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Regulations

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19.1 INTRODUCTION

Since the Clean Air Act Amendments of 1970, when a war against pollution was declared, solvents have been on the U.S. regulatory radar screen.[1] This represented the beginning of new environmental policies which led to today's more stringent regulations with a greater focus on toxic substances.[2] In the U.S., historically, these policies and regulations have been divided by medium (air, water, and land), which has represented a challenge to the regulated industries and the Federal, State, and local regulatory communities. In recent years, however, the U.S. Congress and the Environmental Protection Agency (EPA) have recognized the need to address environmental problems from a more holistic approach considering multimedia and innovative environmental management strategies.[3] Hence, various programs and initiatives have emerged, which have proven to be extremely successful, encouraging voluntary industry participation rather than the old command and control approach.[4]

Almost all solvents are volatile organic compounds (VOCs) and hazardous air pollutants (HAPs), and their evaporation creates environmental problems that have become the focus of many domestic and international regulations and initiatives. A VOC solvent is defined by EPA as any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which is emitted or evaporated into the atmosphere.[5] In 1996, an estimated 19 million short tons of VOCs were emitted in the U.S. of which 33 percent came from solvent utilization (see Table 19.1).[6] In the lower atmosphere VOC solvents participate in photochemical reactions to form, to varying degrees, ground level ozone and other oxidants which affect health, as well as cause damage to materials, crops, and forests. Ozone impairs normal functioning of the lungs and reduces the ability to perform physical exercise. Such effects are more severe in individuals with sensitive respiratory systems. Even healthy adults can experience symptoms and reduction in lung function during moderate exercise at ozone levels below the current ozone standard.

Some solvents are also toxic and/or carcinogenic which contributes to direct health problems. They are pollutants that have been associated with serious health effects such as cancer, liver or kidney damage, reproductive disorders, and developmental or neurological problems.[7,8] They also have detrimental environmental effects on wildlife and degrade wa-

ter or habitat quality. The Clean Air Act of 1990 in section 112(b) lists 188 HAPs,[9] some of which are solvents (see Table 19.2),[10-14] for which sources are identified and regulated. The contents of Table 19.2 will be discussed in more detail later.

Table 19.1. Major categories in the solvent utilization sector and their estimated VOC emissions[6]

Source category	Estimated Emissions, 1996	
	Quantity, tons	distribution in solvent utilization sector, %
Degreasing	661,000	11
Graphic arts	389,000	6
Dry cleaning	190,000	3
Surface coating	2,881,000	46
Other industrial and non-industrial processes	2,153,000	34
Total emissions	6,274,000	100

Table 19.2. Classification of solvents by their codes, exposure limits, and environmental effects

CAS No.	Chemical name	EPA Code[10]	†Permissible Exposure Limits (PEL)[13]		‡TLV[14] ppmv	Environmental Effect			
			ppmv	mg/m^3		O	T	D	G
50-00-0	Formaldehyde	K009; K010; K040; K156; K157	see 29 CFR 1910.1048			✓	✓		
50-21-5	Lactic acid					✓			
50-70-4	Sorbitol					✓			
56-23-5	Carbon tetrachloride	F001; F024; F025; K016; K019; K020; K021; K073; K116; K150; K151; K157; U211; D019		(2)	5	✓	✓	✓	✓
56-38-2	Parathion	P089		(S) 0.1	0.1 mg/m^3	✓	✓		
56-81-5	Glycerine				10 mg/m^3	✓			
56-93-9	Benzyltrimethylammonium chloride					✓			
57-14-7	1,1-Dimethyl hydrazine	K017; K108; K109; K110; U098	(S) 0.5	(S) 1		✓	✓		
57-55-6	Propylene glycol					✓			
57-57-8	β-Propiolactone		see 29 CFR 1910.1013		0.5	✓	✓		
60-29-7	Ethyl ether	U117	400	1200		✓			

CAS No.	Chemical name	EPA Code[10]	†Permissible Exposure Limits (PEL)[13]		‡TLV[14] ppmv	Environmental Effect			
			ppmv	mg/m^3		O	T	D	G
60-34-4	Methyl hydrazine	P068	(C) (S) 0.2	(C)(S)0.35	0.01	✓	✓		
62-53-3	Aniline	K083; K103; K104; U012	(S) 5	(S) 19	2	✓	✓		
62-75-9	N-Nitrosodimethylamine	P082	see 29 CFR 1910.1016		(S)	✓	✓		
64-17-5	Ethyl alcohol		1000	1900		✓			
64-18-6	Formic acid	K009; K010; U123	5	9	5	✓			
64-19-7	Acetic acid		10	25	10	✓			
64-67-5	Diethyl sulfate					✓	✓		
67-56-1	Methanol	U154	200	260	200	✓	✓		
67-63-0	Isopropyl alcohol		400	980	400	✓			
67-64-1	Acetone	U002	1000	2400	500	ε			
67-66-3	Chloroform	K009; K010; K019; K020; K021; K029; K073; K116; K149; K150; K151; U044; D022	(C) 50	(C) 240	10	✓	✓		
67-68-5	Dimethyl sulfoxide					✓			
68-12-2	Dimethyl formamide		(S) 10	(S) 30	10	✓	✓		
71-23-8	n-Propyl alcohol		200	500		✓			
71-36-3	n-Butyl alcohol	U031	100	300		✓			
71-43-2	Benzene	F005; F024; F025; F037; F038; K085; K104; K105; K141; K142; K143; K144; K145; K147; K151; K159; K169; U019; D018	see 29 CFR 1910.1028 Table Z-2		0.5	✓	✓		
71-55-6	1,1,1-Trichloroethane	F001, F002, F024, F025, K019, K020, K028, K029, U226	350	1900	350	ε	✓	✓	✓
74-88-4	Methyl iodide	U138	(S) 5	(S) 28	2	✓	✓		
74-96-4	Ethyl bromide		200	890	5	✓			
75-00-3	Ethyl chloride	K018	1000	2600	100	✓	✓		
75-04-7	Ethylamine		10	18	5	✓			

CAS No.	Chemical name	EPA Code[10]	†Permissible Exposure Limits (PEL)[13]		‡TLV[14] ppmv	Environmental Effect			
			ppmv	mg/m^3		O	T	D	G
75-05-8	Acetonitrile	K011; K013; K014; U003	40	70	40	✓	✓		
75-07-0	Acetaldehyde	U001	200	360		✓	✓		
75-08-1	Ethyl mercaptan		(C) 10	(C) 25		✓			
75-09-2	Dichloromethane	F001; F002; F024; F025; K009; K010; K156; K158; U080		(2)	50	ε	✓		
75-15-0	Carbon disulfide	F005; P022		(2)	10	✓	✓		
75-18-3	Dimethyl sulfide					✓			
75-25-2	Bromoform	U225	(S) 0.5	(S) 5	0.5	✓	✓		
75-31-0	Isopropylamine		5	12	5	✓			
75-33-2	Isopropyl mercaptan					✓			
75-34-3	1,1-Dichloroethane	F024, F025; U076	100	400	100	✓	✓		
75-35-4	Vinylidene chloride	F024; F025; K019; K020; K029; U078; D029			5	✓	✓		
75-52-5	Nitromethane		100	250	20	✓			
75-55-8	Propyleneimine	P067	2	5	2	✓	✓		
75-56-9	Propylene oxide		100	240	20	✓	✓		
75-64-9	tert-Butylamine					✓			
75-65-0	tert-Butyl alcohol		100	300	100	✓			
75-68-3	1-chloro-1,1-difluoroethane (HCFC-142b)	F001				ε		✓	✓
75-69-4	Trichlorofluoromethane (CFC-11)	F001; F002; F024; F025; U121				ε		✓	✓
75-83-2	Neohexane					✓			
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113)	F001; F002	1000	7600	1000	ε		✓	✓
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane(CFC-114)	F001	1000	7000	1000	ε		✓	✓
77-47-4	Hexachlorocyclopentadiene	F024; F025; K032; K033; K034; U130			0.01	✓	✓		
77-78-1	Dimethyl sulfate	K131; U103	(S) 1	(S) 5	0.1	✓	✓		
78-59-1	Isophorone		25	140		✓	✓		

CAS No.	Chemical name	EPA Code[10]	†Permissible Exposure Limits (PEL)[13]		‡TLV[14] ppmv	Environmental Effect			
			ppmv	mg/m^3		O	T	D	G
78-78-4	Isopentane					✓			
78-81-9	Isobutylamine					✓			
78-83-1	Isobutyl alcohol	F005; U140	100	300	50	✓			
78-84-2	Isobutyraldehyde					✓			
78-87-5	1,2-Dichloropropane	U083	75	350	75	✓	✓		
78-88-6	2,3-Dichloropropene	F024; F025				✓			
78-92-2	sec-Butyl alcohol		150	450	100	✓			
78-93-3	Methyl ethyl ketone	F005; U159; D035	200	590	200	✓	✓		
78-96-6	Monoisopropanolamine					✓			
79-01-6	Trichloroethylene	F001; F002; F024; F025; K018; K019; K020; U228; D040		(2)		✓	✓		
79-04-9	Chloroacetyl chloride				0.05 (S)	✓			
79-09-4	Propionic acid				10	✓			
79-10-7	Acrylic acid	U008			2	✓	✓		
79-20-9	Methyl acetate		200	610	250	ε			
79-21-0	Peracetic acid					✓			
79-24-3	Nitroethane		100	310	100	✓			
79-34-5	1,1,2,2-Tetrachloroethane	F001; F024; F025; K019; K020; K030; K073; K095; K150; U209	5	35	1	ε	✓		
79-44-7	Dimethyl carbamoyl chloride	U097				✓	✓		
79-46-9	2-Nitropropane	F005; U171	25	90	10	✓	✓		
80-62-6	Methyl methacrylate	U162	100	410	100	✓	✓		
84-66-2	Diethyl phthalate	U088			5	✓			
84-74-2	Dibutyl phthalate	U069		5	5 mg/m^3	✓	✓		
85-68-7	Butyl benzyl phthalate					✓			
87-68-3	Hexachlorobutadiene	F024; F025; K016; K018; K030; D033			0.02	✓	✓		
90-02-8	Salicyl aldehyde					✓			
91-17-8	Decahydronapthalene					✓			
91-22-5	Quinoline					✓	✓		

CAS No.	Chemical name	EPA Code[10]	†Permissible Exposure Limits (PEL)[13]		‡TLV[14] ppmv	Environmental Effect			
			ppmv	mg/m^3		O	T	D	G
95-47-6	o-Xylene	U239	100	435	100	✓	✓		
95-50-1	1,2-Dichlorobenzene	F024; F025; K042; K085; K105; U070	(C) 50	(C) 300	25	✓			
96-09-3	Styrene oxide					✓	✓		
96-12-8	1,2-Dibromo-3-chloropropane	U066	see 29 CFR 1910.1044			✓	✓		
96-33-3	Methyl acrylate		10	35		✓			
96-37-7	Methyl cyclopentane					✓			
97-63-2	Ethyl methacrylate					✓			
97-64-3	Ethyl lactate					✓			
97-88-1	n-Butyl methacrylate					✓			
98-00-0	Furfuryl alcohol		50	200	10	✓			
98-01-1	Furfural	U125	(S) 5	(S) 20	2	✓			
98-07-7	Benzotrichloride	K015; K149; U023				✓	✓		
98-56-6	p-Chlorobenzotrifluoride					ε			
98-82-8	Cumene	U055	(S) 50	(S) 245	50	✓	✓		
98-95-3	Nitrobenzene	F004; K083; K103; K104; U169; D036	(S) 1	(S) 5	1	✓	✓		
99-87-6	p-Cymene					✓			
100-37-8	Diethylethanolamine					✓			
100-39-0	Benzyl bromide					✓			
100-41-4	Ethyl benzene		100	435	100	✓	✓		
100-42-5	Styrene			(2)	20	✓	✓		
100-44-7	Benzyl chloride	K015; K149; K085; P028	1	5		✓	✓		
100-46-9	Benzylamine					✓			
100-47-0	Benzonitrile					✓			
100-51-6	Benzyl alcohol					✓			
100-52-7	Benzaldehyde					✓			
100-61-8	N-Methylaniline		2	9	0.5	✓			
101-84-8	Diphenyl ether					✓			
103-11-7	2-Ethylhexyl acrylate					✓			

CAS No.	Chemical name	EPA Code[10]	†Permissible Exposure Limits (PEL)[13]		‡TLV[14] ppmv	Environmental Effect			
			ppmv	mg/m^3		O	T	D	G
103-23-1	Dioctyl adipate					✓			
104-72-3	Decylbenzene					✓			
104-76-7	2-Ethyl hexanol					✓			
105-39-5	Ethyl chloroacetate					✓			
105-46-4	sec-Butyl acetate		200	950	200	✓			
105-54-4	Ethyl butyrate					✓			
105-58-8	Diethyl carbonate					✓			
106-35-4	Ethyl butyl ketone		50	230	50	✓			
106-42-3	p-Xylene	U239	100	435	100	✓	✓		
106-43-4	p-Chlorotoluene					✓			
106-63-8	Isobutyl acrylate					✓			
106-88-7	1,2-Epoxybutane				0.3	✓	✓		
106-89-8	Epichlorohydrin	K017; U041	(S) 5	(S) 19		✓	✓		
106-91-2	Glycidyl methacrylate					✓			
106-93-4	Dibromoethane	U067		(2)		✓	✓		
106-99-0	Butadiene		1000	2200		✓	✓		
107-02-8	Acrolein	P003	0.1	0.25		✓	✓		
107-03-9	n-Propyl mercaptan					✓			
107-05-1	Allyl chloride	F024, F025	1	3	1	✓	✓		
107-06-2	1,2-Dichloroethane	F024; F025; K019; K020; K029; K030; U077; D028		(2)	10	✓	✓		
107-07-3	Ethylene chlorohydrin		5	16	(S)	✓			
107-10-8	n-Propylamine					✓			
107-13-1	Acrylonitrile	K011; K013; U009	see 29 CFR 1910.1045		2	✓	✓		
107-15-3	Ethylenediamine					✓			
107-18-6	Allyl alcohol	P005	(S) 2	(S) 5	(2)	✓			
107-21-1	Ethylene glycol					✓	✓		
107-30-2	Chloromethyl methyl ether	U046	see 29 CFR 1910.1006			✓	✓		
107-31-3	Methyl formate		100	250	100	✓			

CAS No.	Chemical name	EPA Code[10]	†Permissible Exposure Limits (PEL)[13]		‡TLV[14] ppmv	Environmental Effect			
			ppmv	mg/m^3		O	T	D	G
107-39-1	Diisobutylene					✓			
107-41-5	Hexylene glycol					✓			
107-66-4	Dibutylphosphate		1	5	1	✓			
107-83-5	Isohexane					✓			
107-87-9	Methyl propyl ketone		200	700	200	✓			
107-92-6	n-Butyric acid					✓			
107-98-2	Propylene glycol methyl ether				100	✓			
108-03-2	1-Nitropropane		25	90	25	✓			
108-10-1	Methyl isobutyl ketone	U161	100	410		✓	✓		
108-11-2	Methylamyl alcohol		(S) 25	(S) 100		✓			
108-18-9	Diisopropylamine		(S) 5	(S) 20	5	✓			
108-20-3	Isopropyl ether		500	2100	250	✓			
108-21-4	Isopropyl acetate		250	950	250	✓			
108-38-3	m-Xylene	U239	100	435	100	✓	✓		
108-39-4	m-Cresol	F004; U052; D024	(S) 5	(S) 22	5	✓	✓		
108-82-7	Diisobutylcarbinol					✓			
108-83-8	Diisobutyl ketone		50	290	25	✓			
108-84-9	Methyl amyl acetate					✓			
108-86-1	Bromobenzene					✓			
108-88-3	Toluene	F005; F024; F025; K015; K027; K036; K037; K149; U220		(2)	50	✓	✓		
108-90-7	Chlorobenzene	F002; F024; F025; K015; K085; K105; U037; D021	75	350	10	✓	✓		
108-91-8	Cyclohexylamine				10	✓			
108-93-0	Cyclohexanol		50	200	50	✓			
108-94-1	Cyclohexanone	U057	50	200	25	✓			
108-95-2	Phenol	K001; K022; K050; K060; K087; U188	(S) 5	(S) 19	5	✓	✓		
109-06-8	2-Methylpyridine	U191				✓			
109-60-4	n-Propyl acetate		200	840	200	✓			
109-66-0	Pentane		1000	2950	600	✓			

CAS No.	Chemical name	EPA Code[10]	†Permissible Exposure Limits (PEL)[13]		‡TLV[14] ppmv	Environmental Effect			
			ppmv	mg/m^3		O	T	D	G
109-67-1	1-Pentene					✓			
109-73-9	Butylamine		(C) (S) 5	(C) (S) 15		✓			
109-78-4	Ethylene cyanohydrin					✓			
109-79-5	n-Butyl mercaptan		10	35	0.5	✓			
109-86-4	Ethylene glycol monomethyl ether					✓			
109-86-4	Methyl cellosolve		(S) 25	(S) 80	5	✓			
109-87-5	Dimethoxymethane		1000	3100		✓			
109-87-5	Methyl formal					✓			
109-89-7	Diethylamine		25	75	5 (S)	✓			
109-94-4	Ethyl formate		100	300		✓			
110-12-3	Methyl isoamyl ketone		100	475	50	✓			
110-19-0	Isobutyl acetate		150	700	250	✓			
110-43-0	Methyl n-amyl ketone		100	465	50	✓			
110-49-6	Methyl cellosolve acetate		(S) 25	(S) 120	5	✓			
110-54-3	Hexane		500	1800	50	✓	✓		
110-63-4	1,4 - Butanediol					✓			
110-66-7	n-Amyl mercaptan					✓			
110-71-4	Ethylene glycol dimethyl ether					✓			
110-80-5	Cellosolve	F005; U359	(S) 200	(S) 740		✓			
110-82-7	Cyclohexane	U056	300	1050	(300)	✓			
110-86-1	Pyridine	F005; K026; K157; U196; D038	5	15	5	✓			
110-87-2	Dihydropyran					✓			
110-91-8	Morpholine		(S) 20	(S) 70	20	✓			
111-15-9	Cellosolve acetate		(S) 100	(S) 540	5	✓			
111-15-9	Ethylene glycol monoethyl ether acetate					✓			
111-27-3	n-Hexanol					✓			
111-40-0	Diethylenetriamine				1 (S)	✓			
111-42-2	Diethanolamine				2 mg/m^3	✓	✓		

CAS No.	Chemical name	EPA Code[10]	†Permissible Exposure Limits (PEL)[13]		‡TLV[14] ppmv	Environmental Effect			
			ppmv	mg/m^3		O	T	D	G
111-46-6	Diethylene glycol					✓			
111-49-9	Hexamethyleneimine					✓			
111-55-7	Ethylene glycol diacetate					✓			
111-65-9	Octane		500	2350	300	✓			
111-66-0	1-Octene					✓			
111-76-2	2-Butoxyethanol		(S) 50	(S) 240	(25)	✓			
111-76-2	Ethylene glycol monobutyl ether					✓			
111-77-3	Diethylene glycol monomethyl ether					✓			
111-84-2	Nonane				200	✓			
111-90-0	Diethylene glycol monoethyl ether					✓			
111-92-2	Di-n-butylamine					✓			
111-96-6	Diethylene glycol dimethyl ether					✓			
112-07-2	Ethylene glycol monobutyl ether acetate					✓			
112-30-1	n-Decyl alcohol					✓			
112-34-5	Diethylene glycol monobutyl ether					✓			
112-41-4	1-Dodecene					✓			
112-50-5	Ethoxy triglycol					✓			
112-55-0	Lauryl mercaptan					✓			
112-80-1	Oleic acid					✓			
115-10-6	Dimethyl ether					✓			
17-81-7	Bis(2-ethylhexyl)phthalate	U028		5		✓	✓		
121-44-8	Triethylamine	K156; K157; U404	25	100	1	✓	✓		
121-69-7	N,N-dimethylaniline		(S) 5	(S) 25	5	✓	✓		
123-38-6	Propionaldehyde		see 29 CFR 1910.1013			✓	✓		
123-42-2	Diacetone alcohol		50	240	50	✓			
123-51-3	Isoamyl alcohol		100	360	100	✓			

CAS No.	Chemical name	EPA Code[10]	†Permissible Exposure Limits (PEL)[13]		‡TLV[14] ppmv	Environmental Effect			
			ppmv	mg/m^3		O	T	D	G
123-62-6	Propionic anhydride					✓			
123-63-7	Paraldehyde	K009; K010; K026; U182				✓			
123-72-8	n-Butyraldehyde					✓			
123-86-4	n-Butyl acetate		150	710	150	✓			
123-91-1	1,4-Dioxane	U108	(S) 100	(S) 360		✓	✓		
123-92-2	Isoamyl acetate		100	525		✓			
124-11-8	1-Nonene					✓			
124-17-4	Diethylene glycol monobutyl ether acetate					✓			
124-40-3	Dimethylamine	U092	10	18	5	✓			
126-33-0	Sulfolane					✓			
126-99-8	Chloroprene		(S) 25	(S) 90	10	✓	✓		
127-18-4	Tetrachloroethylene	F001; F002; F024; F025; K116; K019; K020; K073; K150; K151; U210; D039		(2)	25	ε	✓		
127-19-5	N,N-Dimethylacetamide		(S) 10	(S) 35	10	✓			
131-11-3	Dimethyl phthalate	U102		5	5 mg/m^3	✓	✓		
131-18-0	Di-n-amyl phthalate					✓			
140-88-5	Ethyl acrylate	U113	(S) 25	(S) 100	5	✓	✓		
141-32-2	n-Butyl acrylate				10	✓			
141-43-5	Ethanolamine		3	6		✓			
141-43-5	Monoethanolamine					✓			
141-78-6	Ethyl acetate	U112	400	1400	400	✓			
141-79-7	Mesityl oxide		25	100	15	✓			
141-97-9	Ethyl acetoacetate					✓			
142-82-5	Heptane		500	2000	400	✓			
142-84-7	Di-n-propylamine	U110				✓			
142-96-1	Di-n-butyl ether					✓			
151-56-4	Aziridine	P054	see 29 CFR 1910.1012		0.5	✓	✓		
287-92-3	Cyclopentane				600	✓			

CAS No.	Chemical name	EPA Code[10]	†Permissible Exposure Limits (PEL)[13]		‡TLV[14] ppmv	Environmental Effect			
			ppmv	mg/m^3		O	T	D	G
298-07-7	Di-(2-ethylhexyl)phosphoric acid					✓			
302-01-2	Hydrazine	U133	(S) 1	(S) 1.3	0.01	✓	✓		
306-83-2	2,2-Dichloro-1,1,1-trifluoro ethane (HCFC-123)	F001				ε		✓	✓
502-56-7	Di-n-butyl ketone					✓			
510-15-6	Chlorobenzilate	U038				✓	✓		
513-37-1	Methallyl chloride					✓			
540-59-0	1,2-Dichloroethylene	F024; F025; K073	200	790	200	✓			
540-84-1	2,2,4-Trimethylpentane					✓	✓		
540-88-5	tert-Butyl acetate		200	950	200	✓			
541-41-3	Ethyl chloroformate					✓			
541-85-5	Ethyl amyl ketone		25	130	25	✓			
542-75-6	1,3-Dichloropropene	F024; F025; U084			1	✓	✓		
542-88-1	Bis(chloromethyl)ether	K017; P016				✓	✓		
543-59-9	n-Amyl chloride					✓			
584-84-9	2,4-Toluene diisocyanate	K027	(C) 0.02	(C) 0.14	0.005	✓	✓		
591-78-6	Methyl n-butyl ketone		100	410	10	✓			
592-41-6	1-Hexene				30	✓			
592-76-7	1-Heptene					✓			
594-42-3	Perchloromethyl mercaptan		0.1	0.8	0.1	✓			
624-83-9	Methyl isocyanate		(S) 0.02	(S) 0.05	0.02	✓	✓		
628-63-7	n-Amyl acetate		100	525	100	✓			
626-38-0	sec-Amyl acetate		125	650	125	✓			
629-14-1	Ethylene glycol diethyl ether					✓			
629-76-5	Pentadecanol					✓			
680-31-9	Hexamethylphosphoramide					✓	✓		
696-28-6	Phenyldichloroarsine					✓			
763-29-1	2-Methyl-1-pentene					✓			
822-06-0	Hexamethylene-1,6-diisocyanate				0.005	✓	✓		
872-05-9	1-Decene					✓			

CAS No.	Chemical name	EPA Code[10]	†Permissible Exposure Limits (PEL)[13]		‡TLV[14] ppmv	Environmental Effect			
			ppmv	mg/m^3		O	T	D	G
872-50-4	N-Methylpyrrolidinone					✓			
1191-17-9	2,2-Dichloroethyl ether					✓			
1300-71-6	Xylenol					✓			
1330-20-7	Xylene (isomer mixtures)	U239	100	435	100	✓	✓		
1336-36-3	Polychlorinated biphenyls					✓	✓		
1338-24-5	Naphthenic acids mixtures					✓			
1634-04-4	Methyl tert-butyl ether					✓	✓		
1717-00-6	1,1-dichloro-1-fluoroethane (HCFC-141b)	F001				ε		✓	✓
2837-89-0	2-chloro-1,1,1,2-tetrafluoro ethane (HCFC-124)	F001				ε		✓	✓
4170-30-3	Crotonaldehyde	U053				✓			
7664-39-3	Hydrofluoric acid	U134				✓	✓		
7785-26-4	Dipentene					✓			
8030-30-6	Naphtha: coal tar	K022	100	400		✓			
8032-32-4	Petroleum naphtha or naphtha: VM & P				300	✓			
8052-41-3	Naphtha: Stoddard solvent		500	2900	100	✓			
13360-63-9	N-Ethyl-n-butylamine					✓			
13952-84-6	sec-Butylamine					✓			
25154-52-3	Nonylphenol					✓			
25265-71-8	Dipropylene glycol					✓			
25322-69-4	Polypropylene glycol					✓			
25340-17-4	Diethylbenzene					✓			
25378-22-7	Dodecene					✓			
26761-40-0	Diisodecyl phthalate					✓			
26952-21-6	Isooctyl alcohol				50	✓			
27215-95-8	Nonene					✓			
28473-21-3	Nonanol					✓			
29063-28-3	Octanol					✓			
34590-94-8	Dipropylene glycol methyl ether		(S) 100	(S) 600	100	✓			

CAS No.	Chemical name	EPA Code[10]	†Permissible Exposure Limits (PEL)[13]		‡TLV[14] ppmv	Environmental Effect			
			ppmv	mg/m^3		O	T	D	G
53535-33-4	Heptanol					✓			
64742-81-0	Kerosene					✓			
74806-04-5	Carene					✓			

(ε) Exempt VOC.
†Permissible Exposure Limits (PELs) are 8-hour time weighted averages (TWAs) unless a number is preceded with a (C) which denotes a ceiling limit. When entry is in the mg/m^3 column only, the value is exact; otherwise, it is approximate.
‡Threshold Limit Values (TLVs) are the time weighted average concentrations for a conventional 8-hour workday and a 40-hour workweek.
(C) Indicates ceiling limit, or a concentration that should not be exceeded during any part of the working exposure.
(S) Denotes skin designation as the basis for the value.
O Classified as a volatile organic compound (VOC). VOC can react in the lower atmosphere to form ozone and other oxidants. VOC means any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions. Some compounds are specifically exempted from this definition which is found in 40 C.F.R. § 51.100(s).
T Considered a hazardous air pollutant (HAP) and listed in Title III of the Clean Air Act Amendments of 1990.
D A regulated stratospheric ozone layer depleter.
G May impact climate change.

