

AP-42
FIFTH EDITION
JANUARY 1995

**COMPILATION
OF
AIR POLLUTANT
EMISSION FACTORS**

**VOLUME I:
STATIONARY POINT
AND AREA SOURCES**

Office Of Air Quality Planning And Standards
Office Of Air And Radiation
U. S. Environmental Protection Agency
Research Triangle Park, NC 27711

January 1995

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NOTICE

The Emission Factor And Inventory Group (EFIG) has been working for several months on this Fifth Edition of AP-42. It is the result of a major technical undertaking by EFIG's AP-42 Team and the several contractors who assisted. This document represents a substantial step toward complying with Section 130 of the *Clean Air Act Amendments Of 1990*, which direct the U. S. Environmental Protection Agency to review and revise its air pollutant emission factors every three years. Although such updating is required only for ozone-related pollutants (total organic compounds, oxides of nitrogen, and carbon monoxide), the AP-42 Team has also addressed the other criteria pollutants, hazardous pollutants, global warming gases and speciation information, where data are available. Sections of AP-42 are continuously being developed, reviewed and/or updated.

Even though there are significant additions and improvements in this book, many data gaps and uncertainties still exist. All readers and users of AP-42 are asked to provide comments, test data, and any other information for our evaluation and possible use to improve future updates.

Users familiar with this document may notice changes in factor quality ratings, specifically that some factors, although unchanged or supported by even newer and more extensive data, are rated lower in quality than previously in the AP-42 series. This is attributable to the adoption of more consistent and stringently applied rating criteria. There are some factors in this edition with lower ratings than previously, but they are believed to represent appropriate estimates. AP-42 emission factors are truly for estimation purposes and are no substitute for exact measurements taken at a source.

Users should especially note this edition's expanded "Introduction", for its information on pollutant definition, factor limitations, the factor rating system, and cautionary notes on the use of factors for anything other than emission estimation and inventory and approximation purposes.

In addition to print, the AP-42 series is available in several other media. The *Air CHIEF* compact disc (CD-ROM), with AP-42 and other hazardous air pollutant emission estimation reports and data bases, can be purchased from the Government Printing Office. Also, *The CHIEF* electronic bulletin board (by modem, 919-541-5742) posts the latest AP-42 and other reports and tools before they are available on paper. Final sections of AP-42 can be obtained quickly from our automatic *Fax CHIEF* service (919-541-5626 or -0548). These last two media operate 24 hours per day, 7 days per week. If you have questions or need further information on these tools or other aspects of emission estimation, call our help line, *Info CHIEF*, at 919-541-5285, during regular office hours, eastern time.

If you have factor needs, new data, questions, or suggestions, please send them to the address below. You may also ask for a free subscription to *The CHIEF*, our quarterly newsletter (also on the electronic bulletin board and *Fax CHIEF*). Our abilities to respond to individual questions often get impinged by time and resource constraints and the sheer volume of requests, so please use the above capabilities and tools whenever possible. Though we are a client-oriented organization, we have neither staff nor structure to provide engineering support.

AP-42 Team (MD 14)
Emission Factor And Inventory Group
Emissions, Monitoring, And Analysis Division
Office Of Air Quality Planning And Standards
U. S. Environmental Protection Agency
Research Triangle Park, NC 27711

AP-42 TABLE OF CONTENTS

Page		
	INTRODUCTION	1
1.	EXTERNAL COMBUSTION SOURCES	1.0-1
1.1	Bituminous And Subbituminous Coal Combustion	1.1-1
1.2	Anthracite Coal Combustion	1.2-1
1.3	Fuel Oil Combustion	1.3-1
1.4	Natural Gas Combustion	1.4-1
1.5	Liquefied Petroleum Gas Combustion	1.5-1
1.6	Wood Waste Combustion In Boilers	1.6-1
1.7	Lignite Combustion	1.7-1
1.8	Bagasse Combustion In Sugar Mills	1.8-1
1.9	Residential Fireplaces	1.9-1
1.10	Residential Wood Stoves	1.10-1
1.11	Waste Oil Combustion	1.11-1
2.	SOLID WASTE DISPOSAL	2.0-1
2.1	Refuse Combustion	2.1-1
2.2	Sewage Sludge Incineration	2.2-1
2.3	Medical Waste Incineration	2.3-1
2.4	Landfills	2.4-1
2.5	Open Burning	2.5-1
2.6	Automobile Body Incineration	2.6-1
2.7	Conical Burners	2.7-1
3.	STATIONARY INTERNAL COMBUSTION SOURCES	3.0-1
3.1	Stationary Gas Turbines For Electricity Generation	3.1-1
3.2	Heavy-duty Natural Gas-fired Pipeline Compressor Engines	3.2-1
3.3	Gasoline And Diesel Industrial Engines	3.3-1
3.4	Large Stationary Diesel And All Stationary Dual-fuel Engines	3.4-1
4.	EVAPORATION LOSS SOURCES	4.0-1
4.1	Dry Cleaning	4.1-1
4.2	Surface Coating	4.2-1
4.2.1	Nonindustrial Surface Coating	4.2.1-1
4.2.2	Industrial Surface Coating	4.2.2-1
4.2.2.1	General Industrial Surface Coating	4.2.2.1-1
4.2.2.2	Can Coating	4.2.2.2-1
4.2.2.3	Magnet Wire Coating	4.2.2.3-1
4.2.2.4	Other Metal Coating	4.2.2.4-1
4.2.2.5	Flat Wood Interior Panel Coating	4.2.2.5-1
4.2.2.6	Paper Coating	4.2.2.6-1
4.2.2.7	Polymeric Coating Of Supporting Substrates	4.2.2.7-1
4.2.2.8	Automobile And Light Duty Truck Surface Coating Operations	4.2.2.8-1
4.2.2.9	Pressure Sensitive Tapes And Labels	4.2.2.9-1
4.2.2.10	Metal Coil Surface Coating	4.2.2.10-1
4.2.2.11	Large Appliance Surface Coating	4.2.2.11-1

4.2.2.12	Metal Furniture Surface Coating	4.2.2.12-1
4.2.2.13	Magnetic Tape Manufacturing	4.2.2.13-1
4.2.2.14	Surface Coating Of Plastic Parts For Business Machines	4.2.2.14-1
4.3	Waste Water Collection, Treatment And Storage	4.3-1
4.4	Polyester Resin Plastic Products Fabrication	4.4-1
4.5	Asphalt Paving Operations	4.5-1
4.6	Solvent Degreasing	4.6-1
4.7	Waste Solvent Reclamation	4.7-1
4.8	Tank And Drum Cleaning	4.8-1
4.9	Graphic Arts	4.9-1
4.9.1	General Graphic Printing	4.9.1-1
4.9.2	Publication Gravure Printing	4.9.2-1
4.10	Commercial/Consumer Solvent Use	4.10-1
4.11	Textile Fabric Printing	4.11-1
5.	PETROLEUM INDUSTRY	5.0-1
5.1	Petroleum Refining	5.1-1
5.2	Transportation And Marketing Of Petroleum Liquids	5.2-1
5.3	Natural Gas Processing	5.3-1
6.	ORGANIC CHEMICAL PROCESS INDUSTRY	6.0-1
6.1	Carbon Black	6.1-1
6.2	Adipic Acid	6.2-1
6.3	Explosives	6.3-1
6.4	Paint And Varnish	6.4-1
6.5	Phthalic Anhydride	6.5-1
6.6	Plastics	6.6-1
6.6.1	Polyvinyl Chloride	6.6.1-1
6.6.2	Poly(ethylene terephthalate)	6.6.2-1
6.6.3	Polystyrene	6.6.3-1
6.6.4	Polypropylene	6.6.4-1
6.7	Printing Ink	6.7-1
6.8	Soap And Detergents	6.8-1
6.9	Synthetic Fibers	6.9-1
6.10	Synthetic Rubber	6.10-1
6.11	Terephthalic Acid	6.11-1
6.12	Lead Alkyl	6.12-1
6.13	Pharmaceuticals Production	6.13-1
6.14	Maleic Anhydride	6.14-1
6.15	Methanol	6.15-1
6.16	Acetone And Phenol	6.16-1
6.17	Propylene	6.17-1
6.18	Benzene, Toluene And Xylenes	6.18-1
6.19	Butadiene	6.19-1
6.20	Cumene	6.20-1
6.21	Ethanol	6.21-1
6.22	Ethyl Benzene	6.22-1
6.23	Ethylene	6.23-1

