APPENDIX

I

HISTORICAL PERSPECTIVE ON AIR POLLUTION CONTROL

I1. HISTORICAL BACKGROUND ON AIR POLLUTION

From the beginning of the Industrial Revolution through the mid-1900s, it is a fair criticism to note that industry in general did not have protection of the environment or public health as a significant philosophical or operating concern. In more recent times, the refining, chemical processing, and related industries have been required to meet higher societal expectations in the form of new laws and regulations. The business and industrial community has become increasingly aware of the need to ensure their right-to-operate in the eyes of the general public and the specific communities in which they operate.

Air pollution from human activities began long before the Industrial Revolution. To be sure, the advent of the Industrial Revolution resulted in increasingly larger scale manufacturing and industrial operations that significantly increased the air pollution levels.

These operations required increasingly larger sources of energy, usually from the burning of fossil fuels. They released gases, vapors, and particulates to the atmosphere. Process facilities were frequently concentrated geographically, thus creating new or exacerbating existing local and regional air pollution problems.

In time, power generation from the burning of coal and the emissions from ore processing, metal foundries and mills, cement plants, glass manufacturing, chemical plant processes and other industries became the dominant sources of air pollution. Current United States environmental laws and regulations to improve air quality have resulted from a lengthy list of historical and more recent air pollution events.

In London, England, air pollution was a serious problem beginning as early as the 1300s as low grade coal replaced wood for heating and cooking. Major air pollution events occurred through the 1950s. A few of the milestone events are:

- In 1306, major smoke and soot pollution prompted King Edward I to proclaim a ban on burning sea coal in London.
- In 1873, a particularly dense coal-smoke saturated fog in London resulted in an estimated 268 deaths.
- In 1909, winter inversions and smoke accumulations in Glasgow, Scotland killed over 1,000 persons. In a report about the incidents, Dr. Harold Antoine Des Voeux coined the term "smog" as a contraction for smoke-fog.
- In 1952, a severe sulfur-laden fog killed an estimated 4,000 Londoners and spurred Parliament to enact the 1956 Clean Air Act to reduce coal burning and begin serious air-pollution reform in England.

In the United States, concern for the air quality in and around large cities was increasing during the latter 1800s and resulted in local laws and regulations followed ultimately by federal air pollution control regulations. Some of the noteworthy events included [Ref. 1 and 2]:

- By 1881, a few cities, such as Chicago and Cincinnati, enacted limited municipal smoke abatement laws and regulations to reduce smoke and ash from factories, railroads, and ships.
- In 1928, the United States Public Health Service began checking air pollution in eastern cities and reported that sunlight was reduced by 20 to 50 percent in New York City.
- In November 1939, the city of St. Louis experienced nine days of extreme smoke air pollution with near zero visibility at midday even with street lights on. City officials and community, business, and industry leaders developed and implemented controls and regulations; St. Louis was the first major U. S. city to limit the use of soft, low quality coal.
- During the late 1940s, serious smog incidents in Los Angeles further heightened public awareness and concern about this issue.

- In 1948, an air pollution inversion event in Donora, Pennsylvania, killed 20 people and sickened about 40 percent of the town's 14,000 inhabitants.
- In November 1953, a smog incident in New York City resulted in the death of between 170 and 260 people.
- In 1963 and 1966, regional weather patterns resulted in air inversions that trapped local air pollutants in the New York City area, resulting in 405 and 168 deaths, respectively.

More recently, international signal events involving toxic chemical releases at Bhopal, India and Seveso, Italy brought an even sharper focus on prevention of catastrophic releases and their impact on people and the environment.

I2. BRIEF REVIEW OF LAWS AND REGULATIONS

These and other air pollution events led the U. S. Congress to pass the Air Pollution Control Act of 1955 that established the federal government as having preeminent control over air pollution control matters.

More important for the subject matter of this book, the Clean Air Act amendments in 1967 (also called the Air Quality Control Act) required the setting of national emission standards for pollutants. These emission standards were applied across the country to all stationary sources and recommended some control technologies. The setting of one common standard for each listed pollutant triggered decades of debate between those insisting on a monolithic singular approach to regulating air pollutants and those favoring the more pragmatic approach of regulating on an industry-by-industry basis.

In 1970, Congress re-wrote the original Clean Air Act adding these major features:

- Established National Ambient Air Quality Standards for the most hazardous high volume pollutants, called "criteria" pollutants:
  - Airborne particulates (PM)
  - Sulfur oxides (SO)
  - Carbon monoxide (CO)
  - Nitrogen oxides (NO)
  - Ozone (O)
  - Lead (Pb)

- Established New Source Performance Standards (NSPS) to regulate emissions from new facilities.
- Required identification of "other" hazardous air pollutants (HAPs) and development of standards to reduce their emissions
- Empowered the newly created Environmental Protection Agency (EPA) to set these standards.