Other solvents, known as chlorofluorocarbons (CFCs), cause stratospheric ozone depletion. They gradually release chlorine and other halogens into the atmosphere, which are effective at destroying the ozone layer,[15] our natural protection from damaging ultraviolet light (UV). They also have high global warming potentials (GWPs).[16] These solvents are generally not considered significant precursors of ground level ozone formation. The production and use of many CFCs have been banned[17,18] and new chemicals have been synthesized and are becoming available for various applications (see Table 19.3).[19,20]

Table 19.3. List of acceptable replacement chemicals for ozone-depleting solvents (ODS)[20]

Substitutes	CFC-113[a]				Methyl chloroform[a]				HCFC-141b[b]			
	C	E	M	P	C	E	M	P	C	E	M	P
Alternative Technologies (e.g., powder, hot melt, thermoplastic plasma spray, radiation-cured, moisture-cured, chemical-cured, and reactive liquid)	c											
Aqueous cleaners		c	c	c		c	c	c				
Benzotrifluorides	d	d	d	d	d	d	d	d				
HFC-123				c				c				
HFC-225ca/cb		d		d		d		d				
HFC-4310mee		d	c	c		d	c	c		c	c	c
High-solids formulations	c											

Substitutes	CFC-113[a]				Methyl chloroform[a]				HCFC-141b[b]			
	C	E	M	P	C	E	M	P	C	E	M	P
Hydrofluorether (HFE)		c	c	c		c	c	c		c	c	c
Methoxynanofluorobutane, iso and normal		c	c	c		c	c	c		c	c	c
Methylene chloride	c	c	c	c		c	c	c				
Monochlorotoluenes	d	d	d	d	d	d	d	d				
No clean alternatives		c				c						
Oxygenated solvents (alcohols, ketones, esters, ethers)	c											
Perchloroethylene	c	c	c	c		c	c	c				
Perfluorocarbons (C5F12, C6F12, C6F14, C7F16, C8F18, C5F11NO, C6F13NO, C7F15NO, and C8F16)		e		e		e		e				
Perfluoropolyethers		e		e		e		e				
Petroleum hydrocarbons	c											
Plasma cleaning		c		c		c		c				
Semi aqueous cleaners		c	c	c		c	c	c				
Straight organic solvent cleaning		c	c	c		c	c	c				
Supercritical fluids		c	c	c		c	c	c				
Terpenes	c											
Trans-1,2-dichloroethylene	d	c	c	c	d	c	c	c				
Trichloroethylene	c	c	c	c		c	c	c				
UV/ozone cleaning		c		c		c		c				
Vanishing oils			c				c					
Volatile methyl siloxanes		c	c	c		c	c	c				
Water-based formulations	c											

where:

a	Class I ODS - substance with an ozone depletion potential of 0.2 or higher
b	Class II ODS - substance with an ozone depletion potential of less than 0.2
c	Acceptable
d	Acceptable, subject to use conditions
e	Acceptable, subject to narrowed use limit
C	Adhesive, coating, and ink applications
E	Electronics cleaning
M	Metals cleaning
P	Precision cleaning

Solvents are used commercially and industrially for numerous applications. Some of those applications include polymer synthesis, coating formulations, cleaning (e.g., elec-

tronic circuit board, fabrics, ink supply lines, application equipment, and degreasing), and chemical processes. More than 300 solvents are currently used in the U.S.[21]

Organic chemical solvents are also widely used as ingredients in household products. Paints, varnishes, and wax all contain organic solvents, as well as many cleaning, disinfecting, cosmetic, degreasing, and hobby products.[21] These consumer products can release organic compounds while in use and even when stored. Their release indoors can cause health problems, especially considering that we spend around 90 percent of our time indoors.[22]

All of the environmental and health problems aforementioned have prompted a number of regulations specifically designed to promote and maintain a cleaner and sustainable environment as well as a healthier and safer workplace. This chapter discusses the environmental and safety laws and regulations and the regulatory process in the U.S. Some international regulatory perspectives will also be provided. The purpose of the chapter is to present some key elements of relevant laws and regulations affecting the use of solvents. Solvent users can use this information to understand the range and basic structure of laws and regulations that may affect solvent use. State and federal regulators can use this information to gain a better understanding of the full scope of requirements across all media. In sections 19.2 to 19.4, the discussion follows the single-medium-based regulatory approach used in the U.S. Recognizing, however, that environmental problems may cross medium lines, section 19.5 of this chapter provides a brief discussion of multimedia laws and regulations. Section 19.6 discusses laws and regulations to protect workers from exposure to hazardous chemicals. An overview of international environmental laws and regulations is given in section 19.7.

19.2 AIR LAWS AND REGULATIONS

19.2.1 CLEAN AIR ACT AMENDMENTS OF 1990[9]

19.2.1.1 Background

In the seventies, the Air Quality Act of 1967 was amended twice: first in 1970 and then in 1977. These amendments brought, among other things, the establishment of national ambient air quality standards (NAAQS), new source performance standards (NSPS) for major new or modified stationary sources, and the national emission standards for hazardous air pollutants (NESHAPS). Also in 1970, the decentralized environmental quality programs and oversight were integrated with the founding of EPA.[23] EPA became the federal agency with primary environmental regulatory responsibility in the U.S with 10 Regional Offices located in major cities (see Figure 19.1 and Table 19.4). The Clean Air Act was amended once again in 1990, building on earlier editions while incorporating some significant changes. The old command and control policy changed to a more cooperative effort on the part of the federal government, state agencies, local municipalities, and industry. Similar approaches were implemented as early as 1979. Then, EPA tried to develop market-based concepts in an attempt to limit and control pollution within a given area, also known as a bubble, while permitting some level of flexibility for the affected facilities. Facilities achieving greater control than required, were allowed to sell their excess pollution reduction credit to other facilities within that area provided the overall pollution level was not exceeded.[24] These attempts did not achieve the desired pollution reduction, which prompted revisions and amendments to the CAA.

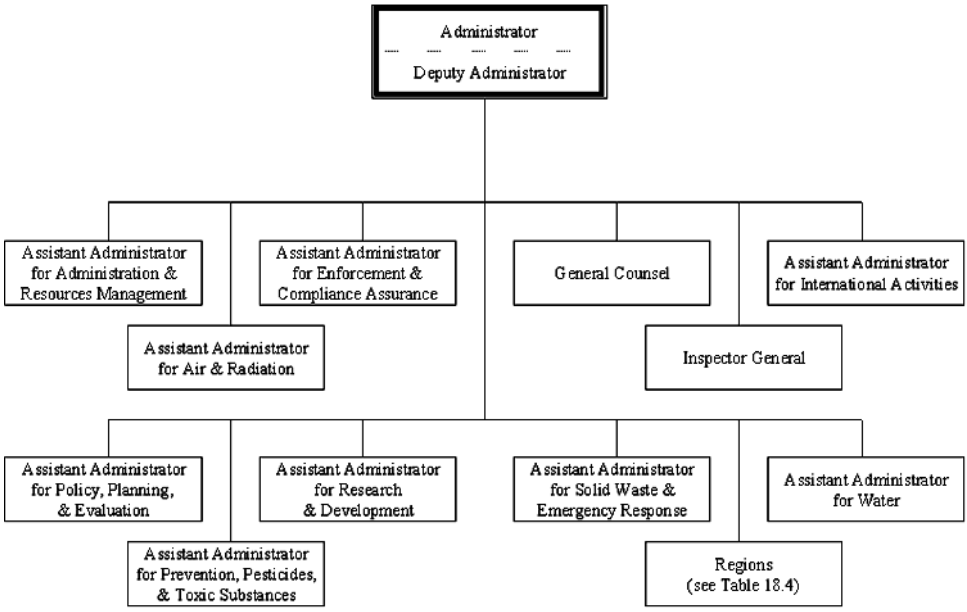


Figure 19.1. EPA organizational structure.

Despite substantial revisions and amendments to the CAA, prior EPA, state, or local laws or regulations were not repealed. In fact, even today, many states still follow prior CAA amendments.[25]

Table 19.4. List of EPA's regional offices

EPA Region	States	Address	Phone Number
1	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	John F. Kennedy Federal Bldg., One Congress Street, Suite 1100, Boston, MA 02114-2023	(617) 918-1111
2	New Jersey, New York, Puerto Rico, Virgin Islands	290 Broadway, New York, NY 10007-1866	(212) 637-3000
3	Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, West Virginia	1650 Arch Street, Philadelphia, PA 19103-2029	(215) 814-5000
4	Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee	61 Forsyth Street, SW, Atlanta, GA 30303-3104	(404) 562-9900
5	Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin	77 West Jackson Boulevard, Chicago, IL 60604-3507	(312) 353-2000

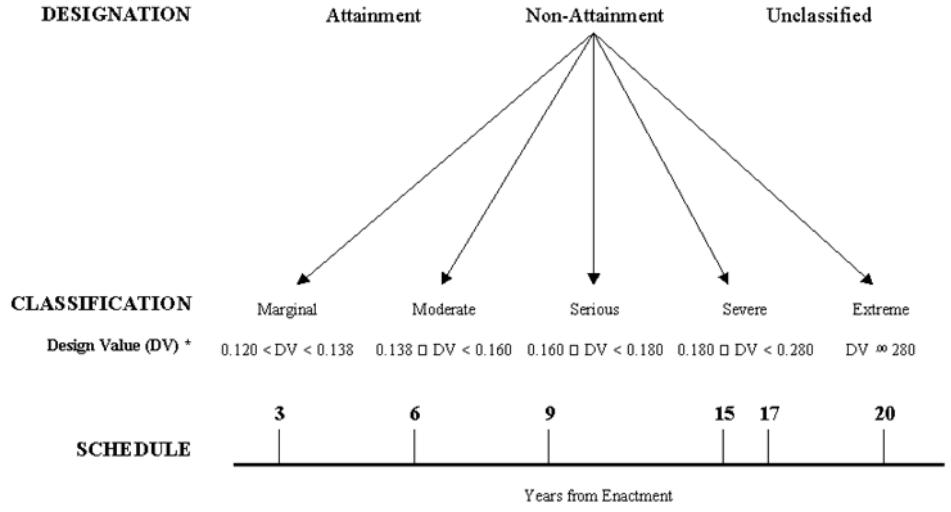
EPA Region	States	Address	Phone Number
6	Arkansas, Louisiana, New Mexico, Oklahoma, Texas	1445 Ross Avenue, 12th Floor, Suite 1200, Dallas, TX 75202-2733	(214) 665-6444
7	Iowa, Kansas, Missouri, Nebraska	726 Minnesota Avenue, Kansas City, KS 66101	(913) 551-7000
8	Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming	999 18th Street, Suite 500, Denver, CO 80202-2466	(303) 312-6312
9	American Samoa, Arizona, California, Guam, Hawaii, Nevada	75 Hawthorne Street, San Francisco, CA 94105	(415) 744-1702
10	Alaska, Idaho, Oregon, Washington	1200 Sixth Avenue, Seattle, WA 98101	(206) 553-1200

The CAA of 1990 contains six titles and related provisions designed to "encourage" air pollution abatement and reduction. These provisions address several environmental pollution problems that affect us all, such as tropospheric ozone, hazardous pollution, mobile emissions, urban pollution, acid deposition, and stratospheric ozone depletion. Because the scope of this chapter is on solvents and the regulations that impact their use, only Titles I, III, V, and VI and their relevance to solvents will be discussed.

19.2.1.2 Title I - Provisions for Attainment and Maintenance of National Ambient Air Quality Standards

Under this Title (Section 108), EPA has issued National Ambient Air Quality Standards (NAAQS) for six criteria pollutants - referred to as traditional pollutants in Canada and the European Union (EU):[26] ground level ozone, nitrogen oxides, carbon monoxide, sulfur dioxide, particulate matter less than 10 μm in aerodynamic diameter (PM_{10}), and lead. They are called criteria pollutants because EPA has developed health-based criteria or science-based guidelines as the basis for establishing permissible levels. The air quality criteria established by EPA must "accurately reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health and welfare which may be expected from the presence of such pollutants in the ambient air."[9] These ambient air pollutants or NAAQS pollutants are generally present nationally and may be detected through the use of ambient monitoring detectors. Other air pollutants may be regulated as HAPs under Section 112 of Title III if they pose danger to human health but their effect is confined to a localized area.[25] NAAQS include standards to allow for an adequate protection of health (primary) and standards to prevent environmental and property damage from anticipated adverse effects (secondary). In July 1997, EPA published its revision to the ozone NAAQS. The new ozone NAAQS limit is 0.08 ppm and is based on an 8-hour air measurement average.

Areas that do not meet the established NAAQS or that affect the ambient air quality in a nearby area that does not meet NAAQS for the pollutant are known as non-attainment areas.[9] In the U.S., an estimated 90 million people live in these areas. These areas may be further classified based on the severity of non-attainment and the availability and flexibility of the pollution control measures believed necessary to achieve attainment.[9] A State Imple-



* Measured in parts per million (ppm).

Figure 19.2. Designation and classification of ozone areas.

mentation Plan (SIP) must be prepared and submitted by each state with a non-attainment area. The SIP must contain strategies to achieve compliance within the state's borders and "Air Quality Control Regions." Once a non-attainment area meets the NAAQS for a given pollutant, it is then classified as a maintenance area.

Ozone non-attainment areas are classified according to the severity of the pollution problem (see Figure 19.2). These areas also have to achieve VOC reduction as determined by the non-attainment classification. A 15 percent VOC reduction in non-attainment areas, classified as moderate and above, was required by 1996. Also, Section 182(c)(2)(B) requires that non-attainment areas classified as serious and above follow with a 3 percent VOC reduction per year.[9]

Each state with a non-attainment area selects reasonable control measures, known as Reasonably Available Control Technologies (RACTs), for major sources to achieve the required reduction. Specific information about RACTs can be found in the EPA published Control Technology Guideline (CTG) documents, which are designed to assist state agencies achieve VOC reduction and ozone NAAQS compliance. States are primarily responsible for meeting NAAQS following measures laid out in their SIPs. States work with stationary and mobile sources to ensure that criteria pollutant levels (ozone in the case of solvents) allow the states to meet NAAQS requirements. If a state is not doing an adequate job in improving and maintaining air quality through the activities identified in the SIP, EPA may step in and insist on more stringent measures. EPA promulgates Federal Implementation Plans (FIPs) to correct inadequacies in SIPs. A FIP includes enforceable emission limitations or other control measures and techniques or economic incentives so compliance with the NAAQS is achieved.

In the case of new major stationary sources, the states try to stay or come into attainment through the New Source Review (NSR) program. The NSR program, sometimes called preconstruction permitting, addresses emissions from new major stationary sources;

i.e., entire facilities or major modifications to existing facilities. Requirements depend on whether the facility is in a non-attainment area or is in a prevention of significant deterioration (PSD) area. Major sources for these areas must obtain a permit before any construction or modification is started. CAA defines a major VOC source as one that emits 9.1 Mg/year in an area classified as severe.[26]

Facilities in PSD areas are required to apply Best Available Control Technology (BACT) which takes into account economic impact. BACT is analyzed by regulators and applied to facilities on a case by case basis. BACT determination must result in emissions reduction as stringent as the federal New Source Performance Standard (NSPS) rule.

Facilities located in non-attainment areas or that are increasing emissions in such areas must apply for a state permit prior to starting construction. The permit must codify that they are applying Lowest Achievable Emissions Rate (LAER). LAER is also established on a case by case basis. They also need to obtain equivalent offsetting emissions reductions (Offsets) from existing sources within the non-attainment area. Unlike BACT, a LAER determination does not consider economic, energy, or other cross-media impacts.

Information about emission control technology, work practices, and reformulations that have been determined to be BACT and LAER for various types of sources is made available to the states through a central database called the RACT/BACT/LAER Clearinghouse.

Most organic solvents in this book are classified as VOCs and are found in commercial and consumer products such as paints, coatings, containers, and packaging (see Table 19.2 for a list of these VOC solvents and exempt solvents). They contribute to the formation of ozone and are regulated under this Title, Section 183(e).[9] Fuels and fuel additives are not the focus of Section 183(e). VOCs, nitrogen oxides, and oxygen undergo a photochemical reaction in the presence of sunlight resulting in the formation of tropospheric or ground level ozone, the primary component of smog. Heat also increases the reaction rates of these reactions. The contribution of some solvents to photochemical reaction may be considered negligible. As a result, some VOC solvents may be reclassified as exempt solvents; e.g., acetone. This reclassification begins with industry submitting a petition to EPA for a solvent or solvents to be reclassified as exempt. As of December 3, 1999, EPA had a list of 18 compounds for which petitions requesting VOC exempt status (see Table 19.5) had been received.[27]

Table 19.5. List of VOCs with requested VOC exempt status

Compound	Submitting		Proposed date
	Organization	Date	
Chlorobromomethane	ICF Kaiser	11/10/95	
Bromopropane	Enviro Tech International	05/10/96	
	Albemarle Corp.	11/18/97	
Methyl bromide	Chemical Manufacturers Association	07/19/96	
n-Alkanes (C_{12} - C_{18})	The Aluminum Association	11/27/96	
Technical white oils	The Printing Industries of America	12/20/96	
	Penzoil Products Company	12/20/96	

Compound	Submitting		Proposed date
	Organization	Date	
t-Butyl acetate	ARCO Chemical Company (now Lyondell)	01/17/97	9/30/99 64 FR 52731
Benzotrifluoride	Occidental Chemical Company	03/11/97	
Carbonyl sulfide	E.I. du Pont de Nemours and Company	08/11/97	
	Texas Mid-Continent Oil & Gas Association	12/05/97	
trans-1,2-Dichloroethylene	3M Corporation	10/08/97	
Dimethyl succinate and dimethyl glutarate	Dibasic Esters Group, affiliated with the Synthetic Organic Chemical Manufacturers Association, Inc.	10/14/97	
Carbon disulfide	Texas Mid-Continent Oil & Gas Association	12/05/97	
Acetonitrile	BP Chemicals	01/21/98	
	GNI Chemicals Corporation	01/21/98	
Toluene diisocyanate (TDI)	Chemical Manufacturers Association	01/22/98	
1,1,1,2,3,3,3-heptafluoropropane (HFC-227)	Great Lakes Chemical Corporation	02/18/98	
Methylene diphenyl diisocyanate (MDI)	Chemical Manufacturers Association	08/19/98	
1,1,1,2,2,3,3-heptafluoro-3-methoxy-propane	3M Performance and Fluids Division	02/05/99	
Propylene carbonate	Huntsman Corporation	07/27/99	
Methyl pivalate	Exxon Chemical Company	11/22/99	

Note: As of December 3, 1999, EPA had not published final actions on these chemicals.

In 1995, under Section 183(e), EPA generated a list of consumer and commercial products categories to be regulated which accounted for at least 80 percent of the VOC emissions from such products in ozone non-attainment areas.[28] The list was divided into four groups, and each group is to be regulated every 2 years (starting in 1997) based on the best available controls (BACs). These four groups are listed in Table 19.6.[29] The term control is broad, including not only end-of-pipe control technology, but also source reduction alternatives. The product categories were selected for regulation based on eight criteria developed to address five factors outlined in Section 183(e)(2):

1. utility
2. commercial demand
3. health or safety functions
4. content of highly reactive compounds
5. availability of alternatives
6. cost effectiveness of controls
7. magnitude of annual VOC emissions
8. regulatory efficiency and program considerations

Table 19.6. Consumer and commercial products categories

Group I (1997) Aerospace Coatings, Architectural Coatings, Autobody Refinishing Coatings, Consumer Products (24 categories), Shipbuilding and Repair Coatings, Wood Furniture Coatings
Group II (1999) Flexible Packaging Printing Materials
Group III (2001) Aerosol Spray Paints, Industrial Cleaning Solvents, Flat Wood Paneling Coating, Lithographic Printing Materials
Group IV (2003) Auto and Light Duty Truck Assembly Coatings, Fiberglass Boat Manufacturing Materials, Large Appliance Coatings, Letterpress Printing Materials, Metal Furniture Coatings, Miscellaneous Industrial Adhesives, Miscellaneous Metal Products Coatings, Paper, Film, and Foil Coatings, Petroleum Drycleaning Solvents, Plastic Parts Coatings

This table reflects the regulatory schedule revised on March 18, 1999 Federal Register (64 FR 13422).

19.2.1.3 Title III - Hazardous Air Pollutants

Section 112 of Title III of the CAA of 1990 lists 188 HAP compounds or groups of compounds (the original list had 189, but caprolactam was removed from the list) which are believed to be carcinogens or can otherwise pose serious health effects. HAP solvents can cause a number of health problems such as cancer, kidney and liver damage, developmental problems in children, nervous system problems, respiratory irritation, birth defects, and miscarriages.[7,8] It may take minutes or years for these health effects to manifest themselves. Approximately half (90 compounds) of the HAP compounds are solvents and are found in many of the source categories regulated under Title III. EPA has the authority to delete chemicals from or add new chemicals to this original list, but no criteria pollutant can be added, only its precursors. If a petition to add or delete a chemical is submitted to EPA, EPA has 18 months to respond with a written explanation of its denial or concurrence. Before the 1990 CAA, EPA listed only eight substances as HAPs (beryllium, mercury, vinyl chloride, asbestos, benzene, radionuclides, arsenic, and coke oven emissions) and issued standards for seven (coke oven emissions were not regulated before the 1990 CAA). After the enactment of the CAA of 1990, a substantially greater number (174) of source categories were identified to be regulated within a period of 10 years. In other words, EPA would promulgate regulations for 174 source categories in half the time that it took to promulgate regulations for only seven. This number of categories to be regulated has been reduced because of subcategorization or deletion of categories.

Many of these categories are major stationary sources which emit HAP or toxic solvents to the atmosphere (see Table 19.2) and are scheduled to be regulated by the year 2000. These regulations are technology-based standards, known as Maximum Achievable Control Technology (MACT) standards. MACT standards are EPA's regulatory means to establish emission limits for air toxics. MACT standards have already been promulgated for 39 source categories (see Table 19.7). EPA will not be developing MACT standards for seven of the originally listed major source categories. There are 66 source categories that remain to be regulated.

Table 19.7. Categories of sources of HAPs for which Maximum Achievable Control Technology (MACT) standards have already been developed[30]

Schedule	Source Categories	Compliance Date
2-Year	Dry Cleaning	09/23/96
	Hazardous Organic NESHAP	F/G - 05/14/01; H - 05/12/99; New Sources - 05/12/98
4-Year	Aerospace Industry	09/01/98
	Asbestos	Delisted
	Chromium Electroplating	Deco - 0 1/25/96; Others -01/25/97
	Coke Ovens	Not available
	Commercial Sterilizers	12/06/98
	Degreasing Organic Cleaners (Halogenated Solvent Cleaning)	12/02/97
	Gasoline Distribution (Stage 1)	12/15/97
	Hazardous Waste Combustion	06/19/01
	Industrial Cooling Towers	03/08/95
	Magnetic Tape	w/o new control devices -12/15/96; w/ new control devices - 12/15/97
	Marine Vessel Loading Operations	MACT - 09/19/99; RACT -09/19/98
	Off-Site Waste Recovery Operations	07/01/00
	Petroleum Refineries	08/18/98
	Polymers & Resins I: Butyl Rubber, Epichlorohydrin Elastomers, Ethylene Propylene Rubber, Hypalon (TM) Production, Neoprene Production, Nitrile Butadiene Rubber, Polybutadiene Rubber, Polysulfide Rubber, Styrene-Butadiene Rubber & Latex	07/31/97
	Polymers & Resins II: Epoxy Resins Production, Non-Nylon Polyamides Production	03/03/98
	Polymers & Resins IV: Acrylontrile-Butadiene-Styrene, Methyl Methacrylate-Acrylonitrile, Methyl Methacrylate-Butadiene, Polystyrene, Styrene Acrylonitrile, Polyethylene Terephthalate	07/31/97
	Printing & Publishing	05/30/99
	Secondary Lead Smelters	06/23/97
	Shipbuilding & Ship Repair	12/16/96
	Wood Furniture	11/21/97
7-Year	Chromium Chemical Manufacturing	Delisted
	Electro Arc Furnace: Stainless & Non-Stainless Steel	Delisted

Schedule	Source Categories	Compliance Date
7-Year	Ferroalloys Production	05/20/01
	Flexible Polyurethane Foam Production	10/08/01
	Generic MACT: Acetal Resins, Hydrogen Fluoride, Polycarbonates Production, Acrylic/Modacrylic Fibers	06/29/02
	Mineral Wool Production	06/01/02
	Nylon 66 Production	Delisted
	Oil & Natural Gas Production	06/17/02
	Pesticide Active Ingredient Production: 4-Chlor-2-Methyl Acid Production; 2,4 Salts & Esters Production; 4,6-dinitro-o-cresol Production; Butadiene Furfural Cotrimer; Captafol Production; Captan Production; Chloroneb Production; Dacthal™ Production; Sodium Pentachlorophenate Production; TordonTM Acid Production	06/30/02
	Pharmaceutical Production	09/21/01
	Phosphoric Acid / Phosphate Fertilizers	06/10/02
	Polyether Polyols Production	06/01/02
	Portland Cement Manufacturing	Not available
	Primary Aluminum Production	10/07/99
	Primary Lead Smelting	06/04/02
	Pulp & Paper (non-combust) - MACT I	04/15/01
	Pulp & Paper (non-combust) - MACT III	04/16/01
	Steel Pickling - HCl Process	06/22/01
	Tetrahydrobenzaldehyde Manufacture (formerly known as Butadiene Dimers Production)	05/12/01
	Wood Treatment MACT	Delisted
	Wool Fiberglass Manufacturing	06/14/01
10-Year	Cyanuric Chloride Production	Delisted
	Lead Acid Battery Manufacturing	Delisted
	Natural Gas Transmission & Storage	06/17/02

Under Section 112 of Title III of the CAA of 1990, EPA will regulate all major sources and area sources deemed appropriate. A major source is a stationary source located within a contiguous area under common control that emits or has the potential to emit ≥ 9.1 Mg/yr (10 tons/yr) of a single HAP or ≥23.7 Mg/yr (25 tons/yr) of a combination of HAPs. An area source is a non-major stationary source. Under Section 112, EPA is required to promulgate 40 categories by 1992, 25 percent of the listed categories by 1994, an additional 25 percent

by 1997, and all categories by the year 2000. A list of sources was developed by EPA in 1992[31] and modified 4 years later.[32] Each MACT standard allows existing sources 3 years to comply. Additional years may be granted to complete the installation of controls, to dry and cover mining waste, and for coke ovens. A new source that began construction after the date a MACT standard was proposed will begin compliance at startup or by the date the final standard is issued, whichever is later. Under the early reduction program, additional time may be given to a facility to meet HAP reduction requirements if about 90 percent of the HAP emissions are reduced before a MACT standard is in effect. Once MACT standards are promulgated, the CAA requires EPA to conduct a risk assessment, if considered necessary for public health, to:

- assess the level of risk or "residual risk" remaining to public health,
- estimate the public health significance of the estimated residual risk,
- identify the technological and commercially available methods and costs to reduce the residual risk,
- estimate the actual health effects in the vicinity of sources,
- identify any health studies and uncertainties in the available risk assessment methodologies,
- determine any negative health and environmental impacts resulting from the reduction of the residual risk, and
- produce recommendations leading to legislation for the residual risk.

This may result in even more stringent regulations for solvent users. Figure 19.3 outlines basic steps involved in the development of a MACT regulatory standard.[28]

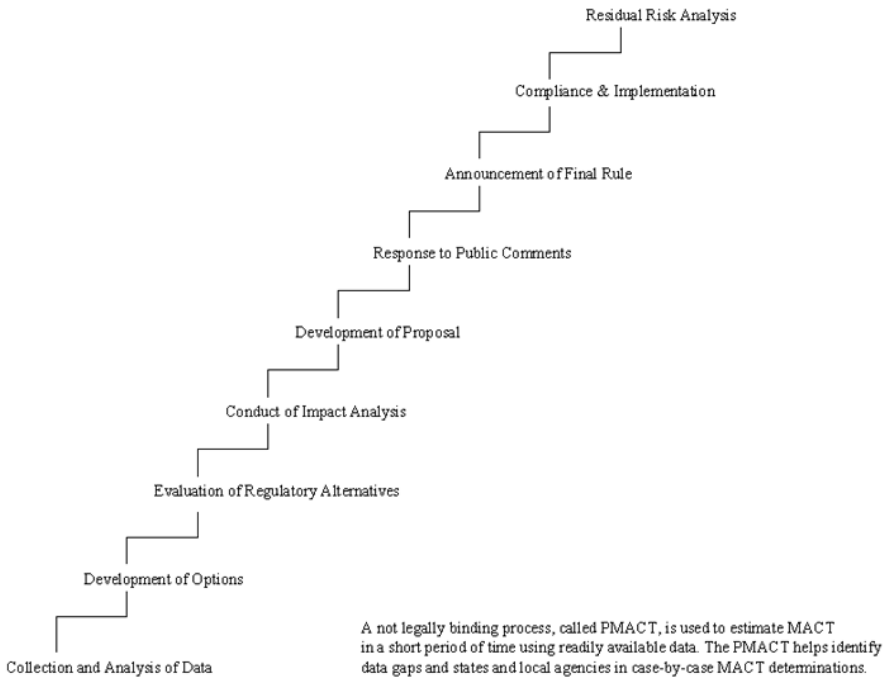


Figure 19.3. Steps for the development of MACT regulations.

The CAA provides for potential delays in the promulgation of MACTs for major HAP sources; i.e., Section 112(j). This is known also as the MACT Hammer.[25] This provision requires major HAP sources to apply for a permit 18 months after the MACT standard scheduled promulgation date. The State must then make a case-by-case determination of MACT for the source. If the delayed MACT standard is later promulgated, the permit will be revised to reflect any new emission limitation requirements and the affected source may be given up to 8 years to comply.[9]

Air toxics have also been regulated at the state level under various air toxic state programs. In the U.S., the State of California has one of the more stringent and complex air toxics programs. California leads with air toxic programs such as Assembly Bill 1807 (AB 1807) that targets emissions that pose greatest risk to public health and Senate Bill 1731 (SB 1731) that regulates air toxics through facility-based controls rather than risk-based controls.[33]

19.2.1.4 Title V - Permits

Title V was added to the CAA, in the 1990 CAA Amendments, to establish a permit program, federally mandated, to be implemented by the states. Under this Title, EPA has established 10 minimum "elements" for an operating permit program to be administered by the states. These elements serve as basic guidelines to be used when establishing an operating permit program. They include requirements for applications, monitoring and reporting, and annual fees to the owner or operator of sources subject to a permit. They also include the following elements to ensure the effectiveness of an operating permit program:

- adequate personnel, funding, and permitting authority to administer the program;
- procedures to expeditiously evaluate permit applications, prevent unreasonable delay by the permitting authority, and allow for revisions and needed changes to existing permits; and
- provisions to allow permitted facilities to change without requiring permit revision.[9]

Each state is required to develop and submit a permit program. By 1997, EPA had approved nearly all states' permit programs, and some sources have already applied for Title V permits.[25] The idea of an operating permit is to consolidate all CAA requirements for a source in one regulatory vehicle. This includes all applicable SIP air emission limitations, monitoring, and reporting requirements along with CAA regulations (HAP regulations, NSPS, etc.).[25]

19.2.1.5 Title VI - Stratospheric Ozone Protection

Title VI of the CAA deals with chemicals, CFCs, and other ozone depleting substances (ODS) that can cause deterioration of the stratospheric ozone layer. Some of these chemicals are used as solvents in cleaning operations (cleaning of metals, electronics, and precision equipment), coatings, adhesives, and inks. Their production and use have been banned both domestically and internationally[34] (except for a few countries). An unprecedented international effort by 20 countries and the Commission of the European Communities resulted in the 1987 Montreal Protocol. The Montreal Protocol became effective on January 1, 1989. In the U.S., the CAA Amendments of 1990 were the domestic response to such a critical environmental issue of global proportions and provided EPA with the regulatory agenda.

ODS solvents are required to be replaced with non-depleting chemicals. Controlling these substances is not an alternative. ODS solvents are listed in Table 19.2. Substitute sol-

vents deemed acceptable have been identified for some of these ODS solvents under EPA's Significant New Alternatives Policy (SNAP), but other health concerns have limited their use. Some exemptions to the use of phase out ODS exist for essential uses as long as they are consistent with the Montreal Protocol (to date, none has been authorized by EPA).[25]

The SNAP program was established to control the commercialization of ODS substitutes and to ensure that such substitutes do not pose greater harm to the environment than the original chemicals. Through the SNAP program, EPA identifies, classifies, restricts, or prohibits the use of ODS substitutes.

19.3 WATER LAWS AND REGULATIONS

19.3.1 CLEAN WATER ACT

19.3.1.1 Background

In 1972, Congress enacted the Federal Water Pollution and Control Act (FWPCA), also known as the Clean Water Act (CWA).[35] The CWA is the primary federal legislation that regulates the quality of streams, lakes, estuaries, and coastal waters in the U.S. The CWA has been amended three times: 1977, 1982, and 1987.[36,37,38,39] The CWA is divided into six titles. Its purpose is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters by eliminating the discharge of pollutants into navigable waters or municipal sewer systems.[39] Waters can become contaminated by pollutants discharged from point sources, non-point sources, and storm water and by pollutants from the degradation of wetlands. Point source discharges originate from industrial and sewage treatment plants while non-point discharges are generated from diffuse sources such as sediment runoff from construction sites, leaks from faulty septic systems, and fertilizer and herbicide runoff from agricultural and residential activities. Point sources are "discernable, confined, and discrete conveyances."[38] Examples of a point source include pipes, ditches, channels, tunnels, conduits, discrete fissures, or containers. These sources are regulated and control through the National Pollutant Discharge Elimination System (NPDES) permit program.

In 1976, EPA's focus changed from control of conventional pollutants (biological oxygen demand and suspended solids) to control of toxic pollutants. This shift in EPA's focus was the result of a lawsuit in 1976 which resulted in the Flannery Decree and in the 1977 amendments.[36,40] These amendments established a permit program for point source discharges to focus on 21 major industrial categories and 65 priority pollutants (see Table 19.2 for list of priority pollutant solvents). Today's list of priority pollutants has been expanded to include 129 toxic pollutants from 34 industrial categories.

In the 1987 amendments of the CWA, Congress incorporated Section 319 to establish a national program to control non-point source discharges which provided a regulatory schedule for storm water. These amendments also established a revolving loan fund for construction of sewage treatment plants and provided EPA with enhanced enforcement tools.[38]

19.3.1.2 Effluent Limitations

Under Title III of the CWA, effluent limitations provide the control conditions for a facility's wastewater discharge under an NPDES permit which regulates the quantity and rate of discharges to navigable waters. Guidelines, called the effluent limitations guidelines, have been developed to establish technology-based limits for all types of industrial discharges. Over 50 industry-specific technology-based effluent guidelines have already been promulgated.[40] There are five technology-based treatment standards currently established by the

CWA to establish the minimum level of control to be required by a permit. They are the Best Practicable Control Technology (BPT), Best Available Technology Economically Achievable (BAT), Best Conventional Pollutant Control Technology (BCT), Best Available Demonstrated Technology (BDT), and Best Management Practices (BMPs). Industries that do not discharge directly into surface waters but into publicly operated treatment works (POTWs) are subject to pretreatment standards under Section 307(b) of the CWA.[38]

19.3.1.3 Permit Program

The CWA, under Section 301 (effluent limitations), prohibits the discharge of any pollutant unless the source obtains a permit and ensures compliance. The NPDES permit program, pursuant to Section 402 of the CWA, requires that commercial and industrial facilities and POTWs apply for permits issued by EPA or a designated state. A permit regulates the amount, concentration, and rate of discharge of each regulated pollutant. According to the CWA, a pollutant includes dredged soil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological and radioactive materials, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste.[39] These pollutants are further classified in three categories: conventional, toxic, and non-conventional. Virtually, any material and characteristics such as toxicity or acidity is considered a pollutant.[40] Solvents fall under the category of toxic pollutants.

An NPDES permit can be issued by EPA or by a state that has received EPA permitting approval. As of 1996, 40 states and territories had received EPA's approval.[40] States and territories that are not authorized to administer the NPDES program are Alaska, Arizona, District of Columbia, Idaho, Louisiana, Maine, Massachusetts, New Hampshire, New Mexico, the Pacific Territories, Puerto Rico, and Texas. For these states and territories, the 10 EPA Regional Offices will issue and administer the NPDES permits. The permit process is elaborate and requires extensive information and numerous steps. First a number of forms need to be completed to provide information about the facility, its operation, and the nature of the discharges. This is followed by a period of discussion between EPA and the discharging facility, and the draft permit is announced for comments from the public for 30 days. Once the comments are reviewed, responded to, and implemented, then the final NPDES permit is issued.

19.3.2 SAFE DRINKING WATER ACT

19.3.2.1 Background

Enacted in 1974, the Safe Drinking Water Act (SDWA) was established to ensure safe drinking water in public water systems. It required that EPA identify substances in drinking water which could adversely affect public health.[41] SDWA safeguards drinking water with two standards. Primary drinking water standards with a maximum contaminant level (MCL) designed to protect human health and secondary drinking water standards to protect public welfare. The secondary standards involve physical characteristics of drinking water such as color, taste, and smell. A total of 83 contaminants are regulated under the SDWA: 49 volatile and synthetic organic chemicals, 23 inorganic chemicals, 6 microbiological contaminants, and 5 radiological contaminants.

In 1986, the SDWA was amended to greatly increase the responsibilities of EPA and state agencies. Under the 1986 amendments, EPA is directed to schedule the promulgation of primary public drinking water regulations, impose civil and criminal penalties for tampering with public water systems, and enforce more stringent standards.[2] Also, under the

1986 amendments, the wellhead protection program was established to focus on potential contamination of surface and subsurface surrounding a well.[42] In 1988, Congress passed the Lead Contamination Control Act (LCCA) as an additional amendment to the SDWA to protect the public against the contamination of drinking water by lead.

In 1996, the SDWA was amended again to place emphasis on sound science and a risk-based standard approach, small water supply systems, and water infrastructure assistance through a revolving loan fund.[43]

19.3.2.2 National Primary Drinking Water Regulations

National Primary Drinking Water Regulations (NPDWRs) are enforceable, unlike secondary regulations that are only considered advisable, and established by EPA for contaminants that may cause adverse health effects. The promulgation of the NPDWRs begins with the publication of the advanced notice of the proposed rule. This notice presents the current scientific and technical knowledge about the contaminant and the approach EPA is taking toward its regulation. During this period, EPA seeks comments and any additional information through public meetings, workshops, etc. Comments are then reviewed, and a proposed rule is announced in the Federal Register which includes MCLs and non-enforceable health goals called maximum contaminant level goals (MCLGs). After additional public comments, the final regulation is announced and promulgated. The schedule for this regulatory development is contained in the SDWA amendments of 1986. The first 9 contaminants were to be regulated by EPA within 1 year of enactment, followed by another 40 contaminants within 2 years of enactment, and 34 contaminants within 3 years of enactment for a total of 83 by 1989. The SDWA of 1986 also required EPA to regulate 25 additional contaminants every 3 years. EPA regulated these 83 contaminants except for arsenic, sulfate, and radionuclides. These three are addressed under the 1996 amendments. With the 1996 amendments of the SDWA, beginning in 2001, EPA is required to make regulatory decisions for a minimum of five listed contaminants every 5 years.

Along with the regulatory development, EPA prepares criteria documents which provide technical support for the final rules. These criteria documents identify fundamental information regarding health effects of contaminants in drinking water. Health-effects-related data such as physical and chemical properties, toxicokinetics, human exposure, health effects in animals and humans, mechanisms of toxicity, and quantification of toxicological effects are evaluated and serve as supporting documentation for the MCLGs.[44]

19.4 LAND LAWS & REGULATIONS

19.4.1 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)[10]

19.4.1.1 Background

The law that regulates solid and hazardous waste management is called RCRA. It was passed as a law in 1976 as an amendment to the Solid Waste Disposal Act (SWDA), and amended in 1980 and 1984, to regulate solid hazardous waste from its creation all the way to its disposal. The 1984 amendments are called the Hazardous and Solid Waste Amendments (HSWAs). These amendments made RCRA a more stringent law giving EPA more increased authority to enforce tighter hazardous waste management standards. They also provided for EPA to revisit problems associated with underground storage tanks. More specifically, Subtitle C regulates hazardous waste while Section D regulates non-hazardous waste such as municipal solid waste and sewage sludge.[45] RCRA requirements were also

amended to include small businesses that manage specified amounts of hazardous waste and show an increase in the number of hazardous wastes.[46]

19.4.1.2 RCRA, Subtitle C - Hazardous Waste

Subtitle C is RCRA's regulatory arm to deal with management of hazardous solid waste. A waste is considered hazardous if it appears on EPA's list of hazardous wastes or if hazardous characteristics can be identified. However, the person generating the solid waste is responsible for determining if the generated solid waste is hazardous. Over 500 solid wastes have been identified and listed by EPA as hazardous. Once a waste appears on the EPA hazardous list (wastes classified as F, K, P, U, or so-called "listed" wastes), such a waste is always considered hazardous regardless of its chemical composition. However, EPA is currently working on developing "exit criteria" for certain chemicals in listed wastes that would allow these wastes to be managed as non-hazardous solid wastes if the chemical concentrations are below specified levels. In Part 26, EPA classifies hazardous wastes by the following codes[10] (see Table 19.2 for EPA's hazardous codes for solvents):

F wastes from non-specific sources
K wastes from specific sources
P discarded acutely hazardous commercial chemical products
U discarded commercial chemical products
D wastes for which the above codes do not apply – considered hazardous only if they exhibit ignitability (I), corrosivity (C), reactivity (R), and/or toxicity (E/H/T).

A solid waste considered hazardous will always maintain its listed classification even if it is found mixed with any other waste or a residue derived from a listed hazardous waste.[10] In addition, land disposal of a hazardous waste is prohibited by RCRA unless it is demonstrated that hazardous constituents will not migrate from the disposal unit, causing harm to the environment and public health (40 CFR 268).[10] Hazardous solid waste generators are classified as small quantity generators (SQGs) (i.e., 100 to 1000 kg/month) or large quantity generators (LQGs) (i.e., ≥ 1000 kg/month or > 1 kg of an acutely toxic hazardous waste). These waste quantities apply to each month, not the average over the year. For example, if a facility generates 5 kg in each of the first 11 months and 1200 kg in the last month, such a facility would be considered a large quantity generator (LQG) even though its average is less than 1000 kg/month. Generators can be further classified as conditionally exempt small quantity generators (CESQGs) if they produce < 100 kg/month of hazardous waste and do not accumulate more than 1000 kg of hazardous waste. CESQGs are exempt from all RCRA notification, reporting, and manifesting requirements. Waste from CESQGs must be sent to properly permitted, licensed, or registered treatment, storage, and disposal (TSD) facilities, recycling/reclamation facilities, or facilities authorized to manage industrial or municipal solid waste.[2]

RCRA regulations also provide for states to have primary responsibility for managing and implementing the RCRA hazardous waste program (40 CFR 271). Currently, most states and territories have been granted this authority. States can receive an interim authorization (40 CFR 271, Subpart B) as a temporary vehicle while developing a program for final authorization, which is fully equivalent with the federal program. Hence, for a state to obtain final authorization, it must also be consistent with and no less stringent than the Federal program.

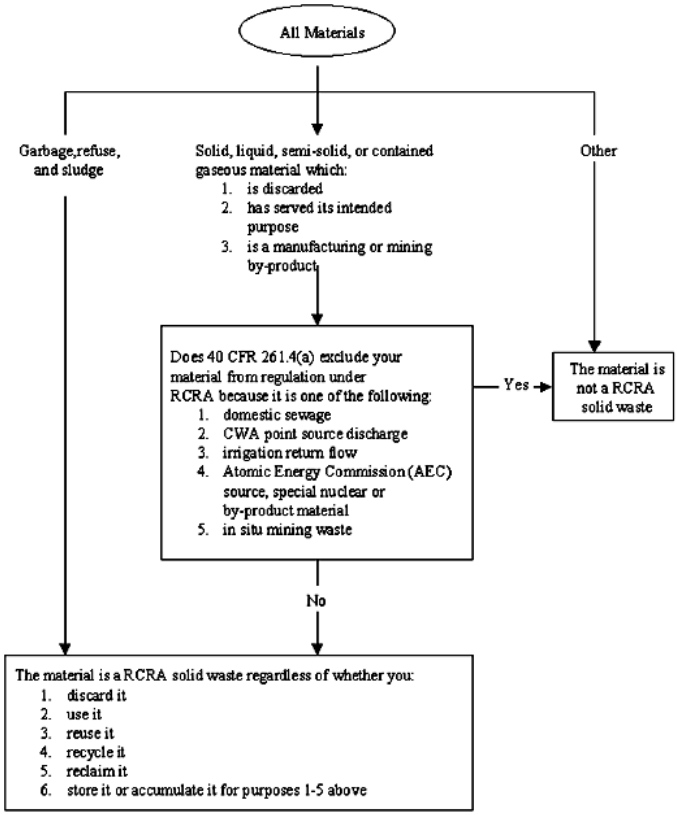


Figure 19.4. Definition of a solid waste (Figure 1 - 40 CFR 260, Appendix I).

RCRA also addresses the transportation of hazardous waste (40 CFR 263). Any transporter of hazardous waste must also comply with the Department of Transportation (DOT) rules under the Hazardous Materials Transportation Act (HMTA) regarding proper labeling, packaging, handling, and placarding.[47]

Finally, a facility generating waste can determine if its waste is regulated under Subtitles C or D by following the steps outlined in the Code of Federal Regulations, Title 40 Part 260, Appendix I (see Figures 19.4, 19.5, and 19.6).

Other provisions exist if the solid waste will be incinerated.

19.5 MULTIMEDIA LAWS AND REGULATIONS

19.5.1 POLLUTION PREVENTION ACT OF 1990[3]

19.5.1.1 Background

Before 1990, most regulations in the U.S. were issued based on the use of conventional pollution management practices usually considering waste management and end-of-pipe control technologies. Only a handful of government activities were considering reduction of pollution at the source. In the area of waste minimization, recycling approaches were employed in addition to add-on control technology to achieve pollution reduction. However, reducing pollution at the source refers to the top of the hierarchy. Although add-on control

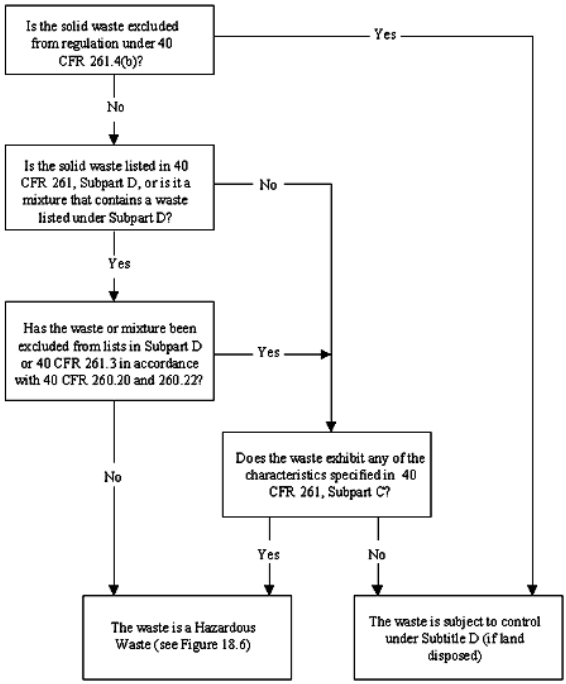


Figure 19.5. Definition of a hazardous waste (Figure 2 - 40 CFR 260, Appendix I).

technology has its place in many applications, new approaches need to be considered to obtain emissions reduction required by new regulations.

In 1990, Congress passed the Pollution Prevention (P2) Act, recognizing that to attain greater levels of pollution reduction, reduction or prevention of pollution at the source "through cost-effective changes in production, operation, and raw materials use" needed to be encouraged and implemented.[3] A fundamental belief expressed in the P2 Act, is that these changes would not only help the environment but would benefit industry's bottom line through the reduction of raw material, pollution control, and liability costs.[3]

19.5.1.2 Source Reduction Provisions

The P2 Act is an attempt by the U.S. to establish a framework for integrated multimedia environmental initiatives. The P2 Act provides for a multimedia, integrated, and cost-effective approach to solving environmental problems while encouraging sustainable development. P2 or source reduction includes any practice that reduces or eliminates the creation of pollutants through increased efficiency in the use of raw materials, energy, water, or other resources, or protection of natural resources by conservation. Pollution may be reduced by modifying equipment or technology, modifying processes, reformulating products, substituting raw materials, and improving housekeeping, maintenance, training, or inventory control.[3] The P2 Act encourages the reduction or elimination of wastes of all types and requires that facilities reporting to the Toxic Release Inventory (TRI) provide documentation of their P2/waste minimization or reuse efforts for TRI-reportable chemicals.

The P2 Act required EPA to establish an Office of Pollution Prevention with the authority of promoting source reduction through a multimedia perspective. The Office of Pollution Prevention already existed under The Office of Policy, Planning, and Evaluation (OPPE). It was established by EPA 2 years prior the enactment of the P2 Act. In response to the P2 Act, in 1991, this office developed a source reduction strategy.

The P2 Act also includes provisions aimed at improving the collection and public access of data. Under the Emergency Planning and Community Right-to-Know Act of 1986, industrial facilities are required to report on their annual releases of toxic chemicals to the

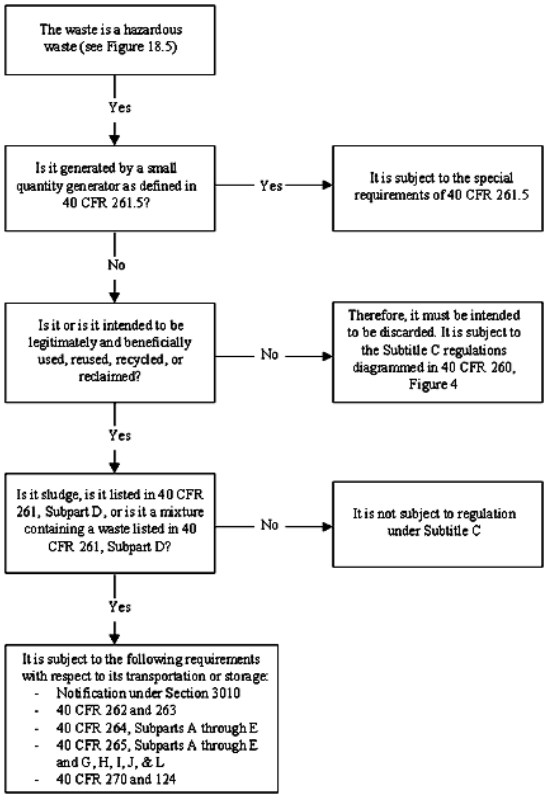


Figure 19.6. Special provisions for certain hazardous wastes (Figure 3 - 40 CFR 260, Appendix I).

environment. In response to the P2 Act, the report must include information on their efforts on source reduction and recycling.

In response to the P2 Act and to help promote source reduction, EPA established various prevention programs and initiatives:

- 33/50 Program - A very successful EPA experimental program based on voluntary industry participation. Companies that reported to TRI any of the 17 target chemicals were encouraged to participate voluntarily to meet a 33 and 50 percent reduction by 1992 and 1995, respectively. Over 1000 companies participated in this program achieving a 55 percent reduction, which translates to an overall reduction of 340 x 106 kg (750 x 106 lb) of toxic chemical releases and transfers.[4] More information about this program can be obtained by contacting the EPA's Office of Pollution Prevention and Toxics website at http://www.epa.gov/opptintr/3350/.
- Common Sense Initiative (CSI) – This initiative consisted of six pilot sectors: automobile manufacturing, computer and electronics, iron and steel, metal finishing, printing, and petroleum refining. The CSI idea was to focus on environmental management by industrial sector rather than by environmental medium.[48] More information can be found at http://www.epa.gov/commonsense.
- Source Reduction Review Project (SRRP)[49] – This was a pilot program designed to ensure that source reduction measures and multimedia issues were considered during the development of air, water, and hazardous waste regulations affecting 17 industrial categories. The SRRP was established to provide a model for the regulatory development process throughout EPA. Some progress has been made, but most regulations are still developed primarily based on a single medium and, while source reduction is encouraged, add-on control technologies are the basis of the regulations.
- Project XL (eXcellence and Leadership) – This is another pilot program recently established by EPA to promote the use of innovative approaches rather than conventional regulatory and policy strategies to achieve more cost-effective

environmental results. The XL project has three key elements: superior environmental performance (SEP) to anticipate superior environmental performance, regulatory flexibility to encourage participation and maximize success, and stakeholder involvement to assist in development and implementation of the project.[50] Visit http://www.yosemite.epa.gov/xl/xl_home.nsf/all/homepage for more information.

Other examples of voluntary programs and initiatives include: AgStar, Climate Wise, Coalbed Methane Outreach, Design for the Environment, Energy Star Builidings, Energy Star Residential, Energy Star Office Equipment, Energy Star Transformer, Environmental Accounting, Environmental Leadership Program, Green Chemistry, Green Lights, Indoor Environments, P2 Information Clearinghouse, P2 Grant Program, Transportation Partners, U.S. Initiative on Joint Implementation, WAVE, Waste Minimization National Plan, and WasteWi$e.

19.5.2 TOXIC SUBSTANCES CONTROL ACT

19.5.2.1 Background

Also referred to by some as the sleeping giant of environmental regulations,[51] the Toxic Substances Control Act (TSCA) was enacted in 1976 to regulate chemicals in commerce that may cause adverse environmental and health effects.[52] TSCA requires testing of manufactured substances to determine the character of their effect and regulates the manufacture, distribution, use, and disposal of new and existing substances. In 1986, TSCA was amended to include the Asbestos Hazardous Emergency Response Act (AHERA). The 1990 amendments provided for coverage of all public and commercial buildings. TSCA does not regulate food and food products, tobacco or tobacco products, and pesticide manufacturing, processing, or distribution in commerce. These areas are regulated under the Federal Food, Drug, and Cosmetic Act (FFDCA) and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). TSCA's regulatory responsibility is not delegated to states, as may be the case with the other regulations previously mentioned. Since the focus of this book is on solvents, only some key provisions of Title I will be briefly discussed.

19.5.2.2 Controlling Toxic Substances

Under Title I of TSCA (Section 4), manufacturers, importers, and processors of chemical substances and mixtures may be required by EPA to obtain health and environmental data on their health and environmental effects if:

their manufacture, processing, use, distribution in commerce, and disposal, or any combination of such activities, poses an unreasonable risk to human health or the environment;

- they are or will be produced and enter the environment in substantial quantities;
- human exposure is significant; and
- data and experience to determine the chemicals' potential impact on human health and the environment are insufficient.

TSCA (Section 5) also provides EPA with the authority to regulate and control the introduction of new chemicals either through manufacture or import, or the processing of an existing chemical for a significant new use. Such manufacturers and importers must file a Premanufacture Notification (PMN) 90 days before producing or importing the chemical. Once a PMN is filed, EPA assesses the information and determines if the chemical poses an unreasonable risk of injury to health or the environment. An additional 90 days may be re-

quired by EPA to complete the revision of the PMN. If during the first 90 days, EPA does not respond to the PMN, the manufacture or import of the chemical can begin. EPA has the authority to limit, prohibit, or ban the production of chemicals based on insufficient evidence to conduct a reasonable evaluation of the risk or because the chemical poses an unreasonable risk to human health and the environment (Section 6). Examples of prohibited substances by TSCA include asbestos, halogenated chlorofluoroalkanes, and polychlorinated biphenyls (PCBs).

TSCA provides specific guidance and requirements for data gathering and reporting. This includes information such as production volume, plant size, amount lost to the environment during production or import, quantity of releases, and worker exposure information pertaining to controlled or uncontrolled releases. Companies are also required to maintain records of allegations of significant health or environmental effects (Section 8).

Since 1979, EPA has maintained and published a list of chemical substances manufactured, imported, or processed for commercial purposes. This list, known as the TSCA Inventory, currently has almost 80,000 chemicals.

19.6 OCCUPATIONAL LAWS AND REGULATIONS

19.6.1 OCCUPATIONAL SAFETY AND HEALTH ACT[53]

19.6.1.1 Background

In April 1971, the Occupational Safety and Health (OSH) Act of 1970 was enacted and resulted in the creation of the Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH). The purpose of this Act is to ensure that workers are provided with workplaces free from recognized safety, health, and environmental hazards. OSHA is part of the Department of Labor (DOL) and responsible for developing and enforcing rules to ensure workplace safety and health. NIOSH is a research agency, part of the Centers for Disease Control and Prevention (CDC), under the Department of Health and Human Services. NIOSH is responsible for developing and establishing new and improved OSH standards and identify potential hazards of new work technologies and practices.

Since 1970, OSHA has issued more than 500 rules dealing with all aspects of worker safety and protection in the workplace. Recent amendments to the 1970 Act require employers to notify employees of potential workplace health hazards, including chemicals. OSHA regulates exposure to about 400 hazardous and toxic substances in the workplace that can cause harm.[54] Under Section 18 of the OSH Act, states are allowed to assume the responsibility for developing and enforcing their own safety and health programs.[53] To date, 25 states have OSHA-approved state plans.[55]

Under the OSH Act, employers are required to provide employees with a workplace free from "recognized hazards." Employers are also required to maintain accurate records of employees' exposure to potentially toxic materials required to be monitored or measured, conduct periodic inspections, and notify employees if they are exposed to toxic materials at higher levels than those prescribed by existing health and safety regulations.

19.6.1.2 Air Contaminants Exposure Limits[12-14]

Information on exposure limits to solvent emissions in the workplace is provided in Table 19.2. These permissible exposure limit (PEL) values were obtained from OSHA's Tables Z-1, Z-2, and Z-3.[13] They are the maximum allowed PELs legally enforceable by OSHA.

For comparison purposes, Table 19.2 provides exposure limit values generated by the American Conference of Governmental Industrial Hygienists (ACGIH) which for many of the listed chemicals are the only values currently available.[14] Usually, the ACGIH values are more stringent than the OSHA values. Both ACGIH and NIOSH have proposed more stringent PELs for over 35 and 25 solvents, respectively.[14,56] Although Table Z-1 has not been formally updated since 1987, new toxicological data on specific chemicals could be used by OSHA to produce directives intended to amend old exposure limit requirements or to add new chemicals to the regulated list. An OSHA PEL is based on an 8-hour, time weighted average (TWA) concentration. These were initially based on ACGHI TLV/TWA values in place since 1971, and many have not been revised since.[57] The lower the value, the more toxic the solvent. PEL values in Table 19.2 are given in parts per million by volume (ppmv) of contaminated air volume and the equivalent milligrams of solvent in a cubic meter of air (mg/m^3). These values are focused only on inhalation exposure, which has been strongly criticized.[54] Although this is the most common exposure route to solvent emissions in the workplace, other exposure risks exist such as skin absorption and eye contamination. It is then very important to observe toxicological data compiled in the Material Safety and Data Sheets (MSDSs). Chemical manufacturers and importers are responsible to produce or obtain an MSDS for each hazardous chemical they produce or import, distributors must provide their customers with a copy of MSDSs, and employers are responsible to maintain a copy of MSDSs for each hazardous chemical used in their facility and make them available to their employees.

There are various sources of additional helpful information on the safe use of solvents in the workplace. The Hazard Evaluation System and Information Service (HESIS) of California's Department of Health Services has a 50-page document (Using Solvent Safely) that describes methods of using solvents in the workplace. This document includes information on solvents that pose reproductive problems to both women and men. For more information, visit their website on http://www.ohb.org/solvmenu.htm.[58]

19.6.1.3 Hazard Communication Standard

The Hazard Communication Standard (HCS) was established to provide workers the "right-to-know" of potential hazards associated with their jobs. HCS is a proactive measure to disseminate information to workers and employers about the health hazards pertaining to the chemicals they handle and the protection required. Employers are required to prepare and implement a hazard communication (HAZCOM) program, ensure that all containers have appropriate labels, provide employees easy access to MSDSs, and conduct training programs. The HAZCOM program is the written plan of action that describes the standard implementation strategy for a given facility.

19.7 INTERNATIONAL PERSPECTIVE

Similar environmental efforts have occurred in other countries as they have made the environment and human health a priority. Many countries around the world have developed policies, laws, and regulations in an effort to improve and maintain a cleaner environment and human health while providing for a sustainable future. This section provides a view of such efforts.

19.7.1 CANADA[59]

In Canada, Environment Canada, which was created in 1971, is the organization responsible for environmental regulation and protection. Environment Canada is divided into five Regional Offices: Ontario, Atlantic, Prairie and Northern Region, Quebec, and Pacific and Yukon. Its environmental services are administered through the Canadian Environment Protection Act (CEPA) which includes the Air Quality Act, the Canadian Water Act, the Ocean Dumping Act, the Environment Contaminant Act, and the Department of the Environment Act. CEPA was recently amended (September 1999), placing more emphasis on pollution prevention and toxic substances. It also provides an increased enforcement authority and resources to carry out necessary research and development activities.

In 1978, Canada signed the Great Lakes Water Quality Agreement with the U.S. which identified specific objectives for minimum levels of water quality for more than 35 substances and compounds.[60] Although this is an international agreement, it has certainly impacted and, to some extent, shaped Canada's domestic environmental laws.

As a result of these statutes, the federal government establishes objectives, guidelines, and emission standards for five national air quality pollutants (carbon monoxide, nitrogen oxides, ozone, sulfur dioxide, and suspended particulate matter). In the case of stationary sources, the regulatory responsibility usually falls under the jurisdiction of 10 provinces. The jurisdiction of water quality management is divided between the provinces and the federal government. The provinces' primary responsibility is to regulate fresh water resources, while the federal government's jurisdiction is over seacoast and inland fisheries, navigation and fisheries, and trade and commerce. The 10 provinces are also primarily responsible for regulating the management of household, non-hazardous, and hazardous solid waste.

19.7.2 EUROPEAN UNION

In Europe, the European Community (EC) was formed by the union of three organizations: the European Coal and Steel Community (ECSC), established in 1951; the European Economic Community (EEC), established by the Treaty of Rome in 1957; and the European Atomic Energy Community (EURATOM), established in 1957.[60,61] In 1967, with the Merger Treaty, these organizations merged to form the EC. After the Maastricht Treaty in 1992, the EC became the European Union (EU) which consists of the European Commission, the European Council, the European Parliament, and the European Court of Justice.[61]

Environmental policy was structured as part of the formation of the integrated European states. This effort was extended and refined later with the Maastricht Treaty of 1992. Over the years, however, EC has taken steps to provide a better environment and health for its member states and citizens. Some of these steps have been through the implementation of comprehensive Environmental Action Programmes (EAPs) and specific legislative measures or directives.[62,63] The fifth EAP started in 1993 with an emphasis on sustainable environmental development and a variety of environmental issues such as climate change, acidification and air pollution, depletion of natural resources and biodiversity, depletion and pollution of water resources, deterioration of the urban environment and coastal zones, and waste.[60] Also in 1993, the European Environment Agency (EEA) was established to collect, organize, and disseminate technical, scientific, and economic information pertaining to the quality of the environment in Europe.

Air legislation is targeting emissions from industrial operations, greenhouse gases, lead, motor vehicle emissions, nitrogen oxides, ODS, sulfur dioxide, and suspended particulate matter. Water legislation in the EU is divided into effect- and source-oriented direc-

tives. Four effect-oriented directives provide objectives for water with specific end uses: Bathing Water, Drinking Water, Fish Water and Shellfish Water, and Fresh Water Quality Information Exchange. Seven source-oriented directives focus on the elimination or reduction of pollution at the source: Asbestos, Dangerous Substances, Groundwater, Nitrate, Titanium Dioxide, Urban Wastewater, and Water Pollution Information Exchange.[64]

Solid and hazardous waste has received great attention in recent years, and directives have been developed to address their definition, classification, generation, management, and transport across frontiers. In 1993, EU implemented the European Waste Catalogue which defines 15 categories of waste and a residual category intended to capture any materials, substances, or products not included in those categories. There are 27 substances defined as toxic and hazardous waste for which specific information had to be provided during transport: nature, composition, quantity of waste, and sender's and receiver's name.[65]

19.8 TOOLS AND RESOURCES FOR SOLVENTS

Various software tools have been developed to identify environmentally benign alternative solvents or equipment modifications to reduce the amount of toxic and volatile solvents. Some tools have attempted to consider life cycle impact in their selection methodologies, but these are the exceptions rather than the rule. This section provides a brief description of some of the tools and resources available to assist in solvent and equipment replacement. In addition, a hotline listing is provided (Table 19.8). Some of these tools are the result of years of research and development by the National Risk Management Research Laboratory of EPA's Office of Research and Development. This laboratory has been researching solvent abatement,[66] replacement, reduction,[67] complete elimination for cleaning and coating operations, and developing tools[68] to assess the overall environmental impact of alternative approaches.

Table 19.8. List of hotlines in the U.S.[69]

Name	Description	E-mail	Phone No.
Air RISC Hotline	Information on health effects, urban toxics, risk assessment, human health, and exposure.	air.risc@epa.gov	919-541-0888
Hazardous Waste Ombudsman	Assists public and regulatory community in resolving problems associated with the Hazardous Waste Program.	N/A	800-262-7937 202-260-9361
Pollution Prevention Information Clearinghouse (PPIC)	Provides answers and referrals in response to questions about pollution prevention.	ppic@epamail.epa.gov	800-424-9346
Office of Pollution Prevention and Toxics (OPPT)	OPPT has the Non-confidential Information Center with public dockets for TSCA and Toxic Release Inventory (TRI) rulemaking actions, TSCA administrative record, and non-confidential case files for documents submitted under TSCA.	N/A	202-260-7099

Name	Description	E-mail	Phone No.
RACT/BACT/LAER Clearinghouse	Provides information on air pollution prevention and control technologies, permit requirements at stationary air pollution sources, and related Federal air pollution emission standards.	N/A	919-541-0800
RCRA Information Center	Provides access to all regulatory materials supporting EPA's actions under RCRA.	N/A	703-603-9230 800-424-9346
RCRA Information Hotline	Responds to requests about hazardous waste concerning identification, generators, transporters, treatment, storage and disposal facilities, recycling sites, export, and import.	N/A	703-603-9230
Safe Drinking Water Hotline	Provides information and assistance regarding drinking water regulations, the wellhead protection program, source water protection and guidance, and education materials.	hotline-sdwa@epamail.epa.gov	800-426-4791
Subsurface Remediation Information Center	Provides technical and scientific information on groundwater protection and remediation.	N/A	580-436-8651
TSCA Assistance Information Service	Provides TSCA regulation information.	tsca-hotline@epamail.epa.gov	202-554-1404
WasteWi$e Helpline	WasteWi$e is a voluntary program to encourage businesses to reduce solid waste.	ww@cais.net	800-372-9473

- Solvent Alternatives Guide (SAGE): SAGE is an Internet-based tool developed by the Surface Cleaning Program at Research Triangle Institute (RTI) in cooperation with EPA's Air Pollution Prevention and Control Division to identify solvent and process alternatives for parts cleaning and degreasing. SAGE works as an expert system asking the user a series of questions concerning the part's size and volume, nature of the soil to be removed, production rate, etc. SAGE then produces a ranked list of candidate processes and chemistries most likely to work for a given situation. Since SAGE is based on readily available and proven processes and chemistries, it does not assist in the design of new solvents. SAGE is available at http://clean.rti.org/.
- Coating Alternatives Guide (CAGE): CAGE is based on similar principles found in SAGE but focuses on identifying alternatives for paint and coating formulations. CAGE was also developed by RTI in cooperation with EPA. It is an expert system designed to provide recommendations on low VOC/HAP coating alternatives for various substrates. It also provides the user with links to other useful websites. CAGE is available at http://cage.rti.org/.
- Enviroene, first opened to the public in 1994, is a central reservoir of pollution prevention and cleaner production information and databases. It provides the user with a solvent substitution data system, compliance and enforcement assistance information, and a site for communication and exchange of information (Enviroene Cooperatives). Enviroene can be reached at http://es.epa.gov/.

- Program for Assisting the Replacement of Industrial Solvents (PARIS): PARIS is a solvent design software system developed by EPA, the National Research Council, and RTI to substitute offending solvents with a single chemical or a mixture of solvents based on physical and chemical properties and activity coefficients. PARIS also evaluates and considers the environmental properties of the substitute chemicals. The program's recommended alternatives may require testing to validate their performance.[70]
- Computer-Aided Molecular Design (CAMD): CAMD was developed by the Department of Chemical Engineering's Computer-Aided Process Engineering Centre at the Technical University of Denmark. CAMD can be used to select and design new solvents based on thermodynamic properties. It contains a database with thousands of chemicals which can be accessed to select the desired chemical. If the chemical does not exist, CAMD uses computational chemistry to build the chemical configuration of the new chemical.[70]
- EPA's Environmental Technology Verification (ETV) program was established to verify the performance of innovative technical solutions to environmental and human health problems. Companies with new commercial-ready environmental technologies can participate in this program. For more information visit ETV's website at http://www.epa.gov/etvprgrm/index.htm. Canada also instituted an ETV program to foster Canada's environmental technologies (http://www2.ec.gc.ca/etad/etv_e.html).
- South Coast Air Quality Management District (SCAQMD) has established a program to certify clean air solvents for industrial cleaning. Large and small industries can be exempted from record-keeping requirements and emission fees if they use clean air solvents. For more information about SCAQMD's Clean Air Solvent (CAS) Certification program visit http://www.aqmd.gov/tao/cas/cas.html.

19.9 SUMMARY

Solvent releases can affect the quality of air, water, and soil which can then have adverse effects on human health and the environment. More stringent environmental laws and regulations have been established to control their utilization and ensure a safer and healthier environment and a sustainable future. They are placing greater emphasis on the elimination or reduction of such releases at the source and the preservation of limited natural resources. However, replacing offensive solvents requires a comprehensive assessment of their overall environmental impact. This will ensure that substitute chemicals will not impose more stress on our environment and human health by transferring the problem to other media.

This chapter was intended to provide a "bird's eye view" of key environmental laws and regulations for solvents. This chapter will not serve as a replacement of the laws discussed herein.

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ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AEC	Atomic Energy Commission
AHERA	Asbestos Hazardous Emergency Response Act
BAC	Best Available Control
BACT	Best Available Control Technology
BAT	Best Available Technology Economically Achievable
BCT	Best Conventional Pollutant Control Technology
BDT	Best Available Demonstrated Technology
BMP	Best Management Practices
BPT	Best Practicable Control Technology
CAA	Clean Air Act
CAGE	Coating Alternatives Guide
CAMD	Computer-Aided Molecular Design
CAS	Clean Air Solvent
CDC	Centers for Disease Control and Prevention
CEPA	Canadian Environment Protection Act
CESQG	conditionally exempt small quantity generator
CFC	chlorofluorocarbon
CSI	Common Sense Initiative
CTG	Control Technology Guideline
CWA	Clean Water Act
DEPH	bis (2-ethylhexyl)phthalate
DOL	Department of Labor
DOT	Department of Transportation
DV	Design Value
EAP	Environmental Action Programme
EC	European Community
ECSC	European Coal and Steel Community
EEA	European Environment Agency
EEC	European Economic Community
ENVIROENE	public environmental information system
EPA	U.S. Environmental Protection Agency
ETV	Environmental Technology Verification
EU	European Union
EURATOM	European Atomic Energy Community
FFDCA	Federal Food, Drug, and Cosmetic Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FIP	Federal Implementation Plan
FWPCA	Federal Water Pollution and Control Act
GWP	global warming potential
HAP	hazardous air pollutant
HAZCOM	hazard communication
HCFC	hydrochlorofluorocarbon
HCS	Hazard Communication Standard
HESIS	Hazard Evaluation System and Information Service
HFE	hydrofluoroether
HMTA	Hazardous Materials Transportation Act

HSWA	Hazardous and Solid Waste Amendments
LAER	Lowest Achievable Emissions Rate
LCCA	Lead Contamination Control Act
LQG	large quantity generator
MACT	Maximum Achievable Control Technology
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MSDS	Material Safety and Data Sheet
NAAQS	national ambient air quality standards
NESHAP	national emission standards for hazardous air pollutants
NIOSH	National Institute for Occupational Safety and Health
NPDES	National Pollutant Discharge Elimination System
NPDWR	National Primary Drinking Water Regulations
NSPS	new source performance standards
NSR	New Source Review
ODS	ozone depleting substance
OPPE	Office of Policy, Planning, and Evaluation
OPPT	Office of Pollution Prevention and Toxics
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
P2	Pollution Prevention
PARIS	Program for Assisting the Replacement of Industrial Solvents
PCB	polychlorinated biphenyl
PCBTF	p-chlorobenzotrifluoride
PEL	permissible exposure limit
PM_{10}	particulate matter of 10 micrometers in aerodynamic diameter or smaller
PMACT	Preliminary Maximum Achievable Control Technology
PMN	Premanufacture Notification
POTW	publicly operated treatment works
PPIC	Pollution Prevention Information Clearinghouse
PSD	prevention of significant deterioration
RACT	Reasonable Available Control Technology
RCRA	Resource Conservation and Recovery Act
RISC	Risk Information Support Center
SAGE	Solvent Alternatives Guide
SCAQMD	South Coast Air Quality Management District
SDWA	Safe Drinking Water Act
SEP	superior environmental performance
SIP	State Implementation Plan
SNAP	Significant New Alternatives Policy
SQG	small quantity generator
SRRP	Source Reduction Review Project
SWDA	Solid Waste Disposal Act
TLV®	Threshold Limit Value
TRI	Toxic Release Inventory
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
TWA	time weighted average
UN	United Nations
UV	ultraviolet light
VOC	volatile organic compound
XL	eXcellence and Leadership

19.10 REGULATIONS IN EUROPE

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The legislative and executive regulations in Europe are generally based on EEC regulations which are converted to and coordinated by national regulations as it is a rule in Europe. EEC regulations do not exist concerning all aspects, or they are not always converted effectively in the EEC Member States.

In Europe environmental law, especially concerning chemical and hazardous substances, was first realized about 30-40 years ago.[1] Main aims of EEC regulations are the registration and the classification of a wide variety of chemical substances, the environmental protection, the health protection, harmonization of national laws, and the liberalization of the market. For these reasons several EEC regulations were created and completed (see 19.10.1). Changes of regulations intended to optimize some aspects, e.g., environmental and health aspects by the obligation of registration and test procedures.[7] The list 19.10.1 shows all relevant regulations in Europe concerning solvents.

Relevant German regulations concerning solvents are listed in 19.10.2 as an example of the conversion of EEC regulations in Member States. In Germany the application of chemical and hazardous substances are based on a few regulations.[28,30] Special and practical applications of these basic regulations are put in concrete terms in different standards, e.g., TRGS[29] or DIN.[31-56]

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20 Council Regulation (EEC) No. 3093/94 of 15 December 1994 on substances that deplete the ozone layer, ABl. EG Nr. L 333/1, 1994.
21 94/904/EEC, Council Decision of 22 December 1994 establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste, ABl. EG Nr. L 356/4, 1994.
22 95/365/EEC, Commission Decision of 25 July 1995 establishing the ecological criteria for the award of the Community eco-label to laundry detergents, ABl. EG Nr. L 217/14, 1995.
23 95/2268/EEC, Commission Regulation of 27 September 1995 concerning the second list of priority substances as foreseen under Council Regulation No. 793/93, ABl. EEC Nr. L 231/18, 1995.
24 96/61/EEC, Council Directive of 24 September 1996 concerning integrated pollution prevention and control, ABl. EG Nr. L 257/26, 1996.
25 97/142/EEC, Commission Regulation of 27 January 1997 concerning the delivery of information about certain existing substances, ABl. EEC Nr. L 25/11, 1997.

19.10.2 GERMAN REGULATIONS

26 Verordnung über Höchstmengen an bestimmten Lösemitteln in Lebensmitteln (LösemittelHöchstmengenVerordnung - LHmV) vom 27. Juli 1989. Regulation concerning maximum quantities of certain solvents in foods (LHmV) of 27 July 1989, BGBl., 1568 (1989).
27 Verordnung über die Entsorgung gebrauchter halogenierter Lösemittel (HKWAbfV) vom 23. Oktober 1989. Regulation concerning the waste management of halogenated solvents (HKWAbfV) of 23 October 1989, BGBl., 1918 (1989).
28 Verordnung zum Schutz vor gefährlichen Stoffen (Gefahrstoffverordnung - GefStoffV) vom 26.10.1993. Regulation concerning the protection against hazardous substances of 26 October 1993.
29 Technische Regeln für Gefahrstoffe (TRGS). Technical Regulations concerning hazardous substances (TRGS), e.g. TRGS 002, TRGS 003, TRGS 101, TRGS 102, TRGS 150, TRGS 220, TRGS 222, TRGS 400, TRGS 402, TRGS 403, TRGS 404, TRGS 415, TRGS 420, TRGS 512, TRGS 519, TRGS 531, TRGS 900, TRGS 903, TRGS 905, TRGS 906, TRGS 910.
30 Gesetz zum Schutz vor gefährlichen Stoffen (Chemikaliengesetz - ChemG) vom 25. Juli 1994. Law concerning the protection against hazardous substances of 25 July 1994, BGBl. I, 1703 (1994).
31 DIN 53169, Solvents for paints and varnishes; determination of density, refractive index, flash point, acid value, saponification value, olefinic and aromatic content in hydrocarbons, 1991.
32 DIN 53170, Solvents for paints and similar coating materials; determination of the evaporation rate, 1991.
33 DIN 53171, Solvents for paints and varnishes; determination of distillation characteristics (boiling range and boiling temperature as a function of distilled volume), 1991.
34 DIN 53172, Solvents for paints and varnishes; determination of evaporation residue, 1993.
35 DIN 53173, Solvents for paints and varnishes; determination of carbonyl value, 1991.
36 DIN 53174-1, Solvents for paints and varnishes - Methods of test for solvent mixtures - Part 1: General references and survey, 1995.

37 DIN 53174-2, Solvents for paints and varnishes and similar coating materials; methods of analysis for solvent mixtures; gas chromatographic method, 1992.
38 DIN 53175, Binders for paints, varnishes and similar coating materials; determination of the solidification point (titer) of fatty acids, 1991.
39 DIN 53245, Solvents for paints and varnishes; alcohols; supply specification, further properties and methods of test, 1994.
40 DIN 53246, Solvents for paints and varnishes - Acetic esters - Delivery specification, further requirements and methods of test, 1997.
41 DIN 53247, Solvents for paints and varnishes - Ketones - Supply specifications, further requirements and methods of test, 1997.
42 DIN 53248, Solvents for paints, varnishes and similar coating materials - Gum spirit of turpentine and wood turpentines - Requirements and methods of test, 1995.
43 DIN 53249, Solvents for paints, varnishes and similar coating materials - Dipentene - Requirements and methods of test, 1995.
44 DIN 55651, Solvents for paints and varnishes - Symbols, 1997.
45 DIN 55681, Solvents; stability testing of trichloroethylene, 1985.
46 DIN 55682, Solvents for paints and varnishes - Determination of solvents in water-thinnable coating materials - Gas chromatographic method, 1994.
47 DIN 55682/A1, Solvents for paints and varnishes - Determination of solvents in water-thinnable coating materials - Gas chromatographic method; Amendment A1, 1998.
48 DIN 55683, Solvents for paints and varnishes - Determination of solvents in coating materials containing organic solvents only - Gas chromatographic method, 1994.
49 DIN 55685, Solvents for paints and varnishes; alcohols; gas chromatographic determination of the degree of purity, 1992.
50 DIN 55686, Solvents for paints and varnishes; acetic esters; gas chromatographic determination of the degree of purity, 1992.
51 DIN 55687, Solvents for paints and varnishes; ketones; gas chromatographic determination of the degree of purity, 1992.
52 DIN 55688, Solvents for paints and varnishes - Ethylene glycol ethers - Gas chromatographic determination of the degree of purity, 1995.
53 DIN 55689, Solvents for paints and varnishes - Propylene glycol ethers - Gas chromatographic determination of the degree of purity, 1995.
54 DIN 55997, Solvents for paints and varnishes - Deionized water - Requirements and methods of test, 1998.
55 DIN 55998, Solvents for paints and varnishes - Propylene glycol ethers - Supply specification, further requirements and methods of test, 1998.
56 DIN 55999, Solvents for paints and varnishes, ethylene glycol ethers; supply specification, further properties and methods of test, 1994.