to remove contaminated air from the worker's breathing zone, by positioning HEPA vacuum cleaners to draw air from the worker's breathing zone, by forcing relatively uncontaminated air past the worker toward an exhaust port, or by using a combination of methods to reduce the worker's exposure.

**Air Handling Unit Exhaust:** The exhaust plume from air handling units should be located away from adjacent personnel and intakes for HVAC systems.

**Air Flow Volume:** The air flow volume (cubic meters per minute) exhausted (removed) from the workplace must exceed the amount of makeup air supplied to the enclosure. The rate of air exhausted from the enclosure should be designed to maintain a negative pressure in the enclosure and air movement past each worker. The volume of air flow removed from the enclosure should replace the volume of the container at every 5 to 15 minutes. Air flow volume will need to be relatively high for large enclosures, enclosures with awkward shapes, enclosures with multiple openings, and operations employing several workers in the enclosure.

**Air Flow Velocity:** At each opening, the air flow velocity must visibly “drag” air into the enclosure. The velocity of air flow within the enclosure must be adequate to remove airborne contamination from each worker's breathing zone without disturbing the asbestos-containing material on surfaces.

**Airlocks:** Airlocks are mechanisms on doors and curtains that control the air flow patterns in the doorways. If air flow occurs, the patterns through doorways must be such that the air flows toward the inside of the enclosure. Sometimes vestibules, double doors, or double curtains are used to prevent air movement through the doorways. To use a vestibule, a worker enters a chamber by opening the door or curtain and then closing the entry before opening the exit door or curtain.

Airlocks should be located between the equipment room and shower room, between the shower room and the clean room, and between the waste storage area and the outside of the enclosure. The air flow between adjacent rooms must be checked using smoke tubes or other visual tests to ensure the flow patterns draw air toward the work area without producing eddies.

## Monitoring for Airborne Concentrations

In addition to the breathing zone samples taken as outlined in paragraph (f) of § 1915.1001, samples of air should be taken to demonstrate the integrity of the enclosure, the cleanliness of the clean room and shower area, and the effectiveness of the HEPA filter. If the clean room is shown to be contaminated, the room must be relocated to an uncontaminated area.

Samples taken near the exhaust of portable ventilation systems must be done with care.

## General Work Practices

Preventing dust dispersion is the primary means of controlling the spread of asbestos within the enclosure. Whenever practical, the point of removal should be isolated, enclosed, covered, or shielded from the workers in the area. Waste asbestos containing materials must be bagged during or immediately after removal; the material must remain saturated until the waste container is sealed.

Waste material with sharp points or corners must be placed in hard air-tight containers rather than bags.

Whenever possible, large components should be sealed in plastic sheeting and removed intact.

Bags or containers of waste will be moved to the waste holding area, washed, and wrapped in a bag with the appropriate labels.

## Cleaning the Work Area

Surfaces within the work area should be kept free of visible dust and debris to the extent feasible. Whenever visible dust appears on surfaces, the surfaces within the enclosure must be cleaned by wiping with a wet sponge, brush, or cloth and then vacuumed with a HEPA vacuum.

All surfaces within the enclosure should be cleaned before the exhaust ventilation system is deactivated and the enclosure is disassembled. An approved encapsulant may be sprayed onto areas after the visible dust has been removed.

## Appendix G to § 1915.1001 [Reserved]

## Appendix H to § 1915.1001—Substance Technical Information for Asbestos. Non-Mandatory

### I. Substance Identification

A. Substance: “Asbestos” is the name of a class of magnesium-silicate minerals that occur in fibrous form. Minerals that are included in this group are chrysotile, crocidolite, amosite, anthophyllite asbestos, tremolite asbestos, and actinolite asbestos.

B. Asbestos is and was used in the manufacture of heat-resistant clothing, automotive brake and clutch linings, and a variety of building materials including floor tiles, roofing felts, ceiling tiles, asbestos-cement pipe and sheet, and fire-resistant drywall. Asbestos is also present in pipe and boiler insulation materials and in sprayed-on materials located on beams, in crawlspaces, and between walls.

C. The potential for an asbestos-containing product to release breathable fibers depends largely on its degree of friability. Friable means that the material can be crumbled with hand pressure and is therefore likely to emit fibers. The fibrous fluffy sprayed-on materials used for fireproofing, insulation, or sound proofing are considered to be friable, and they readily release airborne fibers if disturbed. Materials such as vinyl-asbestos



floor tile or roofing felt are considered non-friable if intact and generally do not emit airborne fibers unless subjected to sanding, sawing and other aggressive operations. Asbestos—cement pipe or sheet can emit airborne fibers if the materials are cut or sawed, or if they are broken.

D. Permissible exposure: Exposure to airborne asbestos fibers may not exceed 0.1 fibers per cubic centimeter of air (0.1 f/cc) averaged over the 8-hour workday, and 1 fiber per cubic centimeter of air (1.0 f/cc) averaged over a 30 minute work period.

## II. Health Hazard Data

A. Asbestos can cause disabling respiratory disease and various types of cancers if the fibers are inhaled. Inhaling or ingesting fibers from contaminated clothing or skin can also result in these diseases. The symptoms of these diseases generally do not appear for 20 or more years after initial exposure.

B. Exposure to asbestos has been shown to cause lung cancer, mesothelioma, and cancer of the stomach and colon. Mesothelioma is a rare cancer of the thin membrane lining of the chest and abdomen. Symptoms of mesothelioma include shortness of breath, pain in the walls of the chest, and/or abdominal pain.

## III. Respirators and Protective Clothing

A. Respirators: You are required to wear a respirator when performing tasks that result in asbestos exposure that exceeds the permissible exposure limit (PEL) of 0.1 f/cc and when performing certain designated operations. Air-purifying respirators equipped with a high-efficiency particulate air (HEPA) filter can be used where airborne asbestos fiber concentrations do not exceed 1.0 f/cc; otherwise, more protective respirators such as air-supplied, positive-pressure, full facepiece respirators must be used. Disposable respirators or dust masks are not permitted to be used for asbestos work. For effective protection, respirators must fit your face and head snugly. Your employer is required to conduct a fit test when you are first assigned a respirator and every 6 months thereafter. Respirators should not be loosened or removed in work situations where their use is required.

B. Protective Clothing: You are required to wear protective clothing in work areas where asbestos fiber concentrations exceed the permissible exposure limit (PEL) of 0.1 f/cc.

## IV. Disposal Procedures and Clean-up

A. Wastes that are generated by processes where asbestos is present include:

1. Empty asbestos shipping containers.
2. Process wastes such as cuttings, trimmings, or reject materials.
3. Housekeeping waste from wet-sweeping or HEPA-vacuuming.
4. Asbestos fireproofing or insulating material that is removed from buildings.
5. Asbestos-containing building products removed during building renovation or demolition.
6. Contaminated disposable protective clothing.



B. Empty shipping bags can be flattened under exhaust hoods and packed into airtight containers for disposal. Empty shipping drums are difficult to clean and should be sealed.

C. Vacuum bags or disposable paper filters should not be cleaned, but should be sprayed with a fine water mist and placed into a labeled waste container.

D. Process waste and housekeeping waste should be wetted with water or a mixture of water and surfactant prior to packaging in disposable containers.

E. Asbestos-containing material that is removed from buildings must be disposed of in leak-tight 6-mil plastic bags, plastic-lined cardboard containers, or plastic-lined metal containers. These wastes, which are removed while wet, should be sealed in containers before they dry out to minimize the release of asbestos fibers during handling.

## V. Access to Information

A. Each year, your employer is required to inform you of the information contained in this standard and appendices for asbestos. In addition, your employer must instruct you in the proper work practices for handling asbestos-containing materials, and the correct use of protective equipment.

B. Your employer is required to determine whether you are being exposed to asbestos. Your employer must treat exposure to thermal system insulation and sprayed-on and troweled-on surfacing material as asbestos exposure, unless results of laboratory analysis show that the material does not contain asbestos. You or your representative has the right to observe employee measurements and to record the results obtained. Your employer is required to inform you of your exposure, and, if you are exposed above the permissible exposure limit, he or she is required to inform you of the actions that are being taken to reduce your exposure to within the permissible limit.

C. Your employer is required to keep records of your exposures and medical examinations. These exposure records must be kept for at least thirty (30) years. Medical records must be kept for the period of your employment plus thirty (30) years.

D. Your employer is required to release your exposure and medical records to your physician or designated representative upon your written request.

## Appendix I to § 1915.1001—Medical Surveillance Guidelines for Asbestos, Non-Mandatory

### I. Route of Entry

Inhalation, ingestion.

### II. Toxicology

Clinical evidence of the adverse effects associated with exposure to asbestos is present in the form of several well-conducted epidemiological studies of occupationally exposed workers, family contacts of workers, and persons living near asbestos mines. These studies have shown a definite association between exposure to

asbestos and an increased incidence of lung cancer, pleural and peritoneal mesothelioma, gastrointestinal cancer, and asbestosis. The latter is a disabling fibrotic lung disease that is caused only by exposure to asbestos. Exposure to asbestos has also been associated with an increased incidence of esophageal, kidney, laryngeal, pharyngeal, and buccal cavity cancers. As with other known chronic occupational diseases, disease associated with asbestos generally appears about 20 years following the first occurrence of exposure: There are no known acute effects associated with exposure to asbestos.

Epidemiological studies indicate that the risk of lung cancer among exposed workers who smoke cigarettes is greatly increased over the risk of lung cancer among non-exposed smokers or exposed nonsmokers. These studies suggest that cessation of smoking will reduce the risk of lung cancer for a person exposed to asbestos but will not reduce it to the same level of risk as that existing for an exposed worker who has never smoked.

### III. Signs and Symptoms of Exposure-Related Disease

The signs and symptoms of lung cancer or gastrointestinal cancer induced by exposure to asbestos are not unique, except that a chest X-ray of an exposed patient with lung cancer may show pleural plaques, pleural calcification, or pleural fibrosis, and may also show asbestosis (*i.e.*, small irregular parenchymal opacities). Symptoms characteristic of mesothelioma include shortness of breath, pain in the chest or abdominal pain. Mesothelioma has a much longer average latency period compared with lung cancer (40 years versus 15–20 years), and mesothelioma is therefore more likely to be found among workers who were first exposed to asbestos at an early age. Mesothelioma is a fatal disease.

Asbestosis is pulmonary fibrosis caused by the accumulation of asbestos fibers in the lungs. Symptoms include shortness of breath, coughing, fatigue, and vague feelings of sickness. When the fibrosis worsens, shortness of breath occurs even at rest. The diagnosis of asbestosis is most commonly based on a history of exposure to asbestos, the presence of characteristic radiologic abnormalities, end-inspiratory crackles (rales), and other clinical features of fibrosing lung disease. Pleural plaques and thickening may be observed on chest X-rays. Asbestosis is often a progressive disease even in the absence of continued exposure, although this appears to be a highly individualized characteristic. In severe cases, death may be caused by respiratory or cardiac failure.

### IV. Surveillance and Preventive Considerations

As noted in section III of this appendix, exposure to asbestos have been linked to an increased risk of lung cancer, mesothelioma, gastrointestinal cancer, and asbestosis among occupationally exposed workers. Adequate screening tests to determine an employee's potential for developing serious chronic diseases, such as a cancer, from exposure to asbestos do not presently exist. However, some tests, particularly chest X-rays and pulmonary function tests, may indicate that an employee has been overexposed to asbestos increasing his or her risk of developing exposure related chronic diseases. It is important for the physician to become familiar with the operating conditions in which occupational exposure to asbestos is likely to occur. This is particularly important in evaluating medical and work histories and in conducting physical examinations. When an active employee has been identified as having been overexposed to asbestos measures taken by the employer to eliminate or mitigate further exposure should also lower the risk of serious long-term consequences.

The employer is required to institute a medical surveillance program for all employees who are or will be exposed to asbestos at or above the permissible exposure limits (0.1 fiber per cubic centimeter of air) for 30 or more days per year and for all employees who are assigned to wear a negative-pressure respirator. All examinations and procedures must be performed by or under the supervision of licensed physician at a reasonable time and place, and at no cost to the employee.

Although broad latitude is given to the physician in prescribing specific tests to be included in the medical surveillance program, OSHA requires inclusion of the following elements in the routine examination,

(i) Medical and work histories with special emphasis directed to symptoms of the respiratory system, cardiovascular system, and digestive tract.

(ii) Completion of the respiratory disease questionnaire contained in appendix D to this section.

(iii) A physical examination including a chest X-ray and pulmonary function test that includes measurement of the employee's forced vital capacity (FVC) and forced expiratory volume at one second (FEV<sub>1</sub>).

(iv) Any laboratory or other test that the examining physician deems by sound medical practice to be necessary.

The employer is required to make the prescribed tests available at least annually to those employees covered; more often than specified if recommended by the examining physician; and upon termination of employment.

The employer is required to provide the physician with the following information: A copy of the standard in this section (including all appendices to this section); a description of the employee's duties as they relate to asbestos exposure; the employee's representative level of exposure to asbestos; a description of any personal protective and respiratory equipment used; and information from previous medical examinations of the affected employee that is not otherwise available to the physician. Making this information available to the physician will aid in the evaluation of the employee's health in relation to assigned duties and fitness to wear personal protective equipment, if required.

The employer is required to obtain a written opinion from the examining physician containing the results of the medical examination; the physician's opinion as to whether the employee has any detected medical conditions that would place the employee at an increased risk of exposure-related disease; any recommended limitations on the employee or on the use of personal protective equipment; and a statement that the employee has been informed by the physician of the results of the medical examination and of any medical conditions related to asbestos exposure that require further explanation or treatment. This written opinion must not reveal specific findings or diagnoses unrelated to exposure to asbestos, and a copy of the opinion must be provided to the affected employee.

## Appendix J to § 1915.1001—Smoking Cessation Program Information for Asbestos—Non-Mandatory

The following organizations provide smoking cessation information.

1. The National Cancer Institute operates a toll-free Cancer Information Service (CIS) with trained personnel to help you. Call 1-800-4-CANCER\* to reach the CIS office serving your area, or write: Office of Cancer Communications, National Cancer Institute, National Institutes of Health, Building 31, Room 10A24, Bethesda, Maryland 20892.

2. American Cancer Society, 3340 Peachtree Road, N.E., Atlanta, Georgia 30026, (404) 320-3333.

The American Cancer Society (ACS) is a voluntary organization composed of 58 divisions and 3,100 local units. Through "The Great American Smokeout" in November, the annual Cancer Crusade in April, and numerous educational materials, ACS helps people learn about the health hazards of smoking and become successful ex-smokers.

3. American Heart Association, 7320 Greenville Avenue, Dallas, Texas 75231, (214) 750-5300.

The American Heart Association (AHA) is a voluntary organization with 130,000 members (physicians, scientists, and laypersons) in 55 state and regional groups. AHA produces a variety of publications and audiovisual materials about the effects of smoking on the heart. AHA also has developed a guidebook for incorporating a weight-control component into smoking cessation programs.

4. American Lung Association, 1740 Broadway, New York, New York 10019, (212) 245-8000.

A voluntary organization of 7,500 members (physicians, nurses, and laypersons), the American Lung Association (ALA) conducted numerous public information programs about the health effects of smoking. ALA has 59 state and 85 local units. The organization actively supports legislation and information campaigns for non-smokers' rights and provides help for smokers who want to quit, for example, through "Freedom From Smoking," a self-help smoking cessation program.

5. Office on Smoking and Health, U.S. Department of Health and Human Services 5600 Fishers Lane, Park Building, Room 110, Rockville, Maryland 20857.

The Office on Smoking and Health (OSHA) is the Department of Health and Human Services' lead agency in smoking control. OSHA has sponsored distribution of publications on smoking-related topics, such as free flyers on relapse after initial quitting, helping a friend or family member quit smoking, the health hazards of smoking, and the effects of parental smoking on teenagers.

\*In Hawaii, on Oahu call 524-1234 (call collect from neighboring islands),

Spanish-speaking staff members are available during daytime hours to callers from the following areas: California, Florida, Georgia, Illinois, New Jersey (area code 201), New York, and Texas. Consult your local telephone directory for listings of local chapters.

## Appendix K to § 1915.1001—Polarized Light Microscopy of Asbestos—Non-Mandatory

Method number: ID-191

Matrix: Bulk

COLLECTION PROCEDURE

Collect approximately 1 to 2 grams of each type of material and place into separate 20 mL scintillation vials.

ANALYTICAL PROCEDURE

A portion of each separate phase is analyzed by gross examination, phase-polar examination, and central stop dispersion microscopy.

Commercial manufacturers and products mentioned in this method are for descriptive use only and do not constitute endorsements by USDOL-OSHA. Similar products from other sources may be substituted.

1. Introduction

This method describes the collection and analysis of asbestos bulk materials by light microscopy techniques including phase- polar illumination and central-stop dispersion microscopy. Some terms unique to asbestos analysis are defined below:

*Amphibole:* A family of minerals whose crystals are formed by long, thin units which have two thin ribbons of double chain silicate with a brucite ribbon in between. The shape of each unit is similar to an “I beam”. Minerals important in asbestos analysis include cummingtonite-grunerite, crocidolite, tremolite- actinolite and anthophyllite.

*Asbestos:* A term for naturally occurring fibrous minerals. Asbestos includes chrysotile, cummingtonite-grunerite asbestos (amosite), anthophyllite asbestos, tremolite asbestos, crocidolite, actinolite asbestos and any of these minerals which have been chemically treated or altered. The precise chemical formulation of each species varies with the location from which it was mined. Nominal compositions are listed:

Chrysotile	Mg <sub>3</sub> Si <sub>2</sub> O <sub>5</sub> (OH) <sub>4</sub>
Crocidolite (Riebeckite asbestos)	Na <sub>2</sub> Fe <sub>3</sub> 2 + Fe <sub>2</sub> 3 + Si <sub>8</sub> O <sub>22</sub> (OH) <sub>2</sub>
Cummingtonite-Grunerite asbestos (Amosite)	(Mg,Fe) <sub>7</sub> Si <sub>8</sub> O <sub>22</sub> (OH) <sub>2</sub>
Tremolite-Actinolite asbestos	Ca <sub>2</sub> (Mg,Fe) <sub>5</sub> Si <sub>8</sub> O <sub>22</sub> (OH) <sub>2</sub>
Anthophyllite asbestos	(Mg,Fe) <sub>7</sub> Si <sub>8</sub> O <sub>22</sub> (OH) <sub>2</sub>

*Asbestos Fiber:* A fiber of asbestos meeting the criteria for a fiber. (See section 3.5.)

*Aspect Ratio:* The ratio of the length of a fiber to its diameter usually defined as “length : width”, e.g. 3:1.

*Brucite:* A sheet mineral with the composition Mg(OH)<sub>2</sub>.

*Central Stop Dispersion Staining (microscope):* This is a dark field microscope technique that images particles using only light refracted by the particle, excluding light that travels through the particle unrefracted. This is usually accomplished with a McCrone objective or other arrangement which places a circular stop with apparent aperture equal to the objective aperture in the back focal plane of the microscope.

*Cleavage Fragments:* Mineral particles formed by the comminution of minerals, especially those characterized by relatively parallel sides and moderate aspect ratio.

*Differential Counting:* The term applied to the practice of excluding certain kinds of fibers from a phase contrast asbestos count because they are not asbestos.

*Fiber:* A particle longer than or equal to 5  $\mu\text{m}$  with a length to width ratio greater than or equal to 3:1. This may include cleavage fragments. (see section 3.5 of this appendix).

*Phase Contrast:* Contrast obtained in the microscope by causing light scattered by small particles to destructively interfere with unscattered light, thereby enhancing the visibility of very small particles and particles with very low intrinsic contrast.

*Phase Contrast Microscope:* A microscope configured with a phase mask pair to create phase contrast. The technique which uses this is called Phase Contrast Microscopy (PCM).

*Phase-Polar Analysis:* This is the use of polarized light in a phase contrast microscope. It is used to see the same size fibers that are visible in air filter analysis. Although fibers finer than 1  $\mu\text{m}$  are visible, analysis of these is inferred from analysis of larger bundles that are usually present.

*Phase-Polar Microscope:* The phase-polar microscope is a phase contrast microscope which has an analyzer, a polarizer, a first order red plate and a rotating phase condenser all in place so that the polarized light image is enhanced by phase contrast.

*Sealing Encapsulant:* This is a product which can be applied, preferably by spraying, onto an asbestos surface which will seal the surface so that fibers cannot be released.

*Serpentine:* A mineral family consisting of minerals with the general composition  $\text{Mg}_3(\text{Si}_2\text{O}_5(\text{OH})_4$  having the magnesium in brucite layer over a silicate layer. Minerals important in asbestos analysis included in this family are chrysotile, lizardite, antigorite.

## 1.1. HISTORY

Light microscopy has been used for well over 100 years for the determination of mineral species. This analysis is carried out using specialized polarizing microscopes as well as bright field microscopes. The identification of minerals is an on-going process with many new minerals described each year. The first recorded use of asbestos was in Finland about 2500 B.C. where the material was used in the mud wattle for the wooden huts the people lived in as well as strengthening for pottery. Adverse health aspects of the mineral were noted nearly 2000 years ago when Pliny the Younger wrote about the poor health of slaves in the asbestos mines. Although known to be injurious for centuries, the first modern references to its toxicity were by the British Labor Inspectorate when it banned asbestos dust from the workplace in 1898. Asbestosis cases were described in the literature after the turn of the century. Cancer was first suspected in the mid 1930's and a causal link to mesothelioma was made in 1965. Because of the public concern for worker and public safety with the use of this material, several different types of analysis were applied to the determination of asbestos content. Light microscopy requires a great deal of experience and craft. Attempts were made to apply less subjective methods to the analysis. X-ray diffraction was partially successful in determining the mineral types but was unable to separate out the fibrous portions from the non-fibrous portions. Also, the minimum detection limit for

asbestos analysis by X-ray diffraction (XRD) is about 1%. Differential Thermal Analysis (DTA) was no more successful. These provide useful corroborating information when the presence of asbestos has been shown by microscopy; however, neither can determine the difference between fibrous and non-fibrous minerals when both habits are present. The same is true of Infrared Absorption (IR).

When electron microscopy was applied to asbestos analysis, hundreds of fibers were discovered present too small to be visible in any light microscope. There are two different types of electron microscope used for asbestos analysis: Scanning Electron Microscope (SEM) and Transmission Electron Microscope (TEM). Scanning Electron Microscopy is useful in identifying minerals. The SEM can provide two of the three pieces of information required to identify fibers by electron microscopy: morphology and chemistry. The third is structure as determined by Selected Area Electron Diffraction—SAED which is performed in the TEM. Although the resolution of the SEM is sufficient for very fine fibers to be seen, accuracy of chemical analysis that can be performed on the fibers varies with fiber diameter in fibers of less than 0.2  $\mu\text{m}$  diameter. The TEM is a powerful tool to identify fibers too small to be resolved by light microscopy and should be used in conjunction with this method when necessary. The TEM can provide all three pieces of information required for fiber identification. Most fibers thicker than 1  $\mu\text{m}$  can adequately be defined in the light microscope. The light microscope remains as the best instrument for the determination of mineral type. This is because the minerals under investigation were first described analytically with the light microscope. It is inexpensive and gives positive identification for most samples analyzed. Further, when optical techniques are inadequate, there is ample indication that alternative techniques should be used for complete identification of the sample.

## 1.2. PRINCIPLE

Minerals consist of atoms that may be arranged in random order or in a regular arrangement. Amorphous materials have atoms in random order while crystalline materials have long range order. Many materials are transparent to light, at least for small particles or for thin sections. The properties of these materials can be investigated by the effect that the material has on light passing through it. The six asbestos minerals are all crystalline with particular properties that have been identified and cataloged. These six minerals are anisotropic. They have a regular array of atoms, but the arrangement is not the same in all directions. Each major direction of the crystal presents a different regularity. Light photons travelling in each of these main directions will encounter different electrical neighborhoods, affecting the path and time of travel. The techniques outlined in this method use the fact that light traveling through fibers or crystals in different directions will behave differently, but predictably. The behavior of the light as it travels through a crystal can be measured and compared with known or determined values to identify the mineral species. Usually, Polarized Light Microscopy (PLM) is performed with strain-free objectives on a bright-field microscope platform. This would limit the resolution of the microscope to about 0.4  $\mu\text{m}$ . Because OSHA requires the counting and identification of fibers visible in phase contrast, the phase contrast platform is used to visualize the fibers with the polarizing elements added into the light path. Polarized light methods cannot identify fibers finer than about 1  $\mu\text{m}$  in diameter even though they are visible. The finest fibers are usually identified by inference from the presence of larger, identifiable fiber bundles. When fibers are present, but not identifiable by light microscopy, use either SEM or TEM to determine the fiber identity.

## 1.3. ADVANTAGES AND DISADVANTAGES

The advantages of light microscopy are:



(a) Basic identification of the materials was first performed by light microscopy and gross analysis. This provides a large base of published information against which to check analysis and analytical technique.

(b) The analysis is specific to fibers. The minerals present can exist in asbestiform, fibrous, prismatic, or massive varieties all at the same time. Therefore, bulk methods of analysis such as X-ray diffraction, IR analysis, DTA, etc. are inappropriate where the material is not known to be fibrous.

(c) The analysis is quick, requires little preparation time, and can be performed on-site if a suitably equipped microscope is available.

The disadvantages are:

(a) Even using phase-polar illumination, not all the fibers present may be seen. This is a problem for very low asbestos concentrations where agglomerations or large bundles of fibers may not be present to allow identification by inference.

(b) The method requires a great degree of sophistication on the part of the microscopist. An analyst is only as useful as his mental catalog of images. Therefore, a microscopist's accuracy is enhanced by experience. The mineralogical training of the analyst is very important. It is the basis on which subjective decisions are made.

(c) The method uses only a tiny amount of material for analysis. This may lead to sampling bias and false results (high or low). This is especially true if the sample is severely inhomogeneous.

(d) Fibers may be bound in a matrix and not distinguishable as fibers so identification cannot be made.

#### 1.4. METHOD PERFORMANCE

1.4.1. This method can be used for determination of asbestos content from 0 to 100% asbestos. The detection limit has not been adequately determined, although for selected samples, the limit is very low, depending on the number of particles examined. For mostly homogeneous, finely divided samples, with no difficult fibrous interferences, the detection limit is below 1%. For inhomogeneous samples (most samples), the detection limit remains undefined. NIST has conducted proficiency testing of laboratories on a national scale. Although each round is reported statistically with an average, control limits, etc., the results indicate a difficulty in establishing precision especially in the low concentration range. It is suspected that there is significant bias in the low range especially near 1%. EPA tried to remedy this by requiring a mandatory point counting scheme for samples less than 10%. The point counting procedure is tedious, and may introduce significant biases of its own. It has not been incorporated into this method.

1.4.2. The precision and accuracy of the quantitation tests performed in this method are unknown. Concentrations are easier to determine in commercial products where asbestos was deliberately added because the amount is usually more than a few percent. An analyst's results can be "calibrated" against the known amounts added by the manufacturer. For geological samples, the degree of homogeneity affects the precision.



1.4.3. The performance of the method is analyst dependent. The analyst must choose carefully and not necessarily randomly the portions for analysis to assure that detection of asbestos occurs when it is present. For this reason, the analyst must have adequate training in sample preparation, and experience in the location and identification of asbestos in samples. This is usually accomplished through substantial on-the-job training as well as formal education in mineralogy and microscopy.

## 1.5. INTERFERENCES

Any material which is long, thin, and small enough to be viewed under the microscope can be considered an interference for asbestos. There are literally hundreds of interferences in workplaces. The techniques described in this method are normally sufficient to eliminate the interferences. An analyst's success in eliminating the interferences depends on proper training.

Asbestos minerals belong to two mineral families: the serpentines and the amphiboles. In the serpentine family, the only common fibrous mineral is chrysotile. Occasionally, the mineral antigorite occurs in a fibril habit with morphology similar to the amphiboles. The amphibole minerals consist of a score of different minerals of which only five are regulated by federal standard: amosite, crocidolite, anthophyllite asbestos, tremolite asbestos and actinolite asbestos. These are the only amphibole minerals that have been commercially exploited for their fibrous properties; however, the rest can and do occur occasionally in asbestiform habit.

In addition to the related mineral interferences, other minerals common in building material may present a problem for some microscopists: gypsum, anhydrite, brucite, quartz fibers, talc fibers or ribbons, wollastonite, perlite, attapulgite, etc. Other fibrous materials commonly present in workplaces are: fiberglass, mineral wool, ceramic wool, refractory ceramic fibers, kevlar, nomex, synthetic fibers, graphite or carbon fibers, cellulose (paper or wood) fibers, metal fibers, etc.

Matrix embedding material can sometimes be a negative interference. The analyst may not be able to easily extract the fibers from the matrix in order to use the method. Where possible, remove the matrix before the analysis, taking careful note of the loss of weight. Some common matrix materials are: vinyl, rubber, tar, paint, plant fiber, cement, and epoxy. A further negative interference is that the asbestos fibers themselves may be either too small to be seen in Phase contrast Microscopy (PCM) or of a very low fibrous quality, having the appearance of plant fibers. The analyst's ability to deal with these materials increases with experience.

## 1.6. USES AND OCCUPATIONAL EXPOSURE

Asbestos is ubiquitous in the environment. More than 40% of the land area of the United States is composed of minerals which may contain asbestos. Fortunately, the actual formation of great amounts of asbestos is relatively rare. Nonetheless, there are locations in which environmental exposure can be severe such as in the Serpentine Hills of California.

There are thousands of uses for asbestos in industry and the home. Asbestos abatement workers are the most current segment of the population to have occupational exposure to great amounts of asbestos. If the material is undisturbed, there is no exposure. Exposure occurs when the asbestos-containing material is abraded or otherwise disturbed during maintenance operations or some other activity. Approximately 95% of the asbestos in place in the United States is chrysotile.

Amosite and crocidolite make up nearly all the difference. Tremolite and anthophyllite make up a very small percentage. Tremolite is found in extremely small amounts in certain chrysotile deposits. Actinolite exposure is probably greatest from environmental sources, but has been identified in vermiculite containing, sprayed-on insulating materials which may have been certified as asbestos-free.

## 1.7. PHYSICAL AND CHEMICAL PROPERTIES

The nominal chemical compositions for the asbestos minerals were given in Section 1. Compared to cleavage fragments of the same minerals, asbestiform fibers possess a high tensile strength along the fiber axis. They are chemically inert, non-combustible, and heat resistant. Except for chrysotile, they are insoluble in Hydrochloric acid (HCl). Chrysotile is slightly soluble in HCl. Asbestos has high electrical resistance and good sound absorbing characteristics. It can be woven into cables, fabrics or other textiles, or matted into papers, felts, and mats.

## 1.8. TOXICOLOGY (THIS SECTION IS FOR INFORMATION ONLY AND SHOULD NOT BE TAKEN AS OSHA POLICY)

Possible physiologic results of respiratory exposure to asbestos are mesothelioma of the pleura or peritoneum, interstitial fibrosis, asbestosis, pneumoconiosis, or respiratory cancer. The possible consequences of asbestos exposure are detailed in the NIOSH Criteria Document or in the OSHA Asbestos Standards 29 CFR 1910.1001 and 29 CFR 1926.1101 and 29 CFR 1915.1001.

# 2. Sampling Procedure

## 2.1. EQUIPMENT FOR SAMPLING

- (a) Tube or cork borer sampling device
- (b) Knife
- (c) 20 mL scintillation vial or similar vial
- (d) Sealing encapsulant

## 2.2. SAFETY PRECAUTIONS

Asbestos is a known carcinogen. Take care when sampling. While in an asbestos-containing atmosphere, a properly selected and fit-tested respirator should be worn. Take samples in a manner to cause the least amount of dust. Follow these general guidelines:

- (a) Do not make unnecessary dust.
- (b) Take only a small amount (1 to 2 g).
- (c) Tightly close the sample container.

- (d) Use encapsulant to seal the spot where the sample was taken, if necessary.

### 2.3. SAMPLING PROCEDURE

Samples of any suspect material should be taken from an inconspicuous place. Where the material is to remain, seal the sampling wound with an encapsulant to eliminate the potential for exposure from the sample site. Microscopy requires only a few milligrams of material. The amount that will fill a 20 mL scintillation vial is more than adequate. Be sure to collect samples from all layers and phases of material. If possible, make separate samples of each different phase of the material. This will aid in determining the actual hazard. *DO NOT USE ENVELOPES, PLASTIC OR PAPER BAGS OF ANY KIND TO COLLECT SAMPLES.* The use of plastic bags presents a contamination hazard to laboratory personnel and to other samples. When these containers are opened, a bellows effect blows fibers out of the container onto everything, including the person opening the container.

If a cork-borer type sampler is available, push the tube through the material all the way, so that all layers of material are sampled. Some samplers are intended to be disposable. These should be capped and sent to the laboratory. If a non-disposable cork borer is used, empty the contents into a scintillation vial and send to the laboratory. Vigorously and completely clean the cork borer between samples.

### 2.4 SHIPMENT

Samples packed in glass vials must not touch or they might break in shipment.

- (a) Seal the samples with a sample seal over the end to guard against tampering and to identify the sample.
- (b) Package the bulk samples in separate packages from the air samples. They may cross-contaminate each other and will invalidate the results of the air samples.
- (c) Include identifying paperwork with the samples, but not in contact with the suspected asbestos.
- (d) To maintain sample accountability, ship the samples by certified mail, overnight express, or hand carry them to the laboratory.

## 3. Analysis

The analysis of asbestos samples can be divided into two major parts: sample preparation and microscopy. Because of the different asbestos uses that may be encountered by the analyst, each sample may need different preparation steps. The choices are outlined below. There are several different tests that are performed to identify the asbestos species and determine the percentage. They will be explained below.

### 3.1. SAFETY

- (a) Do not create unnecessary dust. Handle the samples in HEPA-filter equipped hoods. If samples are received in bags, envelopes or other inappropriate container, open them only in a hood having a face velocity at or greater than 100 fpm. Transfer a small amount to a scintillation vial and only handle the smaller amount.
- (b) Open samples in a hood, never in the open lab area.

- (c) Index of refraction oils can be toxic. Take care not to get this material on the skin. Wash immediately with soap and water if this happens.
- (d) Samples that have been heated in the muffle furnace or the drying oven may be hot. Handle them with tongs until they are cool enough to handle.
- (e) Some of the solvents used, such as THF (tetrahydrofuran), are toxic and should only be handled in an appropriate fume hood and according to instructions given in the safety data sheet (SDS).

### 3.2. EQUIPMENT

- (a) Phase contrast microscope with 10x, 16x and 40x objectives, 10x wide-field eyepieces, G-22 Walton-Beckett graticule, Whipple disk, polarizer, analyzer and first order red or gypsum plate, 100 Watt illuminator, rotating position condenser with oversize phase rings, central stop dispersion objective, Kohler illumination and a rotating mechanical stage. (See figure 1).
- (b) Stereo microscope with reflected light illumination, transmitted light illumination, polarizer, analyzer and first order red or gypsum plate, and rotating stage.
- (c) Negative pressure hood for the stereo microscope
- (d) Muffle furnace capable of 600 °C
- (e) Drying oven capable of 50–150 °C
- (f) Aluminum specimen pans
- (g) Tongs for handling samples in the furnace
- (h) High dispersion index of refraction oils (Special for dispersion staining.)

n = 1.550

n = 1.585

n = 1.590

n = 1.605

n = 1.620

n = 1.670

n = 1.680

n = 1.690

(i) A set of index of refraction oils from about  $n = 1.350$  to  $n = 2.000$  in  $n = 0.005$  increments. (Standard for Becke line analysis.)

(j) Glass slides with painted or frosted ends  $1 \times 3$  inches 1mm thick, precleaned.

(k) Cover Slips  $22 \times 22$  mm, #1 $\frac{1}{2}$

(l) Paper clips or dissection needles

(m) Hand grinder

(n) Scalpel with both #10 and #11 blades

(o) 0.1 molar HCl

(p) Decalcifying solution (Baxter Scientific Products) Ethylenediaminetetraacetic Acid,

Tetrasodium

0.7 g/l

Sodium Potassium Tartrate

8.0 mg/liter

Hydrochloric Acid

99.2 g/liter

Sodium Tartrate

0.14 g/liter

(q) Tetrahydrofuran (THF)

(r) Hotplate capable of 60 °C

(s) Balance

(t) Hacksaw blade

(u) Ruby mortar and pestle

### 3.3. SAMPLE PRE-PREPARATION

Sample preparation begins with pre-preparation which may include chemical reduction of the matrix, heating the sample to dryness or heating in the muffle furnace. The end result is a sample which has been reduced to a powder that is sufficiently fine to fit under the cover slip. Analyze different phases of samples separately, e.g., tile and the tile mastic should be analyzed separately as the mastic may contain asbestos while the tile may not.

#### (A) WET SAMPLES

Samples with a high water content will not give the proper dispersion colors and must be dried prior to sample mounting. Remove the lid of the scintillation vial, place the bottle in the drying oven and heat at 100 °C to dryness (usually about 2 h). Samples which are not submitted to the lab in glass must be removed and placed in glass vials or aluminum weighing pans before placing them in the drying oven.

#### (B) SAMPLES WITH ORGANIC INTERFERENCE—MUFFLE FURNACE

These may include samples with tar as a matrix, vinyl asbestos tile, or any other organic that can be reduced by heating. Remove the sample from the vial and weigh in a balance to determine the weight of the submitted portion. Place the sample in a muffle furnace at 500 °C for 1 to 2 h or until all obvious organic material has been removed. Retrieve, cool and weigh again to determine the weight loss on ignition. This is necessary to determine the asbestos content of the submitted sample, because the analyst will be looking at a reduced sample.

Notes: Heating above 600 °C will cause the sample to undergo a structural change which, given sufficient time, will convert the chrysotile to forsterite. Heating even at lower temperatures for 1 to 2 h may have a measurable effect on the optical properties of the minerals. If the analyst is unsure of what to expect, a sample of standard asbestos should be heated to the same temperature for the same length of time so that it can be examined for the proper interpretation.

#### (C) SAMPLES WITH ORGANIC INTERFERENCE—THF

Vinyl asbestos tile is the most common material treated with this solvent, although, substances containing tar will sometimes yield to this treatment. Select a portion of the material and then grind it up if possible. Weigh the sample and place it in a test tube. Add sufficient THF to dissolve the organic matrix. This is usually about 4 to 5 mL. *Remember, THF is highly flammable.* Filter the remaining material through a tared silver membrane, dry and weigh to determine how much is left after the solvent extraction. Further process the sample to remove carbonate or mount directly.

#### (D) SAMPLES WITH CARBONATE INTERFERENCE

Carbonate material is often found on fibers and sometimes must be removed in order to perform dispersion microscopy. Weigh out a portion of the material and place it in a test tube. Add a sufficient amount of 0.1 M HCl or decalcifying solution in the tube to react all the carbonate as evidenced by gas formation; i.e., when the gas bubbles stop, add a little more solution. If no more gas forms, the reaction is complete. Filter the material out through a tared silver membrane, dry and weigh to determine the weight lost.

### 3.4. SAMPLE PREPARATION

Samples must be prepared so that accurate determination can be made of the asbestos type and amount present. The following steps are carried out in the low-flow hood (a low-flow hood has less than 50 fpm flow):

(1) If the sample has large lumps, is hard, or cannot be made to lie under a cover slip, the grain size must be reduced. Place a small amount between two slides and grind the material between them or grind a small amount in a clean mortar and pestle. The choice of whether to use an alumina, ruby, or diamond mortar depends on the hardness of the material. Impact damage can alter the asbestos mineral if too much mechanical shock occurs. (Freezer mills can completely destroy the observable crystallinity of asbestos and should not be used). For some samples, a portion of material can be shaved off with a scalpel, ground off with a hand grinder or hack saw blade.

The preparation tools should either be disposable or cleaned thoroughly. Use vigorous scrubbing to loosen the fibers during the washing. Rinse the implements with copious amounts of water and air-dry in a dust-free environment.

(2) If the sample is powder or has been reduced as in 1) above, it is ready to mount. Place a glass slide on a piece of optical tissue and write the identification on the painted or frosted end. Place two drops of index of refraction medium  $n = 1.550$  on the slide. (The medium  $n = 1.550$  is chosen because it is the matching index for chrysotile. Dip the end of a clean paper-clip or dissecting needle into the droplet of refraction medium *on the slide* to moisten it. Then dip the probe into the powder sample. Transfer what sticks on the probe to the slide. The material on the end of the probe should have a diameter of about 3 mm for a good mount. If the material is very fine, less sample may be appropriate. For non-powder samples such as fiber mats, forceps should be used to transfer a small amount of material to the slide. Stir the material in the medium on the slide, spreading it out and making the preparation as uniform as possible. Place a cover-slip on the preparation by gently lowering onto the slide and allowing it to fall "trapdoor" fashion on the preparation to push out any bubbles. Press gently on the cover slip to even out the distribution of particulate on the slide. If there is insufficient mounting oil on the slide, one or two drops may be placed near the edge of the coverslip on the slide. Capillary action will draw the necessary amount of liquid into the preparation. Remove excess oil with the point of a laboratory wiper.

Treat at least two different areas of each phase in this fashion. Choose representative areas of the sample. It may be useful to select particular areas or fibers for analysis. This is useful to identify asbestos in severely inhomogeneous samples.

When it is determined that amphiboles may be present, repeat the above process using the appropriate high-dispersion oils until an identification is made or all six asbestos minerals have been ruled out. Note that percent determination must be done in the index medium 1.550 because amphiboles tend to disappear in their matching mediums.

### 3.5. ANALYTICAL PROCEDURE

Note: This method presumes some knowledge of mineralogy and optical petrography.

The analysis consists of three parts: The determination of whether there is asbestos present, what type is present and the determination of how much is present. The general flow of the analysis is:

(1) Gross examination.

(2) Examination under polarized light on the stereo microscope.

- (3) Examination by phase-polar illumination on the compound phase microscope.
- (4) Determination of species by dispersion stain. Examination by Becke line analysis may also be used; however, this is usually more cumbersome for asbestos determination.
- (5) Difficult samples may need to be analyzed by SEM or TEM, or the results from those techniques combined with light microscopy for a definitive identification. Identification of a particle as asbestos requires that it be asbestiform. Description of particles should follow the suggestion of Campbell. (Figure 1)



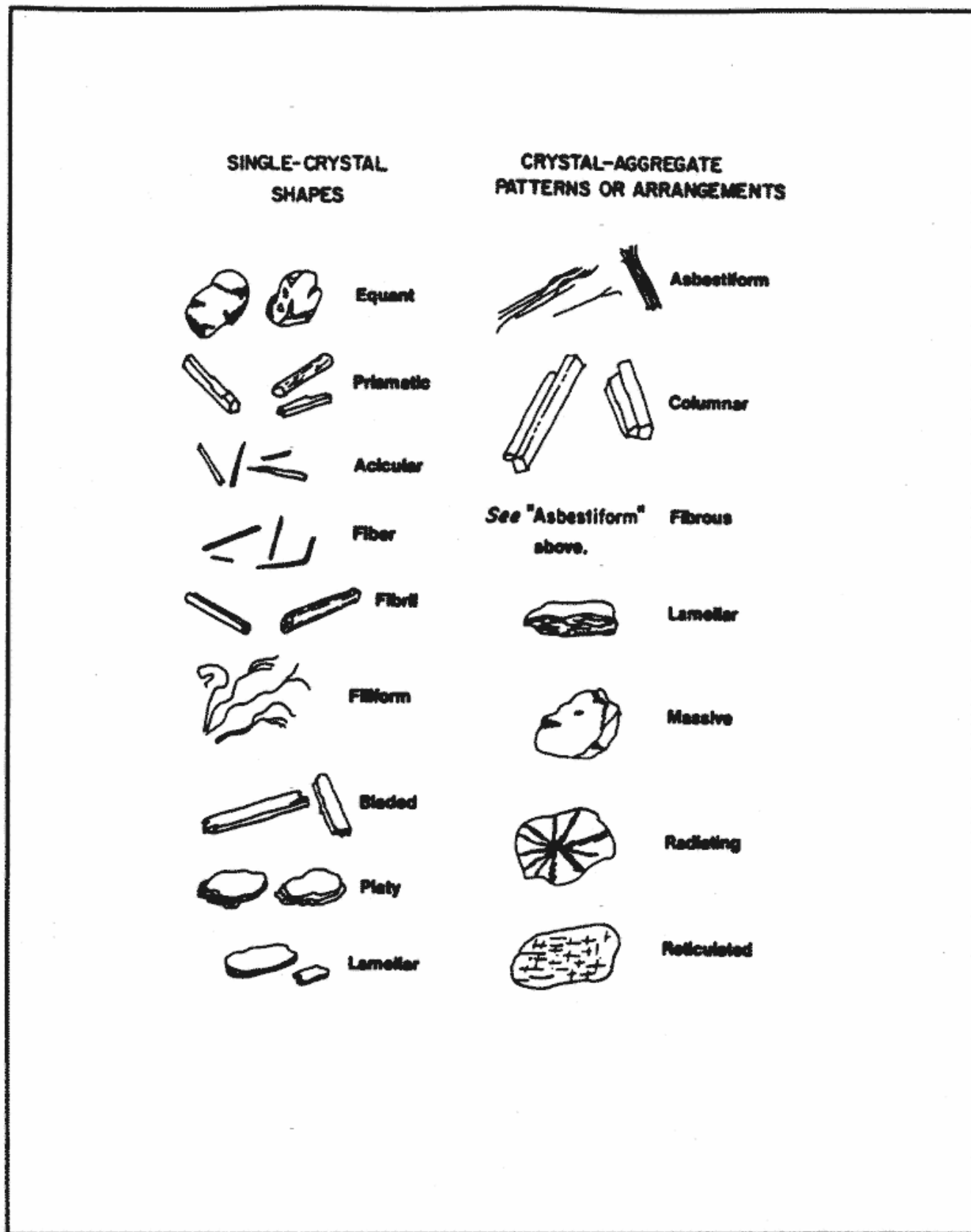


Figure 1. Particle definitions showing mineral growth habits.  
From the U.S. Bureau of Mines

For the purpose of regulation, the mineral must be one of the six minerals covered and must be in the asbestos growth habit. Large specimen samples of asbestos generally have the gross appearance of wood. Fibers are easily parted from it. Asbestos fibers are very long compared with their widths. The fibers have a very high tensile strength as demonstrated by bending without breaking. Asbestos fibers exist in bundles that are easily parted, show longitudinal fine structure and may be tufted at the ends showing "bundle of sticks" morphology. In the microscope some of these properties may not be observable. Amphiboles do not always show striations along their length even when they are asbestos. Neither will they always show tufting. They generally do not show a curved nature except for very long fibers. Asbestos and asbestiform minerals are usually characterized in groups by extremely high aspect ratios (greater than 100:1). While aspect ratio analysis is useful for characterizing populations of fibers, it cannot be used to identify individual fibers of intermediate to short aspect ratio. Observation of many fibers is often necessary to determine whether a sample consists of "cleavage fragments" or of asbestos fibers.

Most cleavage fragments of the asbestos minerals are easily distinguishable from true asbestos fibers. This is because true cleavage fragments usually have larger diameters than 1  $\mu\text{m}$ . Internal structure of particles larger than this usually shows them to have no internal fibrillar structure. In addition, cleavage fragments of the monoclinic amphiboles show inclined extinction under crossed polars with no compensator. Asbestos fibers usually show extinction at zero degrees or ambiguous extinction if any at all. Morphologically, the larger cleavage fragments are obvious by their blunt or stepped ends showing prismatic habit. Also, they tend to be acicular rather than filiform.

Where the particles are less than 1  $\mu\text{m}$  in diameter and have an aspect ratio greater than or equal to 3:1, it is recommended that the sample be analyzed by SEM or TEM if there is any question whether the fibers are cleavage fragments or asbestiform particles.

Care must be taken when analyzing by electron microscopy because the interferences are different from those in light microscopy and may structurally be very similar to asbestos. The classic interference is between anthophyllite and biopyribole or intermediate fiber. Use the same morphological clues for electron microscopy as are used for light microscopy, e.g. fibril splitting, internal longitudinal striation, fraying, curvature, etc.

(1) Gross examination:

Examine the sample, preferably in the glass vial. Determine the presence of any obvious fibrous component. Estimate a percentage based on previous experience and current observation. Determine whether any pre-preparation is necessary. Determine the number of phases present. This step may be carried out or augmented by observation at 6 to 40  $\times$  under a stereo microscope.

(2) After performing any necessary pre-preparation, prepare slides of each phase as described above. Two preparations of the same phase in the same index medium can be made side-by-side on the same glass for convenience. Examine with the polarizing stereo microscope. Estimate the percentage of asbestos based on the amount of birefringent fiber present.

(3) Examine the slides on the phase-polar microscopes at magnifications of 160 and 400  $\times$ . Note the morphology of the fibers. Long, thin, very straight fibers with little curvature are indicative of fibers from the amphibole family. Curved, wavy fibers are usually indicative of chrysotile. Estimate the percentage of asbestos on the phase-polar microscope under conditions of crossed polars and a gypsum plate. Fibers smaller than 1.0  $\mu\text{m}$  in thickness must be identified by inference to the presence of larger, identifiable fibers and morphology. If

no larger fibers are visible, electron microscopy should be performed. At this point, only a tentative identification can be made. Full identification must be made with dispersion microscopy. Details of the tests are included in the appendices.

(4) Once fibers have been determined to be present, they must be identified. Adjust the microscope for dispersion mode and observe the fibers. The microscope has a rotating stage, one polarizing element, and a system for generating dark-field dispersion microscopy (see Section 4.6. of this appendix). Align a fiber with its length parallel to the polarizer and note the color of the Becke lines. Rotate the stage to bring the fiber length perpendicular to the polarizer and note the color. Repeat this process for every fiber or fiber bundle examined. The colors must be consistent with the colors generated by standard asbestos reference materials for a positive identification. In  $n = 1.550$ , amphiboles will generally show a yellow to straw-yellow color indicating that the fiber indices of refraction are higher than the liquid. If long, thin fibers are noted and the colors are yellow, prepare further slides as above in the suggested matching liquids listed below:

Type of asbestos	Index of refraction
Chrysotile	$n = 1.550$ .
Amosite	$n = 1.670$ or $1.680$ .
Crocidolite	$n = 1.690$ .
Anthophyllite	$n = 1.605$ and $1.620$ .
Tremolite	$n = 1.605$ and $1.620$ .
Actinolite	$n = 1.620$ .

Where more than one liquid is suggested, the first is preferred; however, in some cases this liquid will not give good dispersion color. Take care to avoid interferences in the other liquid; e.g., wollastonite in  $n = 1.620$  will give the same colors as tremolite. In  $n = 1.605$  wollastonite will appear yellow in all directions. Wollastonite may be determined under crossed polars as it will change from blue to yellow as it is rotated along its fiber axis by tapping on the cover slip. Asbestos minerals will not change in this way.

Determination of the angle of extinction may, when present, aid in the determination of anthophyllite from tremolite. True asbestos fibers usually have  $0^\circ$  extinction or ambiguous extinction, while cleavage fragments have more definite extinction.

Continue analysis until both preparations have been examined and all present species of asbestos are identified. If there are no fibers present, or there is less than 0.1% present, end the analysis with the minimum number of slides (2).

(5) Some fibers have a coating on them which makes dispersion microscopy very difficult or impossible. Becke line analysis or electron microscopy may be performed in those cases. Determine the percentage by light microscopy. TEM analysis tends to overestimate the actual percentage present.

(6) Percentage determination is an estimate of occluded area, tempered by gross observation. Gross observation information is used to make sure that the high magnification microscopy does not greatly over- or under-estimate the amount of fiber present. This part of the analysis requires a great deal of experience. Satisfactory models for asbestos content analysis have not yet been developed, although some models based

on metallurgical grain-size determination have found some utility. Estimation is more easily handled in situations where the grain sizes visible at about 160 × are about the same and the sample is relatively homogeneous.

View all of the area under the cover slip to make the percentage determination. View the fields while moving the stage, paying attention to the clumps of material. These are not usually the best areas to perform dispersion microscopy because of the interference from other materials. But, they are the areas most likely to represent the accurate percentage in the sample. Small amounts of asbestos require slower scanning and more frequent analysis of individual fields.

Report the area occluded by asbestos as the concentration. This estimate does not generally take into consideration the difference in density of the different species present in the sample. For most samples this is adequate. Simulation studies with similar materials must be carried out to apply microvisual estimation for that purpose and is beyond the scope of this procedure.

(7) Where successive concentrations have been made by chemical or physical means, the amount reported is the percentage of the material in the "as submitted" or original state. The percentage determined by microscopy is multiplied by the fractions remaining after pre-preparation steps to give the percentage in the original sample. For example:

Step 1. 60% remains after heating at 550 °C for 1 h.

Step 2. 30% of the residue of step 1 remains after dissolution of carbonate in 0.1 m HCl.

Step 3. Microvisual estimation determines that 5% of the sample is chrysotile asbestos.

The reported result is:

$R = (\text{Microvisual result in percent}) \times (\text{Fraction remaining after step 2}) \times (\text{Fraction remaining of original sample after step 1})$

$R = (5) \times (.30) \times (.60) = 0.9\%$

(8) Report the percent and type of asbestos present. For samples where asbestos was identified, but is less than 1.0%, report "Asbestos present, less than 1.0%." There must have been at least two observed fibers or fiber bundles in the two preparations to be reported as present. For samples where asbestos was not seen, report as "None Detected."

#### 4. Auxiliary Information

Because of the subjective nature of asbestos analysis, certain concepts and procedures need to be discussed in more depth. This information will help the analyst understand why some of the procedures are carried out the way they are.

#### 4.1. LIGHT

Light is electromagnetic energy. It travels from its source in packets called quanta. It is instructive to consider light as a plane wave. The light has a direction of travel. Perpendicular to this and mutually perpendicular to each other, are two vector components. One is the magnetic vector and the other is the electric vector. We shall only be concerned with the electric vector. In this description, the interaction of the vector and the mineral will describe all the observable phenomena. From a light source such a microscope illuminator, light travels in all different direction from the filament.

In any given direction away from the filament, the electric vector is perpendicular to the direction of travel of a light ray. While perpendicular, its orientation is random about the travel axis. If the electric vectors from all the light rays were lined up by passing the light through a filter that would only let light rays with electric vectors oriented in one direction pass, the light would then be *POLARIZED*.

Polarized light interacts with matter in the direction of the electric vector. This is the polarization direction. Using this property it is possible to use polarized light to probe different materials and identify them by how they interact with light. The speed of light in a vacuum is a constant at about  $2.99 \times 10^8$  m/s. When light travels in different materials such as air, water, minerals or oil, it does not travel at this speed. It travels slower. This slowing is a function of both the material through which the light is traveling and the wavelength or frequency of the light. In general, the more dense the material, the slower the light travels. Also, generally, the higher the frequency, the slower the light will travel. The ratio of the speed of light in a vacuum to that in a material is called the index of refraction ( $n$ ). It is usually measured at 589 nm (the sodium D line). If white light (light containing all the visible wavelengths) travels through a material, rays of longer wavelengths will travel faster than those of shorter wavelengths, this separation is called dispersion. Dispersion is used as an identifier of materials as described in Section 4.6.

#### 4.2. MATERIAL PROPERTIES

Materials are either amorphous or crystalline. The difference between these two descriptions depends on the positions of the atoms in them. The atoms in amorphous materials are randomly arranged with no long range order. An example of an amorphous material is glass. The atoms in crystalline materials, on the other hand, are in regular arrays and have long range order. Most of the atoms can be found in highly predictable locations. Examples of crystalline material are salt, gold, and the asbestos minerals.

It is beyond the scope of this method to describe the different types of crystalline materials that can be found, or the full description of the classes into which they can fall. However, some general crystallography is provided below to give a foundation to the procedures described.

With the exception of anthophyllite, all the asbestos minerals belong to the monoclinic crystal type. The unit cell is the basic repeating unit of the crystal and for monoclinic crystals can be described as having three unequal sides, two 90° angles and one angle not equal to 90°. The orthorhombic group, of which anthophyllite is a member has three unequal sides and three 90° angles. The unequal sides are a consequence of the complexity of fitting the different atoms into the unit cell. Although the atoms are in a regular array, that array is not symmetrical in all directions. There is long range order in the three major directions of the crystal. However, the order is different in each of the three directions. This has the effect that the index of refraction is different in each of the three directions. Using polarized light, we can investigate the index of refraction in each of the directions and identify the mineral or material under investigation. The indices  $\alpha$ ,  $\beta$ , and  $\gamma$  are used to identify

the lowest, middle, and highest index of refraction respectively. The x direction, associated with  $\alpha$  is called the fast axis. Conversely, the z direction is associated with  $\gamma$  and is the slow direction. Crocidolite has  $\alpha$  along the fiber length making it "length-fast". The remainder of the asbestos minerals have the  $\gamma$  axis along the fiber length. They are called "length-slow". This orientation to fiber length is used to aid in the identification of asbestos.

#### 4.3. POLARIZED LIGHT TECHNIQUE

Polarized light microscopy as described in this section uses the phase-polar microscope described in Section 3.2. A phase contrast microscope is fitted with two polarizing elements, one below and one above the sample. The polarizers have their polarization directions at right angles to each other. Depending on the tests performed, there may be a compensator between these two polarizing elements. Light emerging from a polarizing element has its electric vector pointing in the polarization direction of the element. The light will not be subsequently transmitted through a second element set at a right angle to the first element. Unless the light is altered as it passes from one element to the other, there is no transmission of light.

#### 4.4. ANGLE OF EXTINCTION

Crystals which have different crystal regularity in two or three main directions are said to be anisotropic. They have a different index of refraction in each of the main directions. When such a crystal is inserted between the crossed polars, the field of view is no longer dark but shows the crystal in color. The color depends on the properties of the crystal. The light acts as if it travels through the crystal along the optical axes. If a crystal optical axis were lined up along one of the polarizing directions (either the polarizer or the analyzer) the light would appear to travel only in that direction, and it would blink out or go dark. The difference in degrees between the fiber direction and the angle at which it blinks out is called the angle of extinction. When this angle can be measured, it is useful in identifying the mineral. The procedure for measuring the angle of extinction is to first identify the polarization direction in the microscope. A commercial alignment slide can be used to establish the polarization directions or use anthophyllite or another suitable mineral. This mineral has a zero degree angle of extinction and will go dark to extinction as it aligns with the polarization directions. When a fiber of anthophyllite has gone to extinction, align the eyepiece reticle or graticule with the fiber so that there is a visual cue as to the direction of polarization in the field of view. Tape or otherwise secure the eyepiece in this position so it will not shift.

After the polarization direction has been identified in the field of view, move the particle of interest to the center of the field of view and align it with the polarization direction. For fibers, align the fiber along this direction. Note the angular reading of the rotating stage. Looking at the particle, rotate the stage until the fiber goes dark or "blinks out". Again note the reading of the stage. The difference in the first reading and the second is an angle of extinction.

The angle measured may vary as the orientation of the fiber changes about its long axis. Tables of mineralogical data usually report the maximum angle of extinction. Asbestos forming minerals, when they exhibit an angle of extinction, usually do show an angle of extinction close to the reported maximum, or as appropriate depending on the substitution chemistry.

#### 4.5. CROSSED POLARS WITH COMPENSATOR

When the optical axes of a crystal are not lined up along one of the polarizing directions (either the polarizer or the analyzer) part of the light travels along one axis and part travels along the other visible axis. This is characteristic of birefringent materials.

The color depends on the difference of the two visible indices of refraction and the thickness of the crystal. The maximum difference available is the difference between the  $\alpha$  and the  $\gamma$  axes. This maximum difference is usually tabulated as the birefringence of the crystal.

For this test, align the fiber at  $45^\circ$  to the polarization directions in order to maximize the contribution to each of the optical axes. The colors seen are called retardation colors. They arise from the recombination of light which has traveled through the two separate directions of the crystal. One of the rays is retarded behind the other since the light in that direction travels slower. On recombination, some of the colors which make up white light are enhanced by constructive interference and some are suppressed by destructive interference. The result is a color dependent on the difference between the indices and the thickness of the crystal. The proper colors, thicknesses, and retardations are shown on a Michel-Levy chart. The three items, retardation, thickness and birefringence are related by the following relationship:

$$R = t(n\gamma - \alpha)$$

$R$  = retardation,  $t$  = crystal thickness in  $\mu\text{m}$ , and

$\alpha, \gamma$  = indices of refraction.

Examination of the equation for asbestos minerals reveals that the visible colors for almost all common asbestos minerals and fiber sizes are shades of gray and black. The eye is relatively poor at discriminating different shades of gray. It is very good at discriminating different colors. In order to compensate for the low retardation, a compensator is added to the light train between the polarization elements. The compensator used for this test is a gypsum plate of known thickness and birefringence. Such a compensator when oriented at  $45^\circ$  to the polarizer direction, provides a retardation of 530 nm of the 530 nm wavelength color. This enhances the red color and gives the background a characteristic red to red-magenta color. If this "full-wave" compensator is in place when the asbestos preparation is inserted into the light train, the colors seen on the fibers are quite different. Gypsum, like asbestos has a fast axis and a slow axis. When a fiber is aligned with its fast axis in the same direction as the fast axis of the gypsum plate, the ray vibrating in the slow direction is retarded by both the asbestos and the gypsum. This results in a higher retardation than would be present for either of the two minerals. The color seen is a second order blue. When the fiber is rotated  $90^\circ$  using the rotating stage, the slow direction of the fiber is now aligned with the fast direction of the gypsum and the fast direction of the fiber is aligned with the slow direction of the gypsum. Thus, one ray vibrates faster in the fast direction of the gypsum, and slower in the slow direction of the fiber; the other ray will vibrate slower in the slow direction of the gypsum and faster in the fast direction of the fiber. In this case, the effect is subtractive and the color seen is a first order yellow. As long as the fiber thickness does not add appreciably to the color, the same basic colors will be seen for all asbestos types except crocidolite. In crocidolite the colors will be weaker, may be in the opposite directions, and will be altered by the blue absorption color natural to crocidolite. Hundreds of other materials will give the same colors as asbestos, and therefore, this test is not definitive for asbestos. The test is useful in discriminating against fiberglass or other amorphous fibers such as some synthetic fibers. Certain synthetic fibers will show retardation colors different than asbestos; however, there are some forms of



polyethylene and aramid which will show morphology and retardation colors similar to asbestos minerals. This test must be supplemented with a positive identification test when birefringent fibers are present which can not be excluded by morphology. This test is relatively ineffective for use on fibers less than 1  $\mu\text{m}$  in diameter. For positive confirmation TEM or SEM should be used if no larger bundles or fibers are visible.

#### 4.6. DISPERSION STAINING

Dispersion microscopy or dispersion staining is the method of choice for the identification of asbestos in bulk materials. Becke line analysis is used by some laboratories and yields the same results as does dispersion staining for asbestos and can be used in lieu of dispersion staining. Dispersion staining is performed on the same platform as the phase-polar analysis with the analyzer and compensator removed. One polarizing element remains to define the direction of the light so that the different indices of refraction of the fibers may be separately determined. Dispersion microscopy is a dark-field technique when used for asbestos. Particles are imaged with scattered light. Light which is unscattered is blocked from reaching the eye either by the back field image mask in a McCrone objective or a back field image mask in the phase condenser. The most convenient method is to use the rotating phase condenser to move an oversized phase ring into place. The ideal size for this ring is for the central disk to be just larger than the objective entry aperture as viewed in the back focal plane. The larger the disk, the less scattered light reaches the eye. This will have the effect of diminishing the intensity of dispersion color and will shift the actual color seen. The colors seen vary even on microscopes from the same manufacturer. This is due to the different bands of wavelength exclusion by different mask sizes. The mask may either reside in the condenser or in the objective back focal plane. It is imperative that the analyst determine by experimentation with asbestos standards what the appropriate colors should be for each asbestos type. The colors depend also on the temperature of the preparation and the exact chemistry of the asbestos. Therefore, some slight differences from the standards should be allowed. This is not a serious problem for commercial asbestos uses. This technique is used for identification of the indices of refraction for fibers by recognition of color. There is no direct numerical readout of the index of refraction. Correlation of color to actual index of refraction is possible by referral to published conversion tables. This is not necessary for the analysis of asbestos. Recognition of appropriate colors along with the proper morphology are deemed sufficient to identify the commercial asbestos minerals. Other techniques including SEM, TEM, and XRD may be required to provide additional information in order to identify other types of asbestos.

Make a preparation in the suspected matching high dispersion oil, e.g.,  $n = 1.550$  for chrysotile. Perform the preliminary tests to determine whether the fibers are birefringent or not. Take note of the morphological character. Wavy fibers are indicative of chrysotile while long, straight, thin, frayed fibers are indicative of amphibole asbestos. This can aid in the selection of the appropriate matching oil. The microscope is set up and the polarization direction is noted as in Section 4.4. Align a fiber with the polarization direction. Note the color. This is the color parallel to the polarizer. Then rotate the fiber rotating the stage  $90^\circ$  so that the polarization direction is across the fiber. This is the perpendicular position. Again note the color. Both colors must be consistent with standard asbestos minerals in the correct direction for a positive identification of asbestos. If only one of the colors is correct while the other is not, the identification is not positive. If the colors in both directions are bluish-white, the analyst has chosen a matching index oil which is higher than the correct matching oil, e.g. the analyst has used  $n = 1.620$  where chrysotile is present. The next lower oil (Section 3.5.) should be used to prepare another specimen. If the color in both directions is yellow-white to straw-yellow-white, this indicates that the index of the oil is lower than the index of the fiber, e.g. the preparation is in  $n = 1.550$  while anthophyllite is present. Select the next higher oil (Section 3.5.) and prepare another slide. Continue in this fashion until a positive identification of all asbestos species present has been made or all



possible asbestos species have been ruled out by negative results in this test. Certain plant fibers can have similar dispersion colors as asbestos. Take care to note and evaluate the morphology of the fibers or remove the plant fibers in pre-preparation. Coating material on the fibers such as carbonate or vinyl may destroy the dispersion color. Usually, there will be some outcropping of fiber which will show the colors sufficient for identification. When this is not the case, treat the sample as described in Section 3.3. and then perform dispersion staining. Some samples will yield to Becke line analysis if they are coated or electron microscopy can be used for identification.

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## Appendix L to § 1915.1001—Work Practices and Engineering Controls for Automotive Brake and Clutch Inspection, Disassembly, Repair and Assembly—Mandatory

This mandatory appendix specifies engineering controls and work practices that must be implemented by the employer during automotive brake and clutch inspection, disassembly, repair, and assembly operations. Proper use of these engineering controls and work practices by trained employees will reduce employees' asbestos exposure below the permissible exposure level during clutch and brake inspection, disassembly, repair, and assembly operations. The employer shall institute engineering controls and work practices using either the method set forth in paragraph [A] or paragraph [B] of this appendix, or any other method which the employer can demonstrate to be equivalent in terms of reducing employee exposure to asbestos as defined and which meets the requirements described in paragraph [C] of this appendix, for those facilities in which no more than 5 pairs of brakes or 5 clutches are inspected, disassembled, reassembled and/or repaired per week, the method set forth in paragraph [D] of this appendix may be used:

### [A] Negative Pressure Enclosure/HEPA Vacuum System Method

- (1) The brake and clutch inspection, disassembly, repair, and assembly operations shall be enclosed to cover and contain the clutch or brake assembly and to prevent the release of asbestos fibers into the worker's breathing zone.
- (2) The enclosure shall be sealed tightly and thoroughly inspected for leaks before work begins on brake and clutch inspection, disassembly, repair, and assembly.

- (3) The enclosure shall be such that the worker can clearly see the operation and shall provide impermeable sleeves through which the worker can handle the brake and clutch inspection, disassembly, repair and assembly. The integrity of the sleeves and ports shall be examined before work begins.
- (4) A HEPA-filtered vacuum shall be employed to maintain the enclosure under negative pressure throughout the operation. Compressed-air may be used to remove asbestos fibers or particles from the enclosure.
- (5) The HEPA vacuum shall be used first to loosen the asbestos containing residue from the brake and clutch parts and then to evacuate the loosened asbestos containing material from the enclosure and capture the material in the vacuum filter.
- (6) The vacuum's filter, when full, shall be first wetted with a fine mist of water, then removed and placed immediately in an impermeable container, labeled according to paragraph (k)(8) of this section and disposed of according to paragraph (l) of this section.
- (7) Any spills or releases of asbestos containing waste material from inside of the enclosure or vacuum hose or vacuum filter shall be immediately cleaned up and disposed of according to paragraph (l) of the section.

#### [B] Low Pressure/Wet Cleaning Method

- (1) A catch basin shall be placed under the brake assembly, positioned to avoid splashes and spills.
- (2) The reservoir shall contain water containing an organic solvent or wetting agent. The flow of liquid shall be controlled such that the brake assembly is gently flooded to prevent the asbestos-containing brake dust from becoming airborne.
- (3) The aqueous solution shall be allowed to flow between the brake drum and brake support before the drum is removed.
- (4) After removing the brake drum, the wheel hub and back of the brake assembly shall be thoroughly wetted to suppress dust.
- (5) The brake support plate, brake shoes and brake components used to attach the brake shoes shall be thoroughly washed before removing the old shoes.
- (6) In systems using filters, the filters, when full, shall be first wetted with a fine mist of water, then removed and placed immediately in an impermeable container, labeled according to paragraph (k)(8) of this section and disposed of according to paragraph (l) of this section.
- (7) Any spills of asbestos-containing aqueous solution or any asbestos-containing waste material shall be cleaned up immediately and disposed of according to paragraph (l) of this section.
- (8) The use of dry brushing during low pressure/wet cleaning operations is prohibited.

### [C] Equivalent Methods

An equivalent method is one which has sufficient written detail so that it can be reproduced and has been demonstrated that the exposures resulting from the equivalent method are equal to or less than the exposures which would result from the use of the method described in paragraph [A] of this appendix. For purposes of making this comparison, the employer shall assume that exposures resulting from the use of the method described in paragraph [A] of this appendix shall not exceed 0.016 f/cc, as measured by the OSHA reference method and as averaged over at least 18 personal samples.

### [D] Wet Method

(1) A spray bottle, hose nozzle, or other implement capable of delivering a fine mist of water or amended water or other delivery system capable of delivering water at low pressure, shall be used to first thoroughly wet the brake and clutch parts. Brake and clutch components shall then be wiped clean with a cloth.

(2) The cloth shall be placed in an impermeable container, labelled according to paragraph (k)(8) of this section and then disposed of according to paragraph (l) of this section, or the cloth shall be laundered in a way to prevent the release of asbestos fibers in excess of 0.1 fiber per cubic centimeter of air.

(3) Any spills of solvent or any asbestos containing waste material shall be cleaned up immediately according to paragraph (l) of this section.

(4) The use of dry brushing during the wet method operations is prohibited.

*[59 FR 41080, Aug. 10, 1994, as amended at 60 FR 33344, June 28, 1995; 60 FR 33987, June 29, 1995; 60 FR 36044, July 13, 1995; 60 FR 50412, Sept. 29, 1995; 61 FR 43457, Aug. 23, 1996; 63 FR 35137, June 29, 1998; 67 FR 44545, 44546, July 3, 2002; 70 FR 1143, Jan. 5, 2005; 71 FR 16674, Apr. 3, 2006; 71 FR 50191, Aug. 24, 2006; 73 FR 75587, Dec. 12, 2009; 76 FR 33610, June 8, 2011; 77 FR 17888, Mar. 26, 2012; 78 FR 9315, Feb. 8, 2013; 84 FR 21555, 12597, May 14, 2019]*

## § 1915.1002 Coal tar pitch volatiles; interpretation of term.

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1002 of this chapter.

*[61 FR 31430, June 20, 1996]*

## § 1915.1003 13 carcinogens (4-Nitrobiphenyl, etc.).

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1003 of this chapter.

*[61 FR 31430, June 20, 1996]*

### **§ 1915.1004 alpha-Naphthylamine.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1003 of this chapter.

[61 FR 31430, June 20, 1996]

### **§ 1915.1005 [Reserved]**

### **§ 1915.1006 Methyl chloromethyl ether.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1003 of this chapter.

[61 FR 31430, June 20, 1996]

### **§ 1915.1007 3,3'-Dichlorobenzidienne (and its salts).**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1003 of this chapter.

[61 FR 31430, June 20, 1996]

### **§ 1915.1008 bis-Chloromethyl ether.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1003 of this chapter.

[61 FR 31430, June 20, 1996]

### **§ 1915.1009 beta-Naphthylamine.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1003 of this chapter.

[61 FR 31430, June 20, 1996]

### **§ 1915.1010 Benzidine.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1003 of this chapter.

[61 FR 31430, June 20, 1996]

#### **§ 1915.1011 4-Aminodiphenyl.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1003 of this chapter.

[61 FR 31430, June 20, 1996]

#### **§ 1915.1012 Ethyleneimine.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1003 of this chapter.

[61 FR 31430, June 20, 1996]

#### **§ 1915.1013 beta-Propiolactone.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1003 of this chapter.

[61 FR 31430, June 20, 1996]

#### **§ 1915.1014 2-Acetylaminofluorene.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1003 of this chapter.

[61 FR 31430, June 20, 1996]

#### **§ 1915.1015 4-Dimethylaminoazobenzene.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1003 of this chapter.

[61 FR 31430, June 20, 1996]

#### **§ 1915.1016 N-Nitrosodimethylamine.**

Note: The requirements applicable to shipyard employment under this section are identical to

those set forth at § 1910.1003 of this chapter.

[61 FR 31430, June 20, 1996]

### § 1915.1017 Vinyl chloride.

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1017 of this chapter.

[61 FR 31430, June 20, 1996]

### § 1915.1018 Inorganic arsenic.

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1018 of this chapter.

[61 FR 31431, June 20, 1996]

### § 1915.1020 Access to employee exposure and medical records.

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1020 of this chapter.

[61 FR 31431, June 20, 1996]

### § 1915.1024 Beryllium.

#### (a) *Scope and application.*

- (1) This standard applies to occupational exposure to beryllium in all forms, compounds, and mixtures in shipyards, except those articles and materials exempted by paragraphs (a)(2) and (a)(3) of this standard.
- (2) This standard does not apply to articles, as defined in the Hazard Communication standard (HCS) (29 CFR 1910.1200(c)), that contain beryllium and that the employer does not process.
- (3) This standard does not apply to materials containing less than 0.1% beryllium by weight where the employer has objective data demonstrating that employee exposure to beryllium will remain below the action level as an 8-hour TWA under any foreseeable conditions.

#### (b) *Definitions.* As used in this standard:

**Action level** means a concentration of airborne beryllium of 0.1 micrograms per cubic meter of air ( $\mu\text{g}/\text{m}^3$ ) calculated as an 8-hour time-weighted average (TWA).

*Airborne exposure* and *airborne exposure to beryllium* mean the exposure to airborne beryllium that would occur if the employee were not using a respirator.

*Assistant Secretary* means the Assistant Secretary of Labor for Occupational Safety and Health, United States Department of Labor, or designee.

*Beryllium lymphocyte proliferation test (BeLPT)* means the measurement of blood lymphocyte proliferation in a laboratory test when lymphocytes are challenged with a soluble beryllium salt.

*Beryllium sensitization* means a response in the immune system of a specific individual who has been exposed to beryllium. There are no associated physical or clinical symptoms and no illness or disability with beryllium sensitization alone, but the response that occurs through beryllium sensitization can enable the immune system to recognize and react to beryllium. While not every beryllium-sensitized person will develop chronic beryllium disease (CBD), beryllium sensitization is essential for development of CBD.

*CBD diagnostic center* means a medical diagnostic center that has a pulmonologist or pulmonary specialist on staff and on-site facilities to perform a clinical evaluation for the presence of chronic beryllium disease (CBD). The CBD diagnostic center must have the capacity to perform pulmonary function testing (as outlined by the American Thoracic Society criteria), bronchoalveolar lavage (BAL), and transbronchial biopsy. The CBD diagnostic center must also have the capacity to transfer BAL samples to a laboratory for appropriate diagnostic testing within 24 hours. The pulmonologist or pulmonary specialist must be able to interpret the biopsy pathology and the BAL diagnostic test results.

*Chronic beryllium disease (CBD)* means a chronic granulomatous lung disease caused by inhalation of airborne beryllium by an individual who is beryllium-sensitized.

*Confirmed positive* means the person tested has had two abnormal BeLPT test results, an abnormal and a borderline test result, or three borderline test results from tests conducted within a 3-year period. It also means the result of a more reliable and accurate test indicating a person has been identified as having beryllium sensitization.

*Director* means the Director of the National Institute for Occupational Safety and Health (NIOSH), U.S. Department of Health and Human Services, or designee.

*Objective data* means information, such as air monitoring data from industry-wide surveys or calculations based on the composition of a substance, demonstrating airborne exposure to beryllium associated with a particular product or material or a specific process, task, or activity. The data must reflect workplace conditions closely resembling or with a higher airborne exposure potential than the processes, types of material, control methods, work practices, and environmental conditions in the employer's current operations.

*Physician or other licensed health care professional (PLHCP)* means an individual whose legally permitted scope of practice (i.e., license, registration, or certification) allows the individual to independently provide or be delegated the responsibility to provide some or all of the health care services required by paragraph (k) of this standard.

*Regulated area* means an area, including temporary work areas where maintenance or non-routine tasks are performed, where an employee's airborne exposure exceeds, or can reasonably be expected to exceed, either the time-weighted average (TWA) permissible exposure limit (PEL) or short term exposure limit (STEL).



*This standard* means this beryllium standard, 29 CFR 1915.1024.

(c) **Permissible Exposure Limits (PELs)** –

- (1) **Time-weighted average (TWA) PEL.** The employer must ensure that no employee is exposed to an airborne concentration of beryllium in excess of  $0.2 \mu\text{g}/\text{m}^3$  calculated as an 8-hour TWA.
- (2) **Short-term exposure limit (STEL).** The employer must ensure that no employee is exposed to an airborne concentration of beryllium in excess of  $2.0 \mu\text{g}/\text{m}^3$  as determined over a sampling period of 15 minutes.

(d) **Exposure assessment** –

- (1) **General.** The employer must assess the airborne exposure of each employee who is or may reasonably be expected to be exposed to airborne beryllium in accordance with either the performance option in paragraph (d)(2) or the scheduled monitoring option in paragraph (d)(3) of this standard.
- (2) **Performance option.** The employer must assess the 8-hour TWA exposure and the 15-minute short-term exposure for each employee on the basis of any combination of air monitoring data and objective data sufficient to accurately characterize airborne exposure to beryllium.
- (3) **Scheduled monitoring option.**
  - (i) The employer must perform initial monitoring to assess the 8-hour TWA exposure for each employee on the basis of one or more personal breathing zone air samples that reflect the airborne exposure of employees on each shift, for each job classification, and in each work area.
  - (ii) The employer must perform initial monitoring to assess the short-term exposure from 15-minute personal breathing zone air samples measured in operations that are likely to produce airborne exposure above the STEL for each work shift, for each job classification, and in each work area.
  - (iii) Where several employees perform the same tasks on the same shift and in the same work area, the employer may sample a representative fraction of these employees in order to meet the requirements of paragraph (d)(3) of this standard. In representative sampling, the employer must sample the employee(s) expected to have the highest airborne exposure to beryllium.
  - (iv) If initial monitoring indicates that airborne exposure is below the action level and at or below the STEL, the employer may discontinue monitoring for those employees whose airborne exposure is represented by such monitoring.
  - (v) Where the most recent exposure monitoring indicates that airborne exposure is at or above the action level but at or below the TWA PEL, the employer must repeat such monitoring within six months of the most recent monitoring.
  - (vi) Where the most recent exposure monitoring indicates that airborne exposure is above the TWA PEL, the employer must repeat such monitoring within three months of the most recent 8-hour TWA exposure monitoring.
  - (vii) Where the most recent (non-initial) exposure monitoring indicates that airborne exposure is below the action level, the employer must repeat such monitoring within six months of the most recent monitoring until two consecutive measurements, taken 7 or more days apart, are below

the action level, at which time the employer may discontinue 8-hour TWA exposure monitoring for those employees whose exposure is represented by such monitoring, except as otherwise provided in paragraph (d)(4) of this standard.

(viii) Where the most recent exposure monitoring indicates that airborne exposure is above the STEL, the employer must repeat such monitoring within three months of the most recent short-term exposure monitoring until two consecutive measurements, taken 7 or more days apart, are below the STEL, at which time the employer may discontinue short-term exposure monitoring for those employees whose exposure is represented by such monitoring, except as otherwise provided in paragraph (d)(4) of this standard.

(4) **Reassessment of exposure.** The employer must reassess airborne exposure whenever a change in the production, process, control equipment, personnel, or work practices may reasonably be expected to result in new or additional airborne exposure at or above the action level or STEL, or when the employer has any reason to believe that new or additional airborne exposure at or above the action level or STEL has occurred.

(5) **Methods of sample analysis.** The employer must ensure that all air monitoring samples used to satisfy the monitoring requirements of paragraph (d) of this standard are evaluated by a laboratory that can measure beryllium to an accuracy of plus or minus 25 percent within a statistical confidence level of 95 percent for airborne concentrations at or above the action level.

(6) **Employee notification of assessment results.**

(i) Within 15 working days after completing an exposure assessment in accordance with paragraph (d) of this standard, the employer must notify each employee whose airborne exposure is represented by the assessment of the results of that assessment individually in writing or post the results in an appropriate location that is accessible to each of these employees.

(ii) Whenever an exposure assessment indicates that airborne exposure is above the TWA PEL or STEL, the employer must describe in the written notification the corrective action being taken to reduce airborne exposure to or below the exposure limit(s) exceeded where feasible corrective action exists but had not been implemented when the monitoring was conducted.

(7) **Observation of monitoring.**

(i) The employer must provide an opportunity to observe any exposure monitoring required by this standard to each employee whose airborne exposure is measured or represented by the monitoring and each employee's representative(s).

(ii) When observation of monitoring requires entry into an area where the use of personal protective clothing or equipment (which may include respirators) is required, the employer must provide each observer with appropriate personal protective clothing and equipment at no cost to the observer and must ensure that each observer uses such clothing and equipment.

(iii) The employer must ensure that each observer follows all other applicable safety and health procedures.

(e) **Regulated areas —**

- (1) **Establishment.** The employer must establish and maintain a regulated area wherever employees are, or can reasonably be expected to be, exposed to airborne beryllium at levels above the TWA PEL or STEL.
- (2) **Demarcation.** The employer must identify each regulated area in accordance with paragraph (m)(2) of this standard.
- (3) **Access.** The employer must limit access to regulated areas to:
  - (i) Persons the employer authorizes or requires to be in a regulated area to perform work duties;
  - (ii) Persons entering a regulated area as designated representatives of employees for the purpose of exercising the right to observe exposure monitoring procedures under paragraph (d)(7) of this standard; and
  - (iii) Persons authorized by law to be in a regulated area.
- (4) **Provision of personal protective clothing and equipment, including respirators.** The employer must provide and ensure that each employee entering a regulated area uses:
  - (i) Respiratory protection in accordance with paragraph (g) of this standard; and
  - (ii) Personal protective clothing and equipment in accordance with paragraph (h) of this standard.
- (f) **Methods of compliance —**
  - (1) **Written exposure control plan.**
    - (i) The employer must establish, implement, and maintain a written exposure control plan, which must contain:
      - (A) A list of operations and job titles reasonably expected to involve exposure to beryllium;
      - (B) A list of engineering controls, work practices, and respiratory protection required by paragraph (f)(2) of this standard;
      - (C) A list of personal protective clothing and equipment required by paragraph (h) of this standard;
      - (D) Procedures used to ensure the integrity of each containment used to minimize exposures to employees outside of the containment; and
      - (E) Procedures for removing, cleaning, and maintaining personal protective clothing and equipment in accordance with paragraph (h) of this standard.
    - (ii) The employer must review and evaluate the effectiveness of each written exposure control plan at least annually and update it, as necessary, when:
      - (A) Any change in production processes, materials, equipment, personnel, work practices, or control methods results, or can reasonably be expected to result, in new or additional airborne exposure to beryllium;
      - (B) The employer is notified that an employee is eligible for medical removal in accordance with paragraph (l)(1) of this standard, referred for evaluation at a CBD diagnostic center, or shows signs or symptoms associated with exposure to beryllium; or

- (C) The employer has any reason to believe that new or additional airborne exposure is occurring or will occur.
- (iii) The employer must make a copy of the written exposure control plan accessible to each employee who is, or can reasonably be expected to be, exposed to airborne beryllium in accordance with OSHA's Access to Employee Exposure and Medical Records (Records Access) standard (29 CFR 1910.1020(e)).
- (2) **Engineering and work practice controls.** The employer must use engineering and work practice controls to reduce and maintain employee airborne exposure to beryllium to or below the TWA PEL and STEL, unless the employer can demonstrate that such controls are not feasible. Wherever the employer demonstrates that it is not feasible to reduce airborne exposure to or below the PELs with engineering and work practice controls, the employer must implement and maintain engineering and work practice controls to reduce airborne exposure to the lowest levels feasible and supplement these controls by using respiratory protection in accordance with paragraph (g) of this standard.
- (3) **Prohibition of rotation.** The employer must not rotate employees to different jobs to achieve compliance with the PELs.

(g) **Respiratory protection —**

- (1) **General.** The employer must provide respiratory protection at no cost to the employee and ensure that each employee uses respiratory protection:
  - (i) During periods necessary to install or implement feasible engineering and work practice controls where airborne exposure exceeds, or can reasonably be expected to exceed, the TWA PEL or STEL;
  - (ii) During operations, including maintenance and repair activities and non-routine tasks, when engineering and work practice controls are not feasible and airborne exposure exceeds, or can reasonably be expected to exceed, the TWA PEL or STEL;
  - (iii) During operations for which an employer has implemented all feasible engineering and work practice controls when such controls are not sufficient to reduce airborne exposure to or below the TWA PEL or STEL; and
  - (iv) When an employee who is eligible for medical removal under paragraph (l)(1) chooses to remain in a job with airborne exposure at or above the action level, as permitted by paragraph (l)(2)(ii).
- (2) **Respiratory protection program.** Where this standard requires an employer to provide respiratory protection, the selection and use of such respiratory protection must be in accordance with the Respiratory Protection standard (29 CFR 1910.134).
- (3) The employer must provide at no cost to the employee a powered air-purifying respirator (PAPR) instead of a negative pressure respirator when:
  - (i) Respiratory protection is required by this standard;
  - (ii) An employee entitled to such respiratory protection requests a PAPR; and
  - (iii) The PAPR provides adequate protection to the employee in accordance with paragraph (g)(2) of this standard.

(h) **Personal protective clothing and equipment —**

- (1) **Provision and use.** Where airborne exposure exceeds, or can reasonably be expected to exceed, the TWA PEL or STEL, the employer must provide at no cost, and ensure that each employee uses, appropriate personal protective clothing and equipment in accordance with the written exposure control plan required under paragraph (f)(1) of this standard and OSHA's Personal Protective Equipment standards for shipyards (subpart I of this part).
- (2) **Removal of personal protective clothing and equipment.**
  - (i) The employer must ensure that each employee removes all personal protective clothing and equipment required by this standard at the end of the work shift or at the completion of all tasks involving beryllium, whichever comes first.
  - (ii) The employer must ensure that personal protective clothing and equipment required by this standard is not removed in a manner that disperses beryllium into the air, and is removed as specified in the written exposure control plan required by paragraph (f)(1) of this standard.
  - (iii) The employer must ensure that no employee with reasonably expected exposure above the TWA PEL or STEL removes personal protective clothing and equipment required by this standard from the workplace unless it has been cleaned in accordance with paragraph (h)(3)(ii) of this standard.
- (3) **Cleaning and replacement.**
  - (i) The employer must ensure that all reusable personal protective clothing and equipment required by this standard is cleaned, laundered, repaired, and replaced as needed to maintain its effectiveness.
  - (ii) The employer must ensure that beryllium is not removed from personal protective clothing and equipment required by this standard by blowing, shaking, or any other means that disperses beryllium into the air.
- (i) [Reserved]
- (j) **Housekeeping.**
  - (1) When cleaning dust resulting from operations that cause, or can reasonably be expected to cause, airborne exposure above the TWA PEL or STEL, the employer must ensure the use of methods that minimize the likelihood and level of airborne exposure.
  - (2) The employer must not allow dry sweeping or brushing for cleaning up dust resulting from operations that cause, or can reasonably be expected to cause, airborne exposure above the TWA PEL or STEL unless methods that minimize the likelihood and level of airborne exposure are not safe or effective.
  - (3) The employer must not allow the use of compressed air for cleaning where the use of compressed air causes, or can reasonably be expected to cause, airborne exposure above the TWA PEL or STEL.
  - (4) Where employees use dry sweeping, brushing, or compressed air to clean, the employer must provide, and ensure that each employee uses, respiratory protection and personal protective clothing and equipment in accordance with paragraphs (g) and (h) of this standard.
  - (5) The employer must ensure that cleaning equipment is handled and maintained in a manner that minimizes the likelihood and level of airborne exposure and the re-entrainment of airborne beryllium in the workplace.

(k) **Medical surveillance** —

(1) **General.**

- (i) The employer must make medical surveillance required by this paragraph available at no cost to the employee, and at a reasonable time and place, to each employee:
  - (A) Who is or is reasonably expected to be exposed at or above the action level for more than 30 days per year;
  - (B) Who shows signs or symptoms of CBD or other beryllium-related health effects; or
  - (C) Whose most recent written medical opinion required by paragraph (k)(6) or (k)(7) recommends periodic medical surveillance.
- (ii) The employer must ensure that all medical examinations and procedures required by this standard are performed by, or under the direction of, a licensed physician.

(2) **Frequency.** The employer must provide a medical examination:

- (i) Within 30 days after determining that:
  - (A) An employee meets the criteria of paragraph (k)(1)(i)(A) of this standard, unless the employee has received a medical examination, provided in accordance with this standard, within the last two years; or
  - (B) An employee meets the criteria of paragraph (k)(1)(i)(B) of this standard.
- (ii) At least every two years thereafter for each employee who continues to meet the criteria of paragraph (k)(1)(i)(A), (B), or (C) of this standard.
- (iii) At the termination of employment for each employee who meets any of the criteria of paragraph (k)(1)(i) of this standard at the time the employee's employment terminates, unless an examination has been provided in accordance with this standard during the six months prior to the date of termination.

(3) **Contents of examination.**

- (i) The employer must ensure that the PLHCP conducting the examination advises the employee of the risks and benefits of participating in the medical surveillance program and the employee's right to opt out of any or all parts of the medical examination.
- (ii) The employer must ensure that the employee is offered a medical examination that includes:
  - (A) A medical and work history, with emphasis on past and present exposure to beryllium, smoking history, and any history of respiratory system dysfunction;
  - (B) A physical examination with emphasis on the respiratory system;
  - (C) A physical examination for skin rashes;
  - (D) Pulmonary function tests, performed in accordance with the guidelines established by the American Thoracic Society including forced vital capacity (FVC) and forced expiratory volume in one second (FEV<sub>1</sub>);

- (E) A standardized BeLPT or equivalent test, upon the first examination and at least every two years thereafter, unless the employee is confirmed positive. If the results of the BeLPT are other than normal, a follow-up BeLPT must be offered within 30 days, unless the employee has been confirmed positive. Samples must be analyzed in a laboratory certified under the College of American Pathologists/Clinical Laboratory Improvement Amendments (CLIA) guidelines to perform the BeLPT.
  - (F) A low dose computed tomography (LDCT) scan, when recommended by the PLHCP after considering the employee's history of exposure to beryllium along with other risk factors, such as smoking history, family medical history, sex, age, and presence of existing lung disease; and
  - (G) Any other test deemed appropriate by the PLHCP.
- (4) **Information provided to the PLHCP.** The employer must ensure that the examining PLHCP (and the agreed-upon CBD diagnostic center, if an evaluation is required under paragraph (k)(7) of this standard) has a copy of this standard and must provide the following information, if known:
- (i) A description of the employee's former and current duties that relate to the employee's exposure to beryllium;
  - (ii) The employee's former and current levels of airborne exposure;
  - (iii) A description of any personal protective clothing and equipment, including respirators, used by the employee, including when and for how long the employee has used that personal protective clothing and equipment; and
  - (iv) Information from records of employment-related medical examinations previously provided to the employee, currently within the control of the employer, after obtaining written consent from the employee.
- (5) **Licensed physician's written medical report for the employee.** The employer must ensure that the employee receives a written medical report from the licensed physician within 45 days of the examination (including any follow-up BeLPT required under paragraph (k)(3)(ii)(E) of this standard) and that the PLHCP explains the results of the examination to the employee. The written medical report must contain:
- (i) A statement indicating the results of the medical examination, including the licensed physician's opinion as to whether the employee has:
    - (A) Any detected medical condition, such as CBD or beryllium sensitization (*i.e.*, the employee is confirmed positive, as defined in paragraph (b) of this standard), that may place the employee at increased risk from further airborne exposure, and
    - (B) Any medical conditions related to airborne exposure that require further evaluation or treatment.
  - (ii) Any recommendations on:
    - (A) The employee's use of respirators, protective clothing, or equipment; or
    - (B) Limitations on the employee's airborne exposure to beryllium.

- (iii) If the employee is confirmed positive or diagnosed with CBD or if the licensed physician otherwise deems it appropriate, the written report must also contain a referral for an evaluation at a CBD diagnostic center.
- (iv) If the employee is confirmed positive or diagnosed with CBD the written report must also contain a recommendation for continued periodic medical surveillance.
- (v) If the employee is confirmed positive or diagnosed with CBD the written report must also contain a recommendation for medical removal from airborne exposure to beryllium, as described in paragraph (l).

(6) ***Licensed physician's written medical opinion for the employer.***

- (i) The employer must obtain a written medical opinion from the licensed physician within 45 days of the medical examination (including any follow-up BeLPT required under paragraph (k)(3)(ii)(E) of this standard). The written medical opinion must contain only the following:
  - (A) The date of the examination;
  - (B) A statement that the examination has met the requirements of this standard;
  - (C) Any recommended limitations on the employee's use of respirators, protective clothing, or equipment; and
  - (D) A statement that the PLHCP has explained the results of the medical examination to the employee, including any tests conducted, any medical conditions related to airborne exposure that require further evaluation or treatment, and any special provisions for use of personal protective clothing or equipment;
- (ii) If the employee provides written authorization, the written opinion must also contain any recommended limitations on the employee's airborne exposure to beryllium.
- (iii) If the employee is confirmed positive or diagnosed with CBD or if the licensed physician otherwise deems it appropriate, and the employee provides written authorization, the written opinion must also contain a referral for an evaluation at a CBD diagnostic center.
- (iv) If the employee is confirmed positive or diagnosed with CBD and the employee provides written authorization, the written opinion must also contain a recommendation for continued periodic medical surveillance.
- (v) If the employee is confirmed positive or diagnosed with CBD and the employee provides written authorization, the written opinion must also contain a recommendation for medical removal from airborne exposure to beryllium, as described in paragraph (l).
- (vi) The employer must ensure that each employee receives a copy of the written medical opinion described in paragraph (k)(6) of this standard within 45 days of any medical examination (including any follow-up BeLPT required under paragraph (k)(3)(ii)(E) of this standard) performed for that employee.

(7) ***CBD diagnostic center.***

- (i) The employer must provide an evaluation at no cost to the employee at a CBD diagnostic center that is mutually agreed upon by the employer and the employee. The evaluation at the CBD diagnostic center must be scheduled within 30 days, and must occur within a reasonable time, of:



- (A) The employer's receipt of a physician's written medical opinion to the employer that recommends referral to a CBD diagnostic center; or
  - (B) The employee presenting to the employer a physician's written medical report indicating that the employee has been confirmed positive or diagnosed with CBD, or recommending referral to a CBD diagnostic center.
- (ii) The employer must ensure that, as part of the evaluation, the employee is offered any tests deemed appropriate by the examining physician at the CBD diagnostic center, such as pulmonary function testing (as outlined by the American Thoracic Society criteria), bronchoalveolar lavage (BAL), and transbronchial biopsy. If any of the tests deemed appropriate by the examining physician are not available at the CBD diagnostic center, they may be performed at another location that is mutually agreed upon by the employer and the employee.
  - (iii) The employer must ensure that the employee receives a written medical report from the CBD diagnostic center that contains all the information required in paragraph (k)(5)(i), (ii), (iv), and (v) and that the PLHCP explains the results of the examination to the employee within 30 days of the examination.
  - (iv) The employer must obtain a written medical opinion from the CBD diagnostic center within 30 days of the medical examination. The written medical opinion must contain only the information in paragraphs (k)(6)(i), as applicable, unless the employee provides written authorization to release additional information. If the employee provides written authorization, the written opinion must also contain the information from paragraphs (k)(6)(ii), (iv), and (v), if applicable.
  - (v) The employer must ensure that each employee receives a copy of the written medical opinion from the CBD diagnostic center described in paragraph (k)(7) of this standard within 30 days of any medical examination performed for that employee.
  - (vi) After an employee has received the initial clinical evaluation at a CBD diagnostic center described in paragraph (k)(7)(i) of this standard, the employee may choose to have any subsequent medical examinations for which the employee is eligible under paragraph (k) of this standard performed at a CBD diagnostic center mutually agreed upon by the employer and the employee, and the employer must provide such examinations at no cost to the employee.

(l) **Medical removal.**

- (1) An employee is eligible for medical removal, if the employee works in a job with airborne exposure at or above the action level and either:
  - (i) The employee provides the employer with:
    - (A) A written medical report indicating a confirmed positive finding or CBD diagnosis; or
    - (B) A written medical report recommending removal from airborne exposure to beryllium in accordance with paragraph (k)(5)(v) or (k)(7)(ii) of this standard; or
  - (ii) The employer receives a written medical opinion recommending removal from airborne exposure to beryllium in accordance with paragraph (k)(6)(v) or (k)(7)(iii) of this standard.
- (2) If an employee is eligible for medical removal, the employer must provide the employee with the employee's choice of:

- (i) Removal as described in paragraph (l)(3) of this standard; or
- (ii) Remaining in a job with airborne exposure at or above the action level, provided that the employer provides, and ensures that the employee uses, respiratory protection that complies with paragraph (g) of this standard whenever airborne exposures are at or above the action level.

(3) If the employee chooses removal:

- (i) If a comparable job is available where airborne exposures to beryllium are below the action level, and the employee is qualified for that job or can be trained within one month, the employer must remove the employee to that job. The employer must maintain for six months from the time of removal the employee's base earnings, seniority, and other rights and benefits that existed at the time of removal.
- (ii) If comparable work is not available, the employer must maintain the employee's base earnings, seniority, and other rights and benefits that existed at the time of removal for six months or until such time that comparable work described in paragraph (l)(3)(i) becomes available, whichever comes first.

(4) The employer's obligation to provide medical removal protection benefits to a removed employee shall be reduced to the extent that the employee receives compensation for earnings lost during the period of removal from a publicly or employer-funded compensation program, or receives income from another employer made possible by virtue of the employee's removal.

(m) **Communication of hazards —**

(1) **General.**

- (i) Chemical manufacturers, importers, distributors, and employers must comply with all requirements of the HCS (29 CFR 1910.1200) for beryllium.
- (ii) Employers must include beryllium in the hazard communication program established to comply with the HCS. Employers must ensure that each employee has access to labels on containers of beryllium and to safety data sheets, and is trained in accordance with the requirements of the HCS (29 CFR 1910.1200) and paragraph (m)(3) of this standard.

(2) **Warning signs.**

- (i) **Posting.** The employer must provide and display warning signs at each approach to a regulated area so that each employee is able to read and understand the signs and take necessary protective steps before entering the area.
- (ii) **Sign specification.**
  - (A) The employer must ensure that the warning signs required by paragraph (m)(2)(i) of this standard are legible and readily visible.
  - (B) The employer must ensure each warning sign required by paragraph (m)(2)(i) of this standard bears the following legend:

DANGER

REGULATED AREA

BERYLLIUM

MAY CAUSE CANCER

CAUSES DAMAGE TO LUNGS

AUTHORIZED PERSONNEL ONLY

WEAR RESPIRATORY PROTECTION AND PERSONAL PROTECTIVE CLOTHING AND EQUIPMENT  
IN THIS AREA

**(3) Employee information and training.**

- (i) For each employee who has, or can reasonably be expected to have, airborne exposure to beryllium:
  - (A) The employer must provide information and training in accordance with the HCS (29 CFR 1910.1200(h));
  - (B) The employer must provide initial training to each employee by the time of initial assignment; and
  - (C) The employer must repeat the training required under this standard annually for each employee.
- (ii) The employer must ensure that each employee who is, or can reasonably be expected to be, exposed to airborne beryllium can demonstrate knowledge and understanding of the following:
  - (A) The health hazards associated with exposure to beryllium, including the signs and symptoms of CBD;
  - (B) The written exposure control plan, with emphasis on the location(s) of any regulated areas, and the specific nature of operations that could result in airborne exposure, especially airborne exposure above the TWA PEL or STEL;
  - (C) The purpose, proper selection, fitting, proper use, and limitations of personal protective clothing and equipment, including respirators;
  - (D) Measures employees can take to protect themselves from exposure to beryllium;
  - (E) The purpose and a description of the medical surveillance program required by paragraph (k) of this standard including risks and benefits of each test to be offered;
  - (F) The purpose and a description of the medical removal protection provided under paragraph (l) of this standard;
  - (G) The contents of the standard; and
  - (H) The employee's right of access to records under the Records Access standard (29 CFR 1910.1020).

- (iii) When a workplace change (such as modification of equipment, tasks, or procedures) results in new or increased airborne exposure that exceeds, or can reasonably be expected to exceed, either the TWA PEL or the STEL, the employer must provide additional training to those employees affected by the change in airborne exposure.
- (iv) The employer must make a copy of this standard and its appendices readily available at no cost to each employee and designated employee representative(s).

(n) **Recordkeeping –**

(1) **Air monitoring data.**

- (i) The employer must make and maintain a record of all exposure measurements taken to assess airborne exposure as prescribed in paragraph (d) of this standard.
- (ii) This record must include at least the following information:
  - (A) The date of measurement for each sample taken;
  - (B) The task that is being monitored;
  - (C) The sampling and analytical methods used and evidence of their accuracy;
  - (D) The number, duration, and results of samples taken;
  - (E) The type of personal protective clothing and equipment, including respirators, worn by monitored employees at the time of monitoring; and
  - (F) The name and job classification of each employee represented by the monitoring, indicating which employees were actually monitored.
- (iii) The employer must ensure that exposure records are maintained and made available in accordance with the Records Access standard (29 CFR 1910.1020).

(2) **Objective data.**

- (i) Where an employer uses objective data to satisfy the exposure assessment requirements under paragraph (d)(2) of this standard, the employer must make and maintain a record of the objective data relied upon.
- (ii) This record must include at least the following information:
  - (A) The data relied upon;
  - (B) The beryllium-containing material in question;
  - (C) The source of the objective data;
  - (D) A description of the process, task, or activity on which the objective data were based; and
  - (E) Other data relevant to the process, task, activity, material, or airborne exposure on which the objective data were based.
- (iii) The employer must ensure that objective data are maintained and made available in accordance with the Records Access standard (29 CFR 1910.1020).

(3) **Medical surveillance.**

- (i) The employer must make and maintain a record for each employee covered by medical surveillance under paragraph (k) of this standard.
- (ii) The record must include the following information about each employee:
  - (A) Name and job classification;
  - (B) A copy of all licensed physicians' written medical opinions for each employee; and
  - (C) A copy of the information provided to the PLHCP as required by paragraph (k)(4) of this standard.
- (iii) The employer must ensure that medical records are maintained and made available in accordance with the Records Access standard (29 CFR 1910.1020).

(4) **Training.**

- (i) At the completion of any training required by this standard, the employer must prepare a record that indicates the name and job classification of each employee trained, the date the training was completed, and the topic of the training.
- (ii) This record must be maintained for three years after the completion of training.

(5) **Access to records.** Upon request, the employer must make all records maintained as a requirement of this standard available for examination and copying to the Assistant Secretary, the Director, each employee, and each employee's designated representative(s) in accordance the Records Access standard (29 CFR 1910.1020).

(6) **Transfer of records.** The employer must comply with the requirements involving transfer of records set forth in the Records Access standard (29 CFR 1910.1020).

(o) **Dates –**

(1) **Effective date.** This standard shall become effective March 10, 2017.

(2) **Compliance dates.**

- (i) All obligations contained in paragraph (c) of this standard commence and become enforceable on March 12, 2018; and
- (ii) All other obligations of this standard commence and become enforceable on September 30, 2020.

[82 FR 2744, Jan. 9, 2017, as amended at 84 FR 51399, Sept. 30, 2019; 85 FR 53996, Aug. 31, 2020; 86 FR 11119, Feb. 24, 2021]

## § 1915.1025 Lead.

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1025 of this chapter.

[61 FR 31431, June 20, 1996]

## § 1915.1026 Chromium (VI).

### (a) Scope.

- (1) This standard applies to occupational exposures to chromium (VI) in all forms and compounds in shipyards, marine terminals, and longshoring, except:
- (2) Exposures that occur in the application of pesticides regulated by the Environmental Protection Agency or another Federal government agency (e.g., the treatment of wood with preservatives);
- (3) Exposures to portland cement; or
- (4) Where the employer has objective data demonstrating that a material containing chromium or a specific process, operation, or activity involving chromium cannot release dusts, fumes, or mists of chromium (VI) in concentrations at or above  $0.5 \mu\text{g}/\text{m}^3$  as an 8-hour time-weighted average (TWA) under any expected conditions of use.

### (b) Definitions. For the purposes of this section the following definitions apply:

**Action level** means a concentration of airborne chromium (VI) of 2.5 micrograms per cubic meter of air ( $2.5 \mu\text{g}/\text{m}^3$ ) calculated as an 8-hour time-weighted average (TWA).

**Assistant Secretary** means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.

**Chromium (VI) [hexavalent chromium or Cr(VI)]** means chromium with a valence of positive six, in any form and in any compound.

**Director** means the Director of the National Institute for Occupational Safety and Health (NIOSH), U.S. Department of Health and Human Services, or designee.

**Emergency** means any occurrence that results, or is likely to result, in an uncontrolled release of chromium (VI). If an incidental release of chromium (VI) can be controlled at the time of release by employees in the immediate release area, or by maintenance personnel, it is not an emergency.

**Employee exposure** means the exposure to airborne chromium (VI) that would occur if the employee were not using a respirator.

**High-efficiency particulate air [HEPA] filter** means a filter that is at least 99.97 percent efficient in removing mono-dispersed particles of 0.3 micrometers in diameter or larger.

**Historical monitoring data** means data from chromium (VI) monitoring conducted prior to May 30, 2006, obtained during work operations conducted under workplace conditions closely resembling the processes, types of material, control methods, work practices, and environmental conditions in the employer's current operations.

**Objective data** means information such as air monitoring data from industry-wide surveys or calculations based on the composition or chemical and physical properties of a substance demonstrating the employee exposure to chromium (VI) associated with a particular product or material or a specific process, operation, or activity. The data must reflect workplace conditions closely resembling the processes, types of material, control methods, work practices, and environmental conditions in the employer's current operations.

*Physician or other licensed health care professional [PLHCP]* is an individual whose legally permitted scope of practice (i.e., license, registration, or certification) allows him or her to independently provide or be delegated the responsibility to provide some or all of the particular health care services required by paragraph (i) of this section.

*This section* means this § 1915.1026 chromium (VI) standard.

- (c) **Permissible exposure limit (PEL).** The employer shall ensure that no employee is exposed to an airborne concentration of chromium (VI) in excess of 5 micrograms per cubic meter of air (5 µgm/m<sup>3</sup>), calculated as an 8-hour time-weighted average (TWA).
- (d) **Exposure determination —**
  - (1) **General.** Each employer who has a workplace or work operation covered by this section shall determine the 8-hour TWA exposure for each employee exposed to chromium (VI). This determination shall be made in accordance with either paragraph (d)(2) or paragraph (d)(3) of this section.
  - (2) **Scheduled monitoring option.**
    - (i) The employer shall perform initial monitoring to determine the 8-hour TWA exposure for each employee on the basis of a sufficient number of personal breathing zone air samples to accurately characterize full shift exposure on each shift, for each job classification, in each work area. Where an employer does representative sampling instead of sampling all employees in order to meet this requirement, the employer shall sample the employee(s) expected to have the highest chromium (VI) exposures.
    - (ii) If initial monitoring indicates that employee exposures are below the action level, the employer may discontinue monitoring for those employees whose exposures are represented by such monitoring.
    - (iii) If monitoring reveals employee exposures to be at or above the action level, the employer shall perform periodic monitoring at least every six months.
    - (iv) If monitoring reveals employee exposures to be above the PEL, the employer shall perform periodic monitoring at least every three months.
    - (v) If periodic monitoring indicates that employee exposures are below the action level, and the result is confirmed by the result of another monitoring taken at least seven days later, the employer may discontinue the monitoring for those employees whose exposures are represented by such monitoring.
    - (vi) The employer shall perform additional monitoring when there has been any change in the production process, raw materials, equipment, personnel, work practices, or control methods that may result in new or additional exposures to chromium (VI), or when the employer has any reason to believe that new or additional exposures have occurred.
  - (3) **Performance-oriented option.** The employer shall determine the 8-hour TWA exposure for each employee on the basis of any combination of air monitoring data, historical monitoring data, or objective data sufficient to accurately characterize employee exposure to chromium (VI).
  - (4) **Employee notification of determination results.**

(i) Within 5 work days after making an exposure determination in accordance with paragraph (d)(2) or paragraph (d)(3) of this section, the employer shall individually notify each affected employee in writing of the results of that determination or post the results in an appropriate location accessible to all affected employees.

(ii) Whenever the exposure determination indicates that employee exposure is above the PEL, the employer shall describe in the written notification the corrective action being taken to reduce employee exposure to or below the PEL.

(5) **Accuracy of measurement.** Where air monitoring is performed to comply with the requirements of this section, the employer shall use a method of monitoring and analysis that can measure chromium (VI) to within an accuracy of plus or minus 25 percent ( $\pm 25\%$ ) and can produce accurate measurements to within a statistical confidence level of 95 percent for airborne concentrations at or above the action level.

(6) **Observation of monitoring.**

(i) Where air monitoring is performed to comply with the requirements of this section, the employer shall provide affected employees or their designated representatives an opportunity to observe any monitoring of employee exposure to chromium (VI).

(ii) When observation of monitoring requires entry into an area where the use of protective clothing or equipment is required, the employer shall provide the observer with clothing and equipment and shall assure that the observer uses such clothing and equipment and complies with all other applicable safety and health procedures.

(e) **Methods of compliance —**

(1) **Engineering and work practice controls.**

(i) Except as permitted in paragraph (e)(1)(ii) of this section, the employer shall use engineering and work practice controls to reduce and maintain employee exposure to chromium (VI) to or below the PEL unless the employer can demonstrate that such controls are not feasible. Wherever feasible engineering and work practice controls are not sufficient to reduce employee exposure to or below the PEL, the employer shall use them to reduce employee exposure to the lowest levels achievable, and shall supplement them by the use of respiratory protection that complies with the requirements of paragraph (f) of this section.

(ii) Where the employer can demonstrate that a process or task does not result in any employee exposure to chromium (VI) above the PEL for 30 or more days per year (12 consecutive months), the requirement to implement engineering and work practice controls to achieve the PEL does not apply to that process or task.

(2) **Prohibition of rotation.** The employer shall not rotate employees to different jobs to achieve compliance with the PEL.

(f) **Respiratory protection —**

(1) **General.** Where respiratory protection is required by this section, the employer must provide each employee an appropriate respirator that complies with the requirements of this paragraph. Respiratory protection is required during:

(i) Periods necessary to install or implement feasible engineering and work practice controls;



- (ii) Work operations, such as maintenance and repair activities, for which engineering and work practice controls are not feasible;
- (iii) Work operations for which an employer has implemented all feasible engineering and work practice controls and such controls are not sufficient to reduce exposures to or below the PEL;
- (iv) Work operations where employees are exposed above the PEL for fewer than 30 days per year, and the employer has elected not to implement engineering and work practice controls to achieve the PEL; or
- (v) Emergencies.

- (2) **Respiratory protection program.** Where respirator use is required by this section, the employer shall institute a respiratory protection program in accordance with § 1910.134, which covers each employee required to use a respirator.

(g) **Protective work clothing and equipment –**

- (1) **Provision and use.** Where a hazard is present or is likely to be present from skin or eye contact with chromium (VI), the employer shall provide appropriate personal protective clothing and equipment at no cost to employees, and shall ensure that employees use such clothing and equipment.

(2) **Removal and storage.**

- (i) The employer shall ensure that employees remove all protective clothing and equipment contaminated with chromium (VI) at the end of the work shift or at the completion of their tasks involving chromium (VI) exposure, whichever comes first.
- (ii) The employer shall ensure that no employee removes chromium (VI)-contaminated protective clothing or equipment from the workplace, except for those employees whose job it is to launder, clean, maintain, or dispose of such clothing or equipment.
- (iii) When contaminated protective clothing or equipment is removed for laundering, cleaning, maintenance, or disposal, the employer shall ensure that it is stored and transported in sealed, impermeable bags or other closed, impermeable containers.
- (iv) The employer shall ensure that bags or containers of contaminated protective clothing or equipment that are removed from change rooms for laundering, cleaning, maintenance, or disposal are labeled in accordance with the requirements of the Hazard Communication Standard, § 1910.1200.

(3) **Cleaning and replacement.**

- (i) The employer shall clean, launder, repair and replace all protective clothing and equipment required by this section as needed to maintain its effectiveness.
- (ii) The employer shall prohibit the removal of chromium (VI) from protective clothing and equipment by blowing, shaking, or any other means that disperses chromium (VI) into the air or onto an employee's body.
- (iii) The employer shall inform any person who launders or cleans protective clothing or equipment contaminated with chromium (VI) of the potentially harmful effects of exposure to chromium (VI) and that the clothing and equipment should be laundered or cleaned in a manner that minimizes skin or eye contact with chromium (VI) and effectively prevents the release of airborne chromium (VI) in excess of the PEL.

(h) **Hygiene areas and practices** —

- (1) **General.** Where protective clothing and equipment is required, the employer shall provide change rooms in conformance with 29 CFR 1910.141. Where skin contact with chromium (VI) occurs, the employer shall provide washing facilities in conformance with 29 CFR 1915.97. Eating and drinking areas provided by the employer shall also be in conformance with § 1915.97.
- (2) **Change rooms.** The employer shall assure that change rooms are equipped with separate storage facilities for protective clothing and equipment and for street clothes, and that these facilities prevent cross-contamination.
- (3) **Washing facilities.**
  - (i) The employer shall provide readily accessible washing facilities capable of removing chromium (VI) from the skin, and shall ensure that affected employees use these facilities when necessary.
  - (ii) The employer shall ensure that employees who have skin contact with chromium (VI) wash their hands and faces at the end of the work shift and prior to eating, drinking, smoking, chewing tobacco or gum, applying cosmetics, or using the toilet.
- (4) **Eating and drinking areas.**
  - (i) Whenever the employer allows employees to consume food or beverages at a worksite where chromium (VI) is present, the employer shall ensure that eating and drinking areas and surfaces are maintained as free as practicable of chromium (VI).
  - (ii) The employer shall ensure that employees do not enter eating and drinking areas with protective work clothing or equipment unless surface chromium (VI) has been removed from the clothing and equipment by methods that do not disperse chromium (VI) into the air or onto an employee's body.
- (5) **Prohibited activities.** The employer shall ensure that employees do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in areas where skin or eye contact with chromium (VI) occurs; or carry the products associated with these activities, or store such products in these areas.

(i) **Medical surveillance** —

- (1) **General.**
  - (i) The employer shall make medical surveillance available at no cost to the employee, and at a reasonable time and place, for all employees:
    - (A) Who are or may be occupationally exposed to chromium (VI) at or above the action level for 30 or more days a year;
    - (B) Experiencing signs or symptoms of the adverse health effects associated with chromium (VI) exposure; or
    - (C) Exposed in an emergency.
  - (ii) The employer shall assure that all medical examinations and procedures required by this section are performed by or under the supervision of a PLHCP.
- (2) **Frequency.** The employer shall provide a medical examination:

- (i) Within 30 days after initial assignment, unless the employee has received a chromium (VI) related medical examination that meets the requirements of this paragraph within the last twelve months;
  - (ii) Annually;
  - (iii) Within 30 days after a PLHCP's written medical opinion recommends an additional examination;
  - (iv) Whenever an employee shows signs or symptoms of the adverse health effects associated with chromium (VI) exposure;
  - (v) Within 30 days after exposure during an emergency which results in an uncontrolled release of chromium (VI); or
  - (vi) At the termination of employment, unless the last examination that satisfied the requirements of paragraph (i) of this section was less than six months prior to the date of termination.
- (3) **Contents of examination.** A medical examination consists of:
- (i) A medical and work history, with emphasis on: past, present, and anticipated future exposure to chromium (VI); any history of respiratory system dysfunction; any history of asthma, dermatitis, skin ulceration, or nasal septum perforation; and smoking status and history;
  - (ii) A physical examination of the skin and respiratory tract; and
  - (iii) Any additional tests deemed appropriate by the examining PLHCP.
- (4) **Information provided to the PLHCP.** The employer shall ensure that the examining PLHCP has a copy of this standard, and shall provide the following information:
- (i) A description of the affected employee's former, current, and anticipated duties as they relate to the employee's occupational exposure to chromium (VI);
  - (ii) The employee's former, current, and anticipated levels of occupational exposure to chromium (VI);
  - (iii) A description of any personal protective equipment used or to be used by the employee, including when and for how long the employee has used that equipment; and
  - (iv) Information from records of employment-related medical examinations previously provided to the affected employee, currently within the control of the employer.
- (5) **PLHCP's written medical opinion.**
- (i) The employer shall obtain a written medical opinion from the PLHCP, within 30 days for each medical examination performed on each employee, which contains:
    - (A) The PLHCP's opinion as to whether the employee has any detected medical condition(s) that would place the employee at increased risk of material impairment to health from further exposure to chromium (VI);
    - (B) Any recommended limitations upon the employee's exposure to chromium (VI) or upon the use of personal protective equipment such as respirators;

- (C) A statement that the PLHCP has explained to the employee the results of the medical examination, including any medical conditions related to chromium (VI) exposure that require further evaluation or treatment, and any special provisions for use of protective clothing or equipment.
  - (ii) The PLHCP shall not reveal to the employer specific findings or diagnoses unrelated to occupational exposure to chromium (VI).
  - (iii) The employer shall provide a copy of the PLHCP's written medical opinion to the examined employee within two weeks after receiving it.
- (j) **Communication of chromium (VI) hazards to employees –**
  - (1) **Hazard communication.** The employer shall include chromium (VI) in the program established to comply with the Hazard Communication Standard (HCS) (§ 1910.1200). The employer shall ensure that each employee has access to labels on containers of chromium (VI) and safety data sheets, and is trained in accordance with the provisions of HCS and paragraph (j)(2) of this section. The employer shall ensure that at least the following hazards are addressed: Cancer; skin sensitization; and eye irritation.
  - (2) **Employee information and training.**
    - (i) The employer shall ensure that each employee can demonstrate knowledge of at least the following:
      - (A) The contents of this section; and
      - (B) The purpose and a description of the medical surveillance program required by paragraph (i) of this section.
    - (ii) The employer shall make a copy of this section readily available without cost to all affected employees.
- (k) **Recordkeeping –**
  - (1) **Air monitoring data.**
    - (i) The employer shall maintain an accurate record of all air monitoring conducted to comply with the requirements of this section.
    - (ii) This record shall include at least the following information:
      - (A) The date of measurement for each sample taken;
      - (B) The operation involving exposure to chromium (VI) that is being monitored;
      - (C) Sampling and analytical methods used and evidence of their accuracy;
      - (D) Number, duration, and the results of samples taken;
      - (E) Type of personal protective equipment, such as respirators worn; and
      - (F) Name and job classification of all employees represented by the monitoring, indicating which employees were actually monitored.
    - (iii) The employer shall ensure that exposure records are maintained and made available in accordance with 29 CFR 1910.1020.

(2) **Historical monitoring data.**

- (i) Where the employer has relied on historical monitoring data to determine exposure to chromium (VI), the employer shall establish and maintain an accurate record of the historical monitoring data relied upon.
- (ii) The record shall include information that reflects the following conditions:
  - (A) The data were collected using methods that meet the accuracy requirements of paragraph (d)(5) of this section;
  - (B) The processes and work practices that were in use when the historical monitoring data were obtained are essentially the same as those to be used during the job for which exposure is being determined;
  - (C) The characteristics of the chromium (VI) containing material being handled when the historical monitoring data were obtained are the same as those on the job for which exposure is being determined;
  - (D) Environmental conditions prevailing when the historical monitoring data were obtained are the same as those on the job for which exposure is being determined; and
  - (E) Other data relevant to the operations, materials, processing, or employee exposures covered by the exception.
- (iii) The employer shall ensure that historical exposure records are maintained and made available in accordance with 29 CFR 1910.1020.

(3) **Objective data.**

- (i) The employer shall maintain an accurate record of all objective data relied upon to comply with the requirements of this section.
- (ii) This record shall include at least the following information:
  - (A) The chromium containing material in question;
  - (B) The source of the objective data;
  - (C) The testing protocol and results of testing, or analysis of the material for the release of chromium (VI);
  - (D) A description of the process, operation, or activity and how the data support the determination; and
  - (E) Other data relevant to the process, operation, activity, material, or employee exposures.
- (iii) The employer shall ensure that objective data are maintained and made available in accordance with 29 CFR 1910.1020.

(4) **Medical surveillance.**

- (i) The employer shall establish and maintain an accurate record for each employee covered by medical surveillance under paragraph (i) of this section.
- (ii) The record shall include the following information about the employee:
  - (A) Name;

(B) A copy of the PLHCP's written opinions;

(C) A copy of the information provided to the PLHCP as required by paragraph (i)(4) of this section.

(iii) The employer shall ensure that medical records are maintained and made available in accordance with 29 CFR 1910.1020.

(l) **Dates.**

(1) For employers with 20 or more employees, all obligations of this section, except engineering controls required by paragraph (e) of this section, commence November 27, 2006.

(2) For employers with 19 or fewer employees, all obligations of this section, except engineering controls required by paragraph (e) of this section, commence May 30, 2007.

(3) For all employers, engineering controls required by paragraph (e) of this section shall be implemented no later than May 31, 2010.

[71 FR 10378, Feb. 28, 2006, as amended at 73 FR 75587, Dec. 12, 2008; 75 FR 12686, Mar. 17, 2010; 77 FR 17889, Mar. 26, 2012; 84 FR 21597, May 14, 2019]

**§ 1915.1027 Cadmium.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1027 of this chapter.

[61 FR 31431, June 20, 1996]

**§ 1915.1028 Benzene.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1028 of this chapter.

[61 FR 31431, June 20, 1996]

**§ 1915.1030 Bloodborne pathogens.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1030 of this chapter.

[61 FR 31431, June 20, 1996]

**§ 1915.1044 1,2-dibromo-3-chloropropane.**

Note: The requirements applicable to shipyard employment under this section are identical to

those set forth at § 1910.1044 of this chapter.

[61 FR 31431, June 20, 1996]

### **§ 1915.1045 Acrylonitrile.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1045 of this chapter.

[61 FR 31431, June 20, 1996]

### **§ 1915.1047 Ethylene oxide.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1047 of this chapter.

[61 FR 31431, June 20, 1996]

### **§ 1915.1048 Formaldehyde.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1048 of this chapter.

[61 FR 31431, June 20, 1996]

### **§ 1915.1050 Methylenedianiline.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1050 of this chapter.

[61 FR 31431, June 20, 1996]

### **§ 1915.1052 Methylene chloride.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at 29 CFR 1910.1052.

[62 FR 1619, Jan. 10, 1997]

### **§ 1915.1053 Respirable crystalline silica.**

The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1053 of this chapter.

[81 FR 16875, Mar. 25, 2016]

### **§ 1915.1200 Hazard communication.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1200 of this chapter.

[61 FR 31431, June 20, 1996]

### **§ 1915.1450 Occupational exposure to hazardous chemicals in laboratories.**

Note: The requirements applicable to shipyard employment under this section are identical to those set forth at § 1910.1450 of this chapter.

[61 FR 31431, June 20, 1996]

### **§ 1915.1501 COVID–19.**

The requirements applicable to shipyard employment under this section are identical to those set forth at 29 CFR 1910.501.

[86 FR 61554, Nov. 5, 2021]