These latter two points are noteworthy since they required the EPA to significantly reduce day-to-day "routine" emissions of those air pollutants known or suspected to cause serious health problems.

In the 1970s and 1980s, the EPA attempted to regulate air pollutants using the mandated chemical-by-chemical approach based on health risk. There were numerous legal, scientific, and policy debates over which pollutants to regulate and how stringently to regulate them. Debates focused on risk assessment methods and assumptions, the amount of health data needed to justify regulation, analyses of costs to industry, and benefits to human health and environment. This risk-based decision process ran into the inevitable risk quandary question – *what level of risk is acceptable or "how safe is safe"*. The regulatory process proved difficult and minimally effective at reducing emissions.

During the 20 years preceding 1990, the EPA was only able to implement regulations for seven hazardous air pollutants: asbestos, benzene, beryllium, inorganic arsenic, mercury, radionuclides, and vinyl chloride. Collectively, the EPA estimates that these seven standards cut annual air toxics emissions by an estimated 125,000 tons.

A new strategy was adopted by Congress with the passage of the Clean Air Act of 1990. EPA was directed to use a "technology-based" and performance oriented approach to significantly reduce emissions from major sources of air pollution. Section 112(b) of this act established a list of hazardous air pollutants (HAPs). The current list of these Hazardous Air Pollutants (HAPs) contains 188 chemicals or groups of chemicals that are identified in Table I-1.

The 1990 act required EPA to develop regulations termed National Emission Standards for Hazardous Air Pollutants (NESHAP). EPA was directed to identify the principal source industry sectors and develop regulations for each, called Maximum Achievable Control Technology (MACT) standards. These standards require the covered facilities to meet specific emission limits based on levels already being achieved by similar emitting sources in that industry sector.

The 1990 act also further strengthened the National Ambient Air Quality Standards for the "criteria" pollutants established in 1970 particularly regarding the ozone precursors, NOx and Volatile Organic Compounds (VOCs). Much of this authority was delegated to the states to allow regulatory control specific to the local and regional needs for "criteria" pollutant reductions.

I3. IMPROVED AIR QUALITY

Air pollution data collected by EPA indicates that this new "technology-based" approach has produced real, measurable reductions. EPA periodically reports the levels of the criteria pollutants in the air and the amounts of emissions from various sources to see how both have changed over time and to summarize the current status of air quality. These air quality trends are generated using measurements from monitors located across the country.

Table I-2 shows that the air quality based on measured concentrations of the principal air pollutants has improved and that reported emissions for these pollutants have been significantly reduced nationally over the 20-year period 1983 - 2002 [Ref. 3].

Based on the 1996 National Toxics Inventory data, those industry sectors defined as Major Sources accounted for about 26 percent of air toxics emissions, smaller Area Sources and other sources (such as forest fires) for 24 percent, and Mobile Sources for 50 percent. Accidental releases, which obviously contribute air toxics to the atmosphere, are not included in these estimates. Clearly, the processing and related industries for which this book is intended are major contributors to airborne pollution in the U. S., although they are not the largest source.

Table I-1. Current Hazardous Air Pollutants – HAPs as defined in Clean Air Act of 1990, Section 112(b)

Item No.	CAS No.	Chemical Name
1	79345	1,1,2,2-Tetrachloroethane
2	79005	1,1,2-Trichloroethane
3	57147	1,1-Dimethyl hydrazine
4	120821	1,2,4-Trichlorobenzene
5	96128	1,2-Dibromo-3-chloropropane
6	122667	1,2-Diphenylhydrazine
7	106887	1,2-Epoxybutane
8	75558	1,2-Propylenimine (2-Methyl aziridine)
9	106990	1,3-Butadiene
10	542756	1,3-Dichloropropene
11	1120714	1,3-Propane sultone
12	106467	1,4-Dichlorobenzene(p)
13	123911	1,4-Dioxane (1,4-Diethyleneoxide)
14	540841	2,2,4-Trimethylpentane
15	1746016	2,3,7,8-Tetrachlorodibenzo-p-dioxin
16	95954	2,4,5-Trichlorophenol
17	88062	2,4,6-Trichlorophenol
18	94757	2,4-D, salts and esters
19	51285	2,4-Dinitrophenol
20	121142	2,4-Dinitrotoluene
21	95807	2,4-Toluene diamine ?
22	584849	2,4-Toluene diisocyanate
23	53963	2-Acetylaminofluorene
24	532274	2-Chloroacetophenone
25	79469	2-Nitropropane
26	91941	3,3-Dichlorobenzidene
27	119904	3,3-Dimethoxybenzidine
28	119937	3,3'-Dimethyl benzidine
29	101779	4,4¬-Methylenedianiline
30	101144	4,4-Methylene bis(2-chloroaniline)
31	534521	4,6-Dinitro-o-cresol, and salts
32	92671	4-Aminobiphenyl
33	92933	4-Nitrobiphenyl
34	100027	4-Nitrophenol
35	75070	Acetaldehyde
36	60355	Acetamide
37	75058	Acetonitrile
38	98862	Acetophenone
39	107028	Acrolein
40	79061	Acrylamide
41	79107	Acrylic acid
42	107131	Acrylonitrile
43	107051	Allyl chloride
44	62533	Aniline
45	0	Antimony Compounds
46	0	Arsenic Compounds (inorganic including arsine)
47	1332214	Asbestos

Item No.	CAS No.	Chemical Name
48	71432	Benzene (including benzene from gasoline)
49	92875	Benzidine
50	98077	Benzotrichloride
51	100447	Benzyl chloride
52	0	Beryllium Compounds
53	57578	beta-Propiolactone
54	92524	Biphenyl
55	117817	Bis(2-ethylhexyl)phthalate (DEHP)
56	542881	Bis(chloromethyl)ether
57	75252	Bromoform
58	0	Cadmium Compounds
59	156627	Calcium cyanamide
60	133062	Captan
61	63252	Carbaryl
62	75150	Carbon disulfide
63	56235	Carbon tetrachloride
64	463581	Carbonyl sulfide
65	120809	Catechol
66	133904	Chloramben
67	57749	Chlordane
68	7782505	Chlorine
69	79118	Chloroacetic acid
70	108907	Chlorobenzene
71	510156	Chlorobenzilate
72	67663	Chloroform
73	107302	Chloromethyl methyl ether
74	126998	Chloroprene
75	0	Chromium Compounds
76	0	Cobalt Compounds
77	0	Coke Oven Emissions
78	1319773	Cresols/Cresylic acid (isomers and mixture)
79	98828	Cumene
80	0	Cyanide Compounds 1
81	3547044	DDE
82	334883	Diazomethane
83	132649	Dibenzofurans
84	84742	Dibutylphthalate
85	111444	Dichloroethyl ether (Bis(2-chloroethyl)ether)
86	62737	Dichlorvos
87	111422	Diethanolamine
88	64675	Diethyl sulfate
89	60117	Dimethyl aminoazobenzene
90	79447	Dimethyl carbamoyl chloride
91	68122	Dimethyl formamide
92	131113	Dimethyl phthalate
93	77781	Dimethyl sulfate
94	106898	Epichlorohydrin (l-Chloro-2,3-epoxypropane)
95	140885	Ethyl acrylate
96	100414	Ethyl benzene

Item No.	CAS No.	Chemical Name
97	51796	Ethyl carbamate (Urethane)
98	75003	Ethyl chloride (Chloroethane)
99	106934	Ethylene dibromide (Dibromoethane)
100	107062	Ethylene dichloride (1,2-Dichloroethane)
101	107211	Ethylene glycol
102	151564	Ethylene imine (Aziridine)
103	75218	Ethylene oxide
104	96457	Ethylene thiourea
105	75343	Ethylidene dichloride (1,1-Dichloroethane)
106	0	Fine mineral fibers 3
107	50000	Formaldehyde
108	0	Glycol ethers 2
109	76448	Heptachlor
110	118741	Hexachlorobenzene
111	87683	Hexachlorobutadiene
112	77474	Hexachlorocyclopentadiene
113	67721	Hexachloroethane
114	822060	Hexamethylene-1,6-diisocyanate
115	680319	Hexamethylphosphoramide
116	110543	Hexane
117	302012	Hydrazine
118	7647010	Hydrochloric acid
119	7664393	Hydrogen fluoride (Hydrofluoric acid)
120	123319	Hydroquinone
121	78591	Isophorone
122	0	Lead Compounds
123	58899	Lindane (all isomers)
124	108316	Maleic anhydride
125	0	Manganese Compounds
126	108394	m-Cresol
127	0	Mercury Compounds
128	67561	Methanol
129	72435	Methoxychlor
130	74839	Methyl bromide (Bromomethane)
131	74873	Methyl chloride (Chloromethane)
132	71556	Methyl chloroform (1,1,1-Trichloroethane)
133	78933	Methyl ethyl ketone (2-Butanone)
134	60344	Methyl hydrazine
135	74884	Methyl iodide (Iodomethane)
136	108101	Methyl isobutyl ketone (Hexone)
137	624839	Methyl isocyanate
138	80626	Methyl methacrylate
139	1634044	Methyl tert butyl ether
140	75092	Methylene chloride (Dichloromethane)
141	101688	Methylene diphenyl diisocyanate (MDI)
142	108383	m-Xylenes
143	121697	N,N-Diethyl aniline (N,N-Dimethylaniline)
144	91203	Naphthalene
145	0	Nickel Compounds
146	98953	Nitrobenzene

Item No.	CAS No.	Chemical Name
147	62759	N-Nitrosodimethylamine
148	59892	N-Nitrosomorpholine
149	684935	N-Nitroso-N-methylurea
150	90040	o-Anisidine
151	95487	o-Cresol
152	95534	o-Toluidine
153	95476	o-Xylenes
154	56382	Parathion
155	106445	p-Cresol
156	82688	Pentachloronitrobenzene (Quintobenzene)
157	87865	Pentachlorophenol
158	108952	Phenol
159	75445	Phosgene
160	7803512	Phosphine
161	7723140	Phosphorus
162	85449	Phthalic anhydride
163	1336363	Polychlorinated biphenyls (Aroclors)
164	0	Polycylic Organic Matter 4
165	106503	p-Phenylenediamine
166	123386	Propionaldehyde
167	114261	Propoxur (Baygon)
168	78875	Propylene dichloride (1,2-Dichloropropane)
169	75569	Propylene oxide
170	106423	p-Xylenes
171	91225	Quinoline
172	106514	Quinone
173	0	Radionuclides (including radon) 5
174	0	Selenium Compounds
175	100425	Styrene
176	96093	Styrene oxide
177	127184	Tetrachloroethylene (Perchloroethylene)
178	7550450	Titanium tetrachloride
179	108883	Toluene
180	8001352	Toxaphene (chlorinated camphene)
181	79016	Trichloroethylene
182	121448	Triethylamine
183	1582098	Trifluralin
184	108054	Vinyl acetate
185	593602	Vinyl bromide
186	75014	Vinyl chloride
187	75354	Vinylidene chloride (1,1-Dichloroethylene)
188	1330207	Xylenes (isomers and mixture)
189	593602	Vinyl bromide

Notes: For all listings above which contain the word "compounds" and for glycol ethers, the following applies: Unless otherwise specified, these listings are defined as including any unique chemical substance that contains the named chemical (i.e., antimony, arsenic, etc.) as part of that chemical's infrastructure.

1. X'CN where X = H' or any other group where a formal dissociation may occur. For example KCN or Ca(CN)2
2. Includes mono- and di- ethers of ethylene glycol, diethylene glycol, and triethylene glycol R-(OCH2CH2)n -OR' where:
   n = 1, 2, or 3
   R = alkyl or aryl groups
   R' = R, H or groups which, when removed, yield glycol ethers with the structure: R-(OCH2CH)n-OH. Polymers are excluded from the glycol category.
3. Includes mineral fiber emissions from facilities manufacturing or processing glass, rock, or slag fibers (or other mineral derived fibers) of average diameter 1 micrometer or less.
4. Includes organic compounds with more than one benzene ring, and which have a boiling point greater than or equal to 100 º C.
5. A type of atom which spontaneously undergoes radioactive decay.

Table I-2. Improvement in Air Quality and Reduced Emissions 1983-2002

Air Quality Percent Change			Emissions Percent Change		
Pollutant (Ambient Measured)	1983-2002	1993-2002	Pollutant (Reported Emissions)	1983-2002	1993-2002
NO_2	-21	-11	NOx	-15	-12
O_3 1-hour O_3 8-hour	-22 -14	-2[a] +4[a]	VOC (related to O_3 formation)	-40	-25
SO_2	-54	-39	SO_2	-33	-31
Particulate Matter[c]: 10ppm 2.5 ppm	NA NA	-13 -8[b]	Particulate Matter[c]: 10ppm 2.5 ppm	-34[d] NA	-22 -17
CO	-65	-42	CO	-41	-21
Pb	-94	-57	Pb	-93	-5

Note: Negative numbers indicate improved air quality or reduced emissions. Positive numbers indicate worsened air quality or increased emissions.

NA: Trend data not available.

a: Not statistically significant.

b: Based on percentage change from 1999.

c: Includes only directly emitted particles.

d: Based on percentage change from 1985, prior estimates uncertain.

e: Lead emissions are for 1982-2001.

I4. REFERENCES

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I3. U. S. EPA Office of Air Quality, Planning and Standards. August 2003. *Latest Findings on National Air Quality – 2002 Status and Trends.* EPA Doc. 454/K-03-01.