6.24	Ethylene Dichloride And Vinyl Chloride	6.24-1
6.25	Ethylene Glycol	6.25-1
6.26	Ethylene Oxide	6.26-1
6.27	Formaldehyde	6.27-1
6.28	Glycerine	6.28-1
6.29	Isopropyl Alcohol	6.29-1
7.	LIQUID STORAGE TANKS	7.0-1
7.1	Organic Liquid Storage Tanks	7.1-1
8.	INORGANIC CHEMICAL INDUSTRY	8.0-1
8.1	Synthetic Ammonia	8.1-1
8.2	Urea	8.2-1
8.3	Ammonium Nitrate	8.3-1
8.4	Ammonium Sulfate	8.4-1
8.5	Phosphate Fertilizers	8.5-1
8.5.1	Normal Superphosphates	8.5.1-1
8.5.2	Triple Superphosphates	8.5.2-1
8.5.3	Ammonium Phosphate	8.5.3-1
8.6	Hydrochloric Acid	8.6-1
8.7	Hydrofluoric Acid	8.7-1
8.8	Nitric Acid	8.8-1
8.9	Phosphoric Acid	8.9-1
8.10	Sulfuric Acid	8.10-1
8.11	Chlor-Alkali	8.11-1
8.12	Sodium Carbonate	8.12-1
8.13	Sulfur Recovery	8.13-1
8.14	Hydrogen Cyanide	8.14-1
9.	FOOD AND AGRICULTURAL INDUSTRIES	9.0-1
9.1	Tilling Operations	9.1-1
9.2	Growing Operations	9.2-1
9.2.1	Fertilizer Application	9.2.1-1
9.2.2	Pesticide Application	9.2.2-1
9.2.3	Orchard Heaters	9.2.3-1
9.3	Harvesting Operations	9.3-1
9.3.1	Cotton Harvesting	9.3.1-1
9.3.2	Grain Harvesting	9.3.2-1
9.3.3	Rice Harvesting	9.3.3-1
9.3.4	Cane Sugar Harvesting	9.3.4-1
9.4	Livestock And Poultry Feed Operations	9.4-1
9.4.1	Cattle Feedlots	9.4.1-1
9.4.2	Swine Feedlots	9.4.2-1
9.4.3	Poultry Houses	9.4.3-1
9.4.4	Dairy Farms	9.4.4-1
9.5	Animal And Meat Products Preparation	9.5-1
9.5.1	Meat Packing Plants	9.5.1-1
9.5.2	Meat Smokehouses	9.5.2-1

9.5.3	Meat Rendering Plants	9.5.3-1
9.5.4	Manure Processing	9.5.4-1
9.5.5	Poultry Slaughtering	9.5.5-1
9.6	Dairy Products	9.6-1
9.6.1	Natural And Processed Cheese	9.6.1-1
9.7	Cotton Ginning	9.7-1
9.8	Preserved Fruits And Vegetables	9.8-1
9.8.1	Canned Fruits And Vegetables	9.8.1-1
9.8.2	Dehydrated Fruits And Vegetables	9.8.2-1
9.8.3	Pickles, Sauces And Salad Dressings	9.8.3-1
9.9	Grain Processing	9.9-1
9.9.1	Grain Elevators And Processes	9.9.1-1
9.9.2	Cereal Breakfast Food	9.9.2-1
9.9.3	Pet Food	9.9.3-1
9.9.4	Alfalfa Dehydration	9.9.4-1
9.9.5	Pasta Manufacturing	9.9.5-1
9.9.6	Bread Baking	9.9.6-1
9.9.7	Corn Wet Milling	9.9.7-1
9.10	Confectionery Products	9.10-1
9.10.1	Sugar Processing	9.10.1-1
9.10.1.1	Cane Sugar Processing	9.10.1.1-1
9.10.1.2	Beet Sugar Processing	9.10.1.2-1
9.10.2	Salted And Roasted Nuts And Seeds	9.10.2-1
9.10.2.1	Almond Processing	9.10.2.1-1
9.10.2.2	Peanut Processing	9.10.2.2-1
9.11	Fats And Oils	9.11-1
9.11.1	Vegetable Oil Processing	9.11.1-1
9.12	Beverages	9.12-1
9.12.1	Malt Beverages	9.12.1-1
9.12.2	Wines And Brandy	9.12.2-1
9.12.3	Distilled Spirits	9.12.3-1
9.13	Miscellaneous Food And Kindred Products	9.13-1
9.13.1	Fish Processing	9.13.1-1
9.13.2	Coffee Roasting	9.13.2-1
9.13.3	Snack Chip Deep Fat Frying	9.13.3-1
9.13.4	Yeast Production	9.13.4-1
9.14	Tobacco Products	9.14-1
9.15	Leather Tanning	9.15-1
9.16	Agricultural Wind Erosion	9.16-1
10.	WOOD PRODUCTS INDUSTRY	10.0-1
10.1	Lumber	10.1-1
10.2	Chemical Wood Pulping	10.2-1
10.3	Pulp Bleaching	10.3-1
10.4	Papermaking	10.4-1
10.5	Plywood	10.5-1
10.6	Reconstituted Wood Products	10.6-1
10.6.1	Waferboard And Oriented Strand Board	10.6.1-1

10.6.2	Particleboard	10.6.2-1
10.6.3	Medium Density Fiberboard	10.6.3-1
10.7	Charcoal	10.7-1
10.8	Wood Preserving	10.8-1
11.	MINERAL PRODUCTS INDUSTRY	11.0-1
11.1	Hot Mix Asphalt Plants	11.1-1
11.2	Asphalt Roofing	11.2-1
11.3	Bricks And Related Clay Products	11.3-1
11.4	Calcium Carbide Manufacturing	11.4-1
11.5	Refractory Manufacturing	11.5-1
11.6	Portland Cement Manufacturing	11.6-1
11.7	Ceramic Products Manufacturing	11.7-1
11.8	Clay And Fly Ash Sintering	11.8-1
11.9	Western Surface Coal Mining	11.9-1
11.10	Coal Cleaning	11.10-1
11.11	Coal Conversion	11.11-1
11.12	Concrete Batching	11.12-1
11.13	Glass Fiber Manufacturing	11.13-1
11.14	Frit Manufacturing	11.14-1
11.15	Glass Manufacturing	11.15-1
11.16	Gypsum Manufacturing	11.16-1
11.17	Lime Manufacturing	11.17-1
11.18	Mineral Wool Manufacturing	11.18-1
11.19	Construction Aggregate Processing	11.19-1
11.19.1	Sand And Gravel Processing	11.19.1-1
11.19.2	Crushed Stone Processing	11.19.2-1
11.20	Lightweight Aggregate Manufacturing	11.20-1
11.21	Phosphate Rock Processing	11.21-1
11.22	Diatomite Processing	11.22-1
11.23	Taconite Ore Processing	11.23-1
11.24	Metallic Minerals Processing	11.24-1
11.25	Clay Processing	11.25-1
11.26	Talc Processing	11.26-1
11.27	Feldspar Processing	11.27-1
11.28	Vermiculite Processing	11.28-1
11.29	Alumina Manufacturing	11.29-1
11.30	Perlite Manufacturing	11.30-1
11.31	Abrasives Manufacturing	11.31-1
12.	METALLURGICAL INDUSTRY	12.0-1
12.1	Primary Aluminum Production	12.1-1
12.2	Coke Production	12.2-1
12.3	Primary Copper Smelting	12.3-1
12.4	Ferroalloy Production	12.4-1
12.5	Iron And Steel Production	12.5-1
12.6	Primary Lead Smelting	12.6-1
12.7	Zinc Smelting	12.7-1

12.8	Secondary Aluminum Operations	12.8-1
12.9	Secondary Copper Smelting And Alloying	12.9-1
12.10	Gray Iron Foundries	12.10-1
12.11	Secondary Lead Processing	12.11-1
12.12	Secondary Magnesium Smelting	12.12-1
12.13	Steel Foundries	12.13-1
12.14	Secondary Zinc Processing	12.14-1
12.15	Storage Battery Production	12.15-1
12.16	Lead Oxide And Pigment Production	12.16-1
12.17	Miscellaneous Lead Products	12.17-1
12.18	Leadbearing Ore Crushing And Grinding	12.18-1
12.19	Electric Arc Welding	12.19-1
12.20	Electroplating	12.20-1
13.	MISCELLANEOUS SOURCES	13.0-1
13.1	Wildfires And Prescribed Burning	13.1-1
13.2	Fugitive Dust Sources	13.2-1
13.2.1	Paved Roads	13.2.1-1
13.2.2	Unpaved Roads	13.2.2-1
13.2.3	Heavy Construction Operations	13.2.3-1
13.2.4	Aggregate Handling And Storage Piles	13.2.4-1
13.2.5	Industrial Wind Erosion	13.2.5-1
13.3	Explosives Detonation	13.3-1
13.4	Wet Cooling Towers	13.4-1
13.5	Industrial Flares	13.5-1
14.	GREENHOUSE GAS BIOGENIC SOURCES	14.0-1
14.1	Emissions From Soils — Greenhouse Gases	14.1-1
14.2	Termites — Greenhouse Gases	14.2-1
14.3	Lightning Emissions — Greenhouse Gases	14.2-1
APPENDIX A		
	Miscellaneous Data And Conversion Factors	A-1
APPENDIX B.1		
	Particle Size Distribution Data And Sized Emission Factors For Selected Sources	B.1-1
APPENDIX B.2		
	Generalized Particle Size Distributions	B.2-1
APPENDIX C.1		
	Procedures For Sampling Surface/Bulk Dust Loading	C.1-1
APPENDIX C.2		
	Procedures For Laboratory Analysis Of Surface/Bulk Dust Loading Samples	C.2-1

PUBLICATIONS IN SERIES

<i>Issue</i>	<i>Date</i>
COMPILATION OF AIR POLLUTANT EMISSION FACTORS, FIFTH EDITION	1/95
SUPPLEMENT A	11/96
Introduction	
Section 1.1	Bituminous And Subbituminous Coal Combustion
1.2	Anthracite Coal Combustion
1.3	Fuel Oil Combustion
1.4	Natural Gas Combustion
1.6	Wood Waste Combustion In Boilers
1.7	Lignite Combustion
1.11	Waste Oil Combustion
3.1	Stationary Gas Turbines For Electricity Generation
3.2	Heavy-duty Natural Gas-fired Pipeline Compressor Engines
3.4	Large Stationary Diesel And All Stationary Dual-fuel Engines
5.3	Natural Gas Processing
7.0	Liquid Storage Tanks Introduction
7.1	Organic Liquid Storage Tanks
9.5.2	Meat Smokehouses
9.5.3	Meat Rendering Plants
9.8.1	Canned Fruits And Vegetables
9.8.2	Dehydrated Fruits And Vegetables
9.8.3	Pickles, Sauces And Salad Dressings
9.9.1	Grain Elevators And Processes
9.9.2	Cereal Breakfast Food
9.9.5	Pasta Manufacturing
9.11.1	Vegetable Oil Processing
9.12.2	Wines And Brandy
9.13.2	Coffee Roasting
10.7	Charcoal
11.10	Coal Cleaning
11.14	Frit Manufacturing
11.19	Construction Aggregate Processing
11.22	Diatomite Processing
11.26	Talc Processing
11.28	Vermiculite Processing
13.2.1	Paved Roads
12.2.2	Unpaved Roads
Appendix	B.2
Generalized Particle Size Distributions	

SUPPLEMENT B

11/96

Section

- 1.1 Bituminous And Subbituminous Coal Combustion
- 1.2 Anthracite Coal Combustion
- 1.3 Fuel Oil Combustion
- 1.4 Natural Gas Combustion
- 1.5 Liquefied Petroleum Gas Combustion
- 1.6 Wood Waste Combustion In Boilers
- 1.7 Lignite Combustion
- 1.8 Bagasse Combustion In Sugar Mills
- 1.9 Residential Fireplaces
- 1.10 Residential Wood Stoves
- 1.11 Waste Oil Combustion
- 2.1 Refuse Combustion
- 3.1 Stationary Gas Turbines For Electricity Generation
- 3.2 Heavy-duty Natural Gas-fired Pipeline Compressor Engines
- 3.3 Gasoline And Diesel Industrial Engines
- 3.4 Large Stationary Diesel And All Stationary Dual-fuel Engines
- 6.2 Adipic Acid
- 9.7 Cotton Ginning
- 9.9.4 Alfalfa Dehydrating
- 9.12.1 Malt Beverages
- 11.7 Ceramic Products Manufacturing
- 12.20 Electroplating
- 13.1 Wildfires And Prescribed Burning
- 14.0 Greenhouse Gas Biogenic Sources
 - 14.1 Emissions From Soils—Greenhouse Gases
 - 14.2 Termites—Greenhouse Gases
 - 14.3 Lightning Emissions—Greenhouse

SUPPLEMENT C

11/97

Section

- 9.5.1 Meat Packing Plants
- 9.6.1 Natural and Processed Cheese
- 9.9.6 Bread Baking
- 9.10.1.1 Cane Sugar Processing
- 9.10.1.2 Sugarbeet Processing
- 9.12.3 Distilled Spirits
- 9.15 Leather Tanning
- 11.3 Brick And Structural Clay Product Manufacturing
- 11.14 Frit Manufacturing
- 11.23 Taconite Ore Processing

**Instructions For Inserting
Supplement A Of Volume I
Into AP-42**

Pp. 1.1-3 through -24 replace same. Editorial Change.
Pp. 1.2-3 through -6 replace same. Editorial Change.
Pp. 1. 3-1 through - 12 and - 15 through - 18 replace same. Editorial Change.
Pp. 1.4-3 and -4 replace same. Editorial Change.
Pp. 1.6-3 through -6 replace same. Editorial Change.
Pp. 1.7-3 through -8 replace same. Editorial Change.
Pp. 1.11-5and-6 replace same. EditorialChange.
Pp. 3.1-3 through -6 replace same. Editorial Change.
Pp. 3.2-3 and -4 and -7 and -8 replace same. Editorial Change.
Pp. 3.4-3 and -4 replace same. Editorial Change.
Pp. 5.3-1 through -8 (blank) replace same. Editorial Change.
Pp. 7.0-1 and -2 (blank) replace same. Revised Chapter Introduction.
Pp. 7.1-1 through -102 (blank) replace 7.1-1 through-108 (blank). Major Revision.
Pp. 9.5.2-1 through -6 replace 9.5.2-1 and -2 (blank). New Section.
Pp. 9.5.3-1 through -8 replace 9.5.3-1 and -2 (blank). New Section.
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Pp. 9.8.2-1 through -4 replace 9.8.2-1 and -2 (blank). New Section.
Pp. 9.8.3-1 through -4 replace 9.8.3-1 and -2 (blank). New Section.
Pp. 9.9. 1-1 and -2 (blank) replace same. New Information.
Pp. 9.9.2-1 through -12 replace 9.9.2-1 and -2 (blank). New Section.
Pp. 9.9.5-1 through -4 (blank) replace 9.9.5-1 and -2 (blank). New Section.
Pp.9.11.1-Ithrough-12 (blank)replace9.11.1-1and-2 (blank). NewSection.
Pp. 9.12.2-1 through -10 (blank) replace 9.12.2-1 and -2 (blank). New Section.
Pp. 9.13.2-1 through -8 (blank) replace 9.13.2-1 and -2 (blank). New Section.
Pp. 10.7-1 through -8 (blank) replace 10.7-1 and -2 (blank). New Section.
Pp. 11.10-Ithrough-8(blank)replacell.10-Ithrough-4. MajorRevision.
Pp. 11. 14-1 through -6 (blank) replace 11. 14-1 and -2 (blank). New Section.
Pp. 11. 19. 1 -1 through -8 replace I 1. 19. 1 -1 and -2 (blank). New Section.
Pp. 11.22-1 through -6 (blank) replace 11.22-1 and -2 (blank). New Section.
Pp. 11.26-1 through -8 (blank) replace 11.26-1 through -4 (blank). Major Revision.
Pp. 11.28-1 through -4 replace 11.28-1 and -2 (blank). New Section.
Pp. 13.2. 1-1 through -28 replace same. Editorial Change.
Pp. 13.2.2-1 through -8 replace same. Editorial Change.
Pp. B.2-3 and -4 replace same. Editorial Change.
Insert new Technical Report Data Sheet.

**Instructions For Inserting
Supplement B Of Volume I
Into AP-42**

Preliminary Matter	Publications In Series, Contents, Key Word Index	Replace all	Minor Revision
Chap. 1, Sect 1-11	External Combustion Sources	Replace all	New Information
Chap. 2, Sect. 1	Refuse Combustion	Replace entire	Minor Revision
Chap. 3, Sect. 1-4	Stationary Internal Combustion Sources	Replace all	New Information
Chap. 6, Sect. 2	Adipic Acid	Replace entire	Major Revision
Chap. 9, Sect. 7	Cotton Ginning	Replace [Work In Progress] sheet	New Section
Chap. 9, Sect. 9.4	Alfalfa Dehydrating	Replace [Work In Progress] sheet	New Section
Chap. 9, Sect. 12.1	Malt Beverages	Replace [Work In Progress] sheet	New Section
Chap. 11, Sect. 7	Ceramic Products Manufacturing	Replace entire	Major Revision
Chap. 12, Sect. 20	Electroplating	Add	New Section
Chap. 13, Sect. 1	Wildfires And Prescribed Burning	Replace entire	Minor Revision
Chap. 14, Sect. 1-3	Greenhouse Gas Biogenic Sources	Add	New Chapter
Insert new Technical Report Data Sheet.			

**Instructions For Inserting
Supplement C Of Volume I
Into AP-42**

Chap. 9, Sect. 5.1	Meat Packing Plants	Replace [Work In Progress] sheet	New Section
Chap. 9, Sect. 6.1	Natural and Processed Cheese	Replace [Work In Progress] sheet	New Section
Chap. 9, Sect. 9.6	Bread Baking	Replace [Work In Progress] sheet	New Section
Chap. 9, Sect. 10.1.1	Cane Sugar Processing	Replace [Work In Progress] sheet	New Section
Chap. 9, Sect. 10.1.2	Sugarbeet Processing	Replace [Work In Progress] sheet	New Section
Chap. 9, Sect. 12.3	Distilled Spirits	Replace [Work In Progress] sheet	New Section
Chap. 9, Sect. 15	Leather Tanning	Replace [Work In Progress] sheet	New Section
Chap. 11, Sect. 3	Brick And Structural Clay Product Manufacturing	Replace entire	Major Revision
Chap. 11, Sect. 14	Frit Manufacturing	Replace entire	Minor Revision
Chap. 11, Sect. 23	Taconite Ore Processing	Replace entire	Major Revision
Insert new Technical Report Data Sheet.			

KEY WORD INDEX

	Chapter/Section
Abrasives Manufacturing	11.31
Acetone And Phenol	6.16
Acid	
Adipic	6.2
Hydrochloric	8.6
Hydrofluoric	8.7
Nitric	8.8
Phosphoric	8.9
Sulfuric	8.10
Terephthalic	6.11
Adipic Acid	6.2
Aggregate Handling	13.2.4
Aggregate Manufacturing, Lightweight	11.20
Aggregate Processing, Construction	11.19
Aggregate Storage Piles	13.2.4
Agricultural Industries	9.0
Agricultural Wind Erosion	9.16
Alcohol, Isopropyl	6.29
Alfalfa Dehydration	9.9.4
Alkali, Chlor-	8.11
Almond Processing	9.10.2.1
Alumina Manufacturing	11.29
Aluminum	
Operations, Secondary	12.8
Production, Primary	12.1
Ammonia, Synthetic	8.1
Ammonium Nitrate	8.3
Ammonium Phosphate	8.5.3
Ammonium Sulfate	8.4
Analysis, Surface/Bulk Dust Loading	App. C.2
Anhydride, Phthalic	6.5
Animal And Meat Products Preparation	9.5
Anthracite Coal Combustion	1.2
Appliance Surface Coating	4.2.2.11
Ash	
Fly Ash Sintering	11.8
Asphalt	
Hot Mix Plants	11.1
Paving	4.5
Roofing	11.2
Automobile Body Incineration	2.6
Automobile Surface Coating	4.2.2.8
Bagasse Combustion In Sugar Mills	1.8
Baking, Bread	9.9.6

Bark	
Wood Waste Combustion In Boilers	1.6
Batching, Concrete	11.12
Battery Production, Storage	12.15
Beet Sugar Processing	9.10.1.2
Benzene, Toluene And Xylenes	6.18
Beverages	9.12
Brandy	9.12.2
Liquors, Distilled Spirits	9.12.3
Malt	9.12.1
Wines	9.12.2
Bituminous Coal Combustion	1.1
Bleaching, Wood Pulp	10.3
Brandy	9.12.2
Bread Baking	9.9.6
Bricks And Related Clay Products	11.3
Bulk Material Analysis Procedures	App. C.2
Bulk Material Sampling Procedures	App. C.1
Burners, Conical (Teepee)	2.7
Burning, Open	2.5
Burning, Prescribed, And Wildfires	13.1
Business Machines, Plastic Parts Coating	4.2.2.14
Butadiene	6.19
Calcium Carbide Manufacturing	11.4
Can Coating	4.2.2.2
Cane Sugar Processing	9.10.1.1
Canned Fruits And Vegetables	9.8.1
Carbon Black	6.1
Carbonate	
Sodium Carbonate Manufacturing	8.12
Cattle Feedlots	9.4.1
Cement	
Portland Cement Manufacturing	11.6
Ceramic Products Manufacturing	11.7
Cereal Breakfast Food	9.9.2
Charcoal	10.7
Cheese, Natural And Processed	9.6.1
Chemical Wood Pulping	10.2
Chemicals, Inorganic	8.0
Chemicals, Organic	6.0
Chlor-Alkali	8.11
Clay	
Bricks And Related Clay Products	11.3
Ceramic Products Manufacturing	11.7
Clay And Fly Ash Sintering	11.8
Clay Processing	11.25

Cleaning	
Coal	11.10
Drum	4.8
Dry Cleaning	4.1
Tank	4.8
Coal	
Anthracite Combustion	1.2
Bituminous Combustion	1.1
Cleaning	11.10
Conversion	11.11
Subbituminous Combustion	1.1
Surface Mining, Western	11.9
Coating, Surface	4.2
Appliance, Large	4.2.2.11
Automobile And Light Duty Truck	4.2.2.8
Can	4.2.2.2
Fabric	4.2.2.7
Flat Wood Interior Panel	4.2.2.5
Labels, Pressure Sensitive	4.2.2.9
Magnet Wire	4.2.2.3
Magnetic Tape	4.2.2.13
Metal Coil	4.2.2.10
Metal Furniture	4.2.2.12
Metal, General	4.2.2.4
Paper	4.2.2.6
Plastic Parts For Business Machines	4.2.2.14
Polymeric Coating Of Supporting Substrates	4.2.2.7
Tapes, Pressure Sensitive	4.2.2.9
Coffee Roasting	9.13.2
Coke Manufacturing	12.2
Collection, Waste Water	4.3
Combustion	
Anthracite Coal	1.2
Bagasse, In Sugar Mills	1.8
Bituminous Coal	1.1
Fuel Oil	1.3
Internal, Mobile	Vol. II
Internal, Stationary	3.0
Lignite	1.7
Liquefied Petroleum Gas	1.5
Natural Gas	1.4
Orchard Heaters	9.2.3
Refuse	2.1
Residential Fireplaces	1.9
Residential Wood Stoves	1.10
Subbituminous Coal	1.1
Waste Oil	1.11
Wood Waste In Boilers	1.6
Compressors, Pipeline, Natural Gas Fired	3.2
Concrete Batching	11.12
Confectionery Products	9.10
Conical Burners	2.7
Construction Aggregate Processing	11.19

Construction Operations, Heavy	13.2.3
Conversion factors, units, etc. – Miscellaneous	App. A
Cooling Towers, Wet	13.4
Copper	
Alloying	12.9
Smelting, Primary	12.3
Smelting, Secondary	12.9
Corn Wet Milling	9.9.7
Cotton	
Ginning	9.7
Harvesting	9.3.1
Crushed Stone Processing	11.19.2
Cumene	6.20
Cyanide, Hydrogen	8.14
Dairy Farms	9.4.4
Dairy Products	9.6
Deep Fat Frying, Snack Chip	9.13.3
Degreasing, Solvent	4.6
Dehydrated Fruits And Vegetables	9.8.2
Dehydration, Alfalfa	9.9.4
Detergents	
Soap And Detergents	6.8
Detonation, Explosives	13.3
Diatomite Processing	11.22
Diesel Engines, Industrial	3.3
Diesel Engines, Stationary	3.4
Distilled Spirits	9.12.3
Drum Cleaning	4.8
Dry Cleaning	4.1
Dual Fuel Engines, Stationary	3.4
Dust Loading Analysis, Surface/Bulk	App. C.2
Dust Loading Sampling Procedures, Surface/Bulk	App. C.1
Dust Sources, Fugitive	13.2
Electric Arc Welding	12.19
Electric Utility Power Plants, Gas	3.1
Electricity Generators, Stationary Gas Turbine	3.1
Electroplating	12.20
Erosion, Wind, Industrial	13.2.5
Ethanol	6.21
Ethyl Benzene	6.22
Ethylene	6.23
Ethylene Dichloride And Vinyl Chloride	6.24
Ethylene Glycol	6.25
Ethylene Oxide	6.26
Evaporation Loss Sources	4.0
Explosives	6.3
Explosives Detonation	13.3
External Combustion Sources	1.0
Fabric Coating	4.2.2.7
Fabric Printing, Textile	4.11

Fats, Cooking	9.11
Feedlots	
Cattle	9.4.1
Dairy Farms	9.4.4
Poultry Houses	9.4.3
Swine	9.4.2
Feldspar Processing	11.27
Ferroalloy Production	12.4
Fertilizer Application	9.2.1
Fertilizers	
Ammonium Phosphate	8.5.3
Phosphate	8.5
Fiberboard, Medium Density	10.6.3
Fiber Manufacturing, Glass	11.13
Fibers, Synthetic	6.9
Fireplaces, Residential	1.9
Fires	
Forest Wildfires And Prescribed Burning	13.1
Fish Processing	9.13.1
Flares, Industrial	13.5
Flat Wood Interior Panel Coating	4.2.2.5
Fly Ash	
Clay And Fly Ash Sintering	11.8
Food And Agricultural Industries	9.0
Food And Kindred Products, Miscellaneous	9.13
Coffee Roasting	9.13.2
Fish Processing	9.13.1
Snack Chip Deep Fat Frying	9.13.3
Yeast Production	9.13.4
Formaldehyde	6.27
Foundries	
Gray Iron	12.10
Steel	12.13
Frit Manufacturing	11.14
Fruits, Preserved	9.8
Canned	9.8.1
Dehydrated	9.8.2
Fuel Oil Combustion	1.3
Fugitive Dust Sources	13.2
Furniture Surface Coating, Metal	4.2.2.12
Gas Combustion, Liquefied Petroleum	1.5
Gas, Natural	
Combustion	1.4
Pipeline Compressors	3.2
Processing	5.3
Turbines, Electricity-generating	3.1
Gasoline/Diesel Industrial Engines	3.3
Ginning, Cotton	9.7
Glass Fiber Manufacturing	11.13
Glass Manufacturing	11.15
Graphic Arts	4.9
General Graphic Printing	4.9.1

Publication Gravure Printing	4.9.2
Glycerine	6.28
Grain	
Alfalfa Dehydration	9.9.4
Bread Baking	9.9.6
Cereal Breakfast Food	9.9.2
Corn Wet Milling	9.9.7
Elevators And Processes	9.9.1
Harvesting	9.3.2
Pasta Manufacturing	9.9.5
Pet Food	9.9.3
Processing	9.9
Gravel Processing	11.19.1
Gray Iron Foundries	12.10
Greenhouse Gas biogenic Sources	14.0
Growing Operations	9.2
Gypsum Manufacturing	11.16
Harvesting Operations	9.3
Cotton Harvesting	9.3.1
Grain Harvesting	9.3.2
Rice Harvesting	9.3.3
Sugar Cane Harvesting	9.3.4
Heaters, Orchard	9.2.3
Highway Vehicles	Vol. II
Hot Mix Asphalt Plants	11.1
Hydrochloric Acid	8.6
Hydrofluoric Acid	8.7
Hydrogen Cyanide	8.14
Incineration	
Automobile Body	2.6
Medical Waste	2.3
Open Burning	2.5
Sewage Sludge	2.2
Industrial Engines, Gasoline And Diesel	3.3
Industrial Flares	13.5
Industrial Surface Coating	4.2.2
Industrial Surface Coating, General	4.2.2.1
Industrial Wind Erosion	13.2.5
Ink, Printing	6.7
Inorganic Chemical Industry	8.0
Interior Panel Coating, Flat Wood	4.2.2.5
Internal Combustion Engines	
Highway Vehicle	Vol. II
Off-highway Mobile	Vol. II
Off-highway Stationary	3.0
Iron	
Gray Iron Foundries	12.10
Iron Production	12.5
Isopropyl Alcohol	6.29

Labels, Pressure Sensitive	4.2.2.9
Landfills	2.4
Large Bore Engines	3.4
Lead	
Ore Crushing And Grinding	12.18
Processing, Secondary	12.11
Products, Miscellaneous	12.17
Smelting, Primary	12.6
Lead Alkyl	6.12
Lead Oxide Production	12.16
Lead Pigment Production	12.16
Leadbearing Ore Crushing And Grinding	12.18
Leather Tanning	9.15
Light Duty Truck Surface Coating	4.2.2.8
Lightning	14.1
Lightweight Aggregate Manufacturing	11.20
Lignite Combustion	1.7
Lime Manufacturing	11.17
Liquefied Petroleum Gas Combustion	1.5
Liquid Storage Tanks	7.0
Livestock Feed Operations	9.4
Lumber	10.1
Magnesium, Secondary Smelting	12.12
Magnet Wire Coating	4.2.2.3
Magnetic Tape Manufacturing	4.2.2.13
Maleic Anhydride	6.14
Malt Beverages	9.12.1
Manure Processing	9.5.4
Marketing, Petroleum Liquids	5.2
Meat Packing Plants	9.5.1
Meat Products Preparation	9.5
Meat Rendering Plants	9.5.3
Meat Smokehouses	9.5.2
Medical Waste Incineration	2.3
Metal Coating, General	4.2.2.4
Metal Coil Surface Coating	4.2.2.10
Metal Furniture Surface Coating	4.2.2.12
Metallic Minerals Processing	11.24
Metallurgical Industry	12.0
Methanol	6.15
Mineral Products Industry	11.0
Mineral Wool Manufacturing	11.18
Minerals Processing, Metallic	11.24
Mining, Western Surface Coal	11.9
Miscellaneous Sources	13.0
Mobile Sources	
Highway	Vol. II
Off-highway	Vol. II
Natural And Processed Cheese	9.6.1
Natural Gas Combustion	1.4
Natural Gas Fired Pipeline Compressors	3.2

Natural Gas Processing	5.3
Nitric Acid Manufacturing	8.8
Nonindustrial Surface Coating	4.2.1
Normal Superphosphates	8.5.1
Nuts And Seeds, Salted And Roasted	9.10.2
Almond Processing	9.10.2.1
Peanut Processing	9.10.2.2
Off-highway Mobile Sources	Vol. II
Off-highway Stationary Sources	3.0
Oil	
Fuel Oil Combustion	1.3
Waste Oil Combustion	1.11
Oils, Cooking	9.11
Vegetable Oil Processing	9.11.1
Open Burning	2.5
Orchard Heaters	9.2.3
Ore Processing	
Leadbearing Ore Crushing And Grinding	12.18
Taconite	11.23
Organic Chemical Process Industry	6.0
Organic Liquid Storage Tanks	7.1
Oriented Strand Board	10.6.1
Paint And Varnish	6.4
Panel Coating, Flat Wood Interior	4.2.2.5
Paper Coating	4.2.2.6
Papermaking	10.4
Particleboard	10.6.2
Particle size distribution data, factors, generalized	App. B.2
Particle size distribution data, factors, selected	App. B.1
Pasta Manufacturing	9.9.5
Paved Roads	13.2.1
Paving, Asphalt	4.5
Peanut Processing	9.10.2.2
Perlite Manufacturing	11.30
Pesticide Application	9.2.2
Pet Food	9.9.3
Petroleum	
Liquefied Petroleum Gas Combustion	1.5
Liquids, Transportation And Marketing	5.2
Refining	5.1
Storage Of Organic Liquids	7.1
Petroleum Industry	5.0
Pharmaceuticals Production	6.13
Phenol	6.16
Phosphate, Ammonium	8.5.3
Phosphate Fertilizers	8.5
Phosphate Rock Processing	11.21
Phosphoric Acid	8.9
Phthalic Anhydride	6.5
Pickles	9.8.3
Pigment	

Lead Oxide And Pigment Production	12.16
Pipeline Compressors, Natural Gas Fired	3.2
Plastic Part Surface Coating, Business Machine	4.2.2.14
Plastics	6.6
Plywood	10.5
Polyester Resin Plastic Products Fabrication	4.4
Poly(ethylene terephthalate)	6.6.2
Polymeric Coating Of Supporting Substrates	4.2.2.7
Polypropylene	6.6.4
Polystyrene	6.6.3
Polyvinyl Chloride	6.6.1
Portland Cement Manufacturing	11.6
Poultry Feed Operations	9.4
Poultry Houses	9.4.3
Poultry Slaughtering	9.5.5
Prescribed Burning, Wildfires And	13.1
Preserved Fruits And Vegetables	9.8
Preserving, Wood	10.8
Printing, General Graphic	4.9.1
Printing, Publication Gravure	4.9.2
Printing, Textile Fabric	4.11
Printing Ink	6.7
Processed Cheese	9.6.1
Propylene	6.17
Pulp Bleaching, Wood	10.3
Pulping, Chemical Wood	10.2
Reclamation, Waste Solvent	4.7
Reconstituted Wood Products	10.6
Recovery, Sulfur	8.13
Refining, Petroleum	5.1
Refractory Manufacturing	11.5
Refuse Combustion	2.1
Rendering Plants, Meat	9.5.3
Residential Fireplaces	1.9
Resin, Polyester, Plastic Product Fabrication	4.4
Rice Harvesting	9.3.3
Roads	
Paved	13.2.1
Unpaved	13.2.2
Roasted Nuts And Seeds	9.10.2
Roasting, Coffee	9.13.2
Rock Processing, Phosphate	11.21
Roofing, Asphalt	11.2
Rubber, Synthetic	6.10
Salad Dressings	9.8.3
Salted And Roasted Nuts And Seeds	9.10.2
Almond Processing	9.10.2.1
Peanut Processing	9.10.2.2
Sampling, Surface/Bulk Loading	App. C.1
Sand And Gravel Processing	11.19.1
Sauces	9.8.3

Seeds, Salted And Roasted	9.10.2
Sewage Sludge Incineration	2.2
Sized emission factors, generalized	App. B.2
Sized emission factors, selected	App. B.1
Smelting	
Primary Copper	12.3
Primary Lead	12.6
Secondary Copper Smelting And Alloying	12.9
Secondary Magnesium	12.12
Zinc	12.7
Smokehouses, Meat	9.5.2
Snack Chip Deep Fat Frying	9.13.3
Soap And Detergent Manufacturing	6.8
Sodium Carbonate Manufacturing	8.12
Soils	14.1
Solid Waste Disposal	2.0
Solvent	
Commercial/Consumer Use	4.10
Degreasing	4.6
Waste, Reclamation	4.7
Stationary Gas Turbines	3.1
Stationary Internal Combustion Sources, Off-highway	3.0
Steel	
Foundries	12.13
Production	12.5
Stone Processing, Crushed	11.19.2
Storage, Waste Water	4.3
Storage Battery Production	12.15
Storage Piles, Aggregate	13.2.4
Storage Tanks, Liquid	7.0
Organic Liquid Storage Tanks	7.1
Subbituminous Coal Combustion	1.1
Substrates, Supporting, Polymeric Coating Of	4.2.2.7
Sugar Harvesting, Cane	9.3.4
Sugar Mills, Bagasse Combustion In	1.8
Sugar Processing	9.10.1
Sugar Processing, Beet	9.10.1.2
Sugar Processing, Cane	9.10.1.1
Sulfur Recovery	8.13
Sulfuric Acid	8.10
Surface/Bulk Dust Loading Analysis	App. C.2
Surface/Bulk Dust Loading Sampling Procedures	App. C.1
Surface Coal Mining, Western	11.9
Surface Coating	4.2
Surface Coating, Industrial	4.2.2
Surface Coating, Nonindustrial	4.2.1
Surface Material Analysis Procedures	App. C.2
Surface Material Sampling Procedures	App. C.1
Swine Feedlots	9.4.2
Synthetic Ammonia	8.1
Synthetic Fibers	6.9
Synthetic Rubber	6.10

Taconite Ore Processing	11.23
Talc Processing	11.26
Tank And Drum Cleaning	4.8
Tape, Magnetic, Manufacturing	4.2.2.13
Tapes And Labels, Pressure Sensitive	4.2.2.9
Teepee (Conical) Burners	2.7
Terephthalic Acid	6.11
Termites	14.2
Textile Fabric Printing	4.11
Tilling Operations	9.1
Tobacco Products	9.14
Toluene	6.18
Transportation And Marketing Of Petroleum Liquids	5.2
Treatment, Waste Water	4.3
Triple Superphosphates	8.5.2
Truck, Light Duty, Surface Coating,	4.2.2.8
Turbines, Natural Gas Fired	3.1
Unpaved Roads	13.2.2
Urea	8.2
Varnish	
Paint And Varnish Manufacturing	6.4
Vegetable Oil Processing	9.11.1
Vegetables, Canned	9.8.1
Vegetables, Dehydrated	9.8.2
Vegetables, Preserved	9.8
Vehicles, Highway And Off-highway	Vol. II
Vermiculite Processing	11.28
Vinyl Chloride	6.24
Waferboard	10.6.1
Waste Disposal, Solid	2.0
Waste Oil Combustion	1.11
Waste Solvent Reclamation	4.7
Waste Water Collection, Treatment and Storage	4.3
Welding, Electric Arc	12.19
Wet Cooling Towers	13.4
Wet Milling, Corn	9.9.7
Wildfires	13.1
Wind Erosion	
Agricultural	9.16
Industrial	13.2.5
Wine	9.12.2
Wire Coating, Magnet	4.2.2.3
Wood	
Charcoal	10.7
Flat Interior Panel Coating	4.2.2.5
Lumber	10.1
Medium Density Fiberboard	10.6.3
Oriented Strand Board	10.6.1
Papermaking	10.4
Particleboard	10.6.2

Plywood	10.5
Pulp Bleaching	10.3
Pulping, Chemical	10.2
Reconstituted Wood Products	10.6
Stoves	1.10
Waferboard	10.6.1
Waste Combustion In Boilers	1.6
Wood Preserving	10.8
Wood Products Industry	10.0
Xylenes	6.18
Yeast Production	9.13.4
Zinc	
Processing, Secondary	12.14
Smelting	12.7

INTRODUCTION

Emission factors and emission inventories have long been fundamental tools for air quality management. Emission estimates are important for developing emission control strategies, determining applicability of permitting and control programs, ascertaining the effects of sources and appropriate mitigation strategies, and a number of other related applications by an array of users, including federal, state, and local agencies, consultants, and industry. Data from source-specific emission tests or continuous emission monitors are usually preferred for estimating a source's emissions because those data provide the best representation of the tested source's emissions. However, test data from individual sources are not always available and, even then, they may not reflect the variability of actual emissions over time. Thus, emission factors are frequently the best or only method available for estimating emissions, in spite of their limitations.

The passage of the *Clean Air Act Amendments Of 1990 (CAAA)* and the *Emergency Planning And Community Right-To-Know Act (EPCRA)* of 1986 has increased the need for both criteria and Hazardous air pollutant (HAP) emission factors and inventories. The Emission Factor And Inventory Group (EFIG), in the U. S. Environmental Protection Agency's (EPA) Office Of Air Quality Planning And Standards (OAQPS), develops and maintains emission estimating tools to support the many activities mentioned above. The AP-42 series is the principal means by which EFIG can document its emission factors. These factors are cited in numerous other EPA publications and electronic data bases, but without the process details and supporting reference material provided in AP-42.

What Is An AP-42 Emission Factor?

An emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e. g., kilograms of particulate emitted per megagram of coal burned). Such factors facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category (i. e., a population average).

The general equation for emission estimation is:

$$E = A \times EF \times (1-ER/100)$$

where:

- E = emissions,
- A = activity rate,
- EF = emission factor, and
- ER = overall emission reduction efficiency, %.

ER is further defined as the product of the control device destruction or removal efficiency and the capture efficiency of the control system. When estimating emissions for a long time period

(e. g., one year), both the device and the capture efficiency terms should account for upset periods as well as routine operations.

Emission factor ratings in AP-42 (discussed below) provide indications of the robustness, or appropriateness, of emission factors for estimating average emissions for a source activity. Usually, data are insufficient to indicate the influence of various process parameters such as temperature and reactant concentrations. For a few cases, however, such as in estimating emissions from petroleum storage tanks, this document contains empirical formulae (or emission models) that relate emissions to variables such as tank diameter, liquid temperature, and wind velocity. Emission factor formulae that account for the influence of such variables tend to yield more realistic estimates than would factors that do not consider those parameters.

The extent of completeness and detail of the emissions information in AP-42 is determined by the information available from published references. Emissions from some processes are better documented than others. For example, several emission factors may be listed for the production of one substance: one factor for each of a number of steps in the production process such as neutralization, drying, distillation, and other operations. However, because of less extensive information, only one emission factor may be given for production facility releases for another substance, though emissions are probably produced during several intermediate steps. There may be more than one emission factor for the production of a certain substance because differing production processes may exist, or because different control devices may be used. Therefore, it is necessary to look at more than just the emission factor for a particular application and to observe details in the text and in table footnotes.

The fact that an emission factor for a pollutant or process is not available from EPA does not imply that the Agency believes the source does not emit that pollutant or that the source should not be inventoried, but it is only that EPA does not have enough data to provide any advice.

Uses Of Emission Factors

Emission factors may be appropriate to use in a number of situations such as making source-specific emission estimates for areawide inventories. These inventories have many purposes including ambient dispersion modeling and analysis, control strategy development, and in screening sources for compliance investigations. Emission factor use may also be appropriate in some permitting applications, such as in applicability determinations and in establishing operating permit fees.

Emission factors in AP-42 are neither EPA-recommended emission limits (e. g., best available control technology or BACT, or lowest achievable emission rate or LAER) nor standards (e. g., National Emission Standard for Hazardous Air Pollutants or NESHAP, or New Source Performance Standards or NSPS). Use of these factors as source-specific permit limits and/or as emission regulation compliance determinations is not recommended by EPA. Because emission factors essentially represent an average of a range of emission rates, approximately half of the subject sources will have emission rates greater than the emission factor and the other half will have emission rates less than the factor. As such, a permit limit using an AP-42 emission factor would result in half of the sources being in noncompliance.

Also, for some sources, emission factors may be presented for facilities having air pollution control equipment in place. Factors noted as being influenced by control technology do not necessarily reflect the best available or state-of-the-art controls, but rather reflect the level of (typical) control for which data were available at the time the information was published. Sources often are

tested more frequently when they are new and when they are believed to be operating properly, and either situation may bias the results.

As stated, source-specific tests or continuous emission monitors can determine the actual pollutant contribution from an existing source better than can emission factors. Even then, the results will be applicable only to the conditions existing at the time of the testing or monitoring. To provide the best estimate of longer-term (e. g., yearly or typical day) emissions, these conditions should be representative of the source's routine operations.

A material balance approach also may provide reliable average emission estimates for specific sources. For some sources, a material balance may provide a better estimate of emissions than emission tests would. In general, material balances are appropriate for use in situations where a high percentage of material is lost to the atmosphere (e. g., sulfur in fuel, or solvent loss in an uncontrolled coating process.) In contrast, material balances may be inappropriate where material is consumed or chemically combined in the process, or where losses to the atmosphere are a small portion of the total process throughput. As the term implies, one needs to account for all the materials going into and coming out of the process for such an emission estimation to be credible.

If representative source-specific data cannot be obtained, emissions information from equipment vendors, particularly emission performance guarantees or actual test data from similar equipment, is a better source of information for permitting decisions than an AP-42 emission factor. When such information is not available, use of emission factors may be necessary as a last resort. Whenever factors are used, one should be aware of their limitations in accurately representing a particular facility, and the risks of using emission factors in such situations should be evaluated against the costs of further testing or analyses.

Figure 1 depicts various approaches to emission estimation, in a hierarchy of requirements and levels of sophistication, that one should consider when analyzing the tradeoffs between cost of the estimates and the quality of the resulting estimates. Where risks of either adverse environmental effects or adverse regulatory outcomes are high, more sophisticated and more costly emission determination methods may be necessary. Where the risks of using a poor estimate are low, and the costs of more extensive methods are unattractive, then less expensive estimation methods such as emission factors and emission models may be both satisfactory and appropriate. In cases where no emission factors are available but adverse risk is low, it may even be acceptable to apply factors from similar source categories using engineering judgment. Selecting the method to be used to estimate source-specific emissions may warrant a case-by-case analysis considering the costs and risks in the specific situation. All sources and regulatory agencies should be aware of these risks and costs and should assess them accordingly.

Variability Of Emissions

Average emissions differ significantly from source to source and, therefore, emission factors frequently may not provide adequate estimates of the average emissions for a specific source. The extent of between-source variability that exists, even among similar individual sources, can be large depending on process, control system, and pollutant. Although the causes of this variability are considered in emission factor development, this type of information is seldom included in emission test reports used to develop AP-42 factors. As a result, some emission factors are derived from tests that may vary by an order of magnitude or more. Even when the major process variables are accounted for, the emission factors developed may be the result of averaging source tests that differ by factors of five or more.

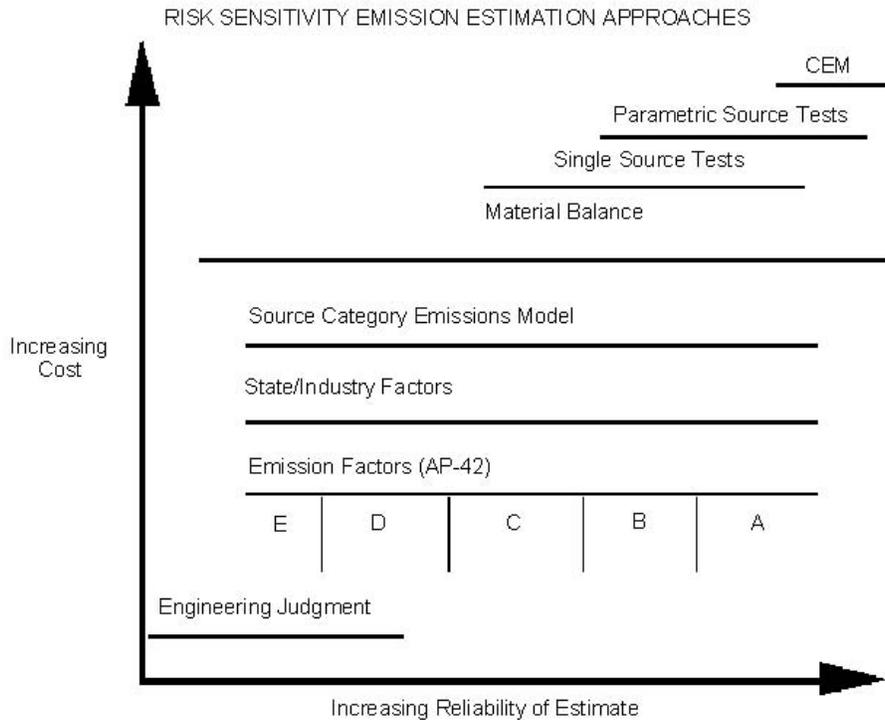


Figure 1. Approach to emission estimation.

Air pollution control devices also may cause differing emission characteristics. The design criteria of air pollution control equipment affect the resulting emissions. Design criteria include such items as the type of wet scrubber used, the pressure drop across a scrubber, the plate area of an electrostatic precipitator, and the alkali feed rate to an acid gas scrubber. Often, design criteria are not included in emission test reports (at least not in a form conducive to detailed analysis of how varying process parameters can affect emissions) and therefore may not be accounted for in the resulting factors.

Before simply applying AP-42 emission factors to predict emissions from new or proposed sources, or to make other source-specific emission assessments, the user should review the latest literature and technology to be aware of circumstances that might cause such sources to exhibit emission characteristics different from those of other, typical existing sources. Care should be taken to assure that the subject source type and design, controls, and raw material input are those of the source(s) analyzed to produce the emission factor. This fact should be considered, as well as the age of the information and the user's knowledge of technology advances.

Estimates of short-term or peak (e. g., daily or hourly) emissions for specific sources are often needed for regulatory purposes. Using emission factors to estimate short-term emissions will add further uncertainty to the emission estimate. Short-term emissions from a single specific source often vary significantly with time (i. e., within-source variability) because of fluctuations in process operating conditions, control device operating conditions, raw materials, ambient conditions, and other such factors. Emission factors generally are developed to represent long-term average emissions, so testing is usually conducted at normal operating conditions. Parameters that can cause short-term fluctuations in emissions are generally avoided in testing and are not taken into account in test evaluation. Thus, using emission factors to estimate short-term emissions will cause even greater

uncertainty. The AP-42 user should be aware of this limitation and should evaluate the possible effects on the particular application.

To assess within-source variability and the range of short-term emissions from a source, one needs either a number of tests performed over an extended period of time or continuous monitoring data from an individual source. Generally, material balance data are not likely to be sufficient for assessing short-term emission variability because the accuracy of a material balance is greatly reduced for shorter time intervals. In fact, one of the advantages of a material balance approach is that it averages out all of the short-term fluctuations to provide a good long-term average.

Pollutant Terminology And Conventions

The need for clearly and precisely defined terms in AP-42 should be evident to all. The factors in this document represent units of pollutants (or for ozone, precursors) for which there are National Ambient Air Quality Standards (NAAQS). These are often referred to as "criteria" pollutants. Factors may be presented also for HAPs ("hazardous" air pollutants designated in the *Clean Air Act*) and for other "regulated" and unregulated air pollutants. If the pollutants are organic compounds or particulate matter, additional species or analytical information may be needed for specific applications. It is often the case that the ideal measure of a pollutant for a specific application may not be available, or even possible, because of test method or data limitations, costs, or other problems. When such qualifications exist in AP-42, they will be noted in the document. If a pollutant is not mentioned in AP-42, that does not necessarily mean that the pollutant is not emitted.

Many pollutants are defined by their chemical names, which often may have synonyms and trade names. Trade names are often given to mixtures to obscure proprietary information, and the same components may have several trade names. For assurance of the use of the proper chemical identification, the Chemical Abstract Service (CAS) number for the chemical should be consulted along with the list of synonyms. Some pollutants, however, follow particular conventions when used in air quality management practices. The pollutant terminology and conventions currently used in AP-42 are discussed below.

Particulate Matter -

Terms commonly associated with the general pollutant, "particulate matter" (PM), include PM-10, PM-X, total particulate, total suspended particulate (TSP), primary particulate, secondary particulate, filterable particulate, and condensable particulate. TSP consists of matter emitted from sources as solid, liquid, and vapor forms, but existing in the ambient air as particulate solids or liquids. Primary particulate matter includes that solid, liquid, or gaseous material at the pressure and temperature in the process or stack that would be expected to become a particulate at ambient temperature and pressure. AP-42 contains emission factors for pollutants that are expected to be primary particulate matter. Primary particulate matter includes matter that may eventually revert to a gaseous condition in the ambient air, but it does not include secondary particulate matter. Secondary particulate matter is gaseous matter that may eventually convert to particulate matter through atmospheric chemical reactions. The term "total particulate" is used in AP-42 only to describe the emissions that are primary particulate matter. The term "Total PM-X" is used in AP-42 to describe those emissions expected to become primary particulate matter smaller than "X" micrometers (μm) in aerodynamic diameter. For example, "PM-10" is emitted particulate matter less than 10 μm in diameter. In AP-42, "Total Particulate" and "Total PM-X" may be divided into "Filterable Particulate", "Filterable PM-X", "Condensable Organic Particulate", and "Condensable Inorganic Particulate". The filterable portions include that material that is smaller than the stated size and is collected on the filter of the particulate sampling train.

Unless noted, it is reasonable to assume that the emission factors in AP-42 for processes that operate above ambient temperatures are for filterable particulate, as defined by EPA Method 5 or its equivalent (a filter temperature of 121°C (250°F)). The condensable portions of the particulate matter consist of vaporous matter at the filter temperature that is collected in the sampling train impingers and is analyzed by EPA Method 202 or its equivalent. AP-42 follows conventions in attempts to define Total Particulate and its subcomponents, filterable particulate, condensable particulate, and

PM-10 and their interrelationships. Because of test method and data limitations, this attempt may not always be successful, and some sources may not generate such components.

Because emission factors in AP-42 are usually based upon the results of emission test reports, and because Method 202 was only recently developed, AP-42 emission factors often may adequately characterize only in-stack filterable PM-10. Recent parts of the AP-42 series have used a clearer nomenclature for the various particulate fractions. It is reasonable to assume that, where AP-42 does not define the components of particulate clearly and specifically, the PM-10 factor includes only the filterable portion of the total PM-10. Therefore, an evaluation of potential condensable particulate emissions should be based upon additional data or engineering judgment.

As an additional convention, users should note that many hazardous or toxic compounds may be emitted in particulate form. In such cases, AP-42 factors for particulate matter represent the total, and factors for such compounds or elements are reported as mass of that material.

Organic Compounds -

Precursors of the criteria pollutant "ozone" include organic compounds. "Volatile organic compounds" (VOC) are required in a State Implementation Plan (SIP) emission inventory. VOCs have been defined by EPA (40 CFR 51.100, February 3, 1992) as "any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric chemical reactions". There are a number of compounds deemed to have "negligible photochemical reactivity", and these are therefore exempt from the definition of VOC. These exempt compounds include methane, ethane, methylene chloride, methyl chloroform, many chlorofluorocarbons, and certain classes of perfluorocarbons. Additional compounds may be added to the exempt list in the future.

Though the regulatory definition of VOC is followed in ozone control programs, the exempt organic compounds are of concern when developing the complete emission inventory that is needed for broader applications. Therefore, this document strives to report the total organic emissions and component species, so that the user may choose those that are necessary for a particular application. In many cases, data are not available to identify and quantify either all the components (such as some oxygenated compounds that are not completely measured by many common test methods), the total organics, or other variations of the quantities desired. In such cases, the available information is annotated in an effort to provide the data to the user in a clear and unambiguous manner. It is not always possible to present a complete picture with the data that are available.

The term "total organic compounds" (TOC) is used in AP-42 to indicate all VOCs and all exempted organic compounds including methane, ethane, chlorofluorocarbons, toxics and HAPs, aldehydes, and semivolatile compounds. Component species are separately identified and quantified, if data are available, and these component species are included in TOCs. Often, a test method will produce a data set that excludes methane. In such cases, the term total nonmethane organic compound (TNMOC) may be used. Here, methane will be separately quantified if the data are available. Factors are nominally given in terms of actual weight of the emitted substance. However, in some cases where data do not allow calculation of the result in this form, factors may be given "as methane", "as

propane", etc. Once the species distribution is determined, actual mass can be calculated based on molecular weight of each compound represented. In an AP-42 table giving organic emission factors, the ideal table headings would be:

TOC	Methane	Ethane	VOC	Other Species
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Many organic compounds are also HAPs. Where such species can be quantified, an emission factor representing their individual mass will be presented. This quantity will also be included in the total VOC and/or TOC factors, as appropriate. To avoid double counting regarding permit fees, etc., this fact should be taken into consideration.

Sulfur Dioxide -

The primary product from combustion of sulfur is sulfur dioxide, SO₂. However, other oxidation states are usually formed. When reported in this document, these compounds are jointly referred to as SO_x, or oxides of sulfur. SO₂ means sulfur dioxide, and SO_x means the combination of all such emissions reported on the basis of the molecular weight of SO₂.

Oxides Of Nitrogen -

The primary combustion product of nitrogen is nitrogen dioxide, NO₂. However, several other nitrogen compounds are usually emitted at the same time (nitric oxide or NO, nitrous oxide or N₂O, etc.), and these may or may not be distinguishable in available test data. They are usually in a rapid state of flux, with NO₂ being, in the short term, the ultimate product emitted or formed shortly downstream of the stack. The convention followed in AP-42 is to report the distinctions wherever possible, but to report total NO_x on the basis of the molecular weight of NO₂.

Lead -

Lead is emitted and measured as particulate and often will be reported for a process both separately and as a component of the particulate matter emission factor. The lead may exist as pure metal or as compounds. The convention followed in AP-42 is that all emissions of lead are expressed as the weight of the elemental lead. Lead compounds will also be reported on the basis of the weight of those compounds if the information is available.

Toxic, Hazardous, And Other Noncriteria Pollutants -

Hazardous Air Pollutants are defined for EPA regulatory purposes in Title III of the CAAA. However, many states and other authorities designate additional toxic or hazardous compounds, organic or inorganic, that can exist in gaseous or particulate form. Also, as mentioned, compounds emitted as VOCs may be of interest for their participation in photochemical reactivity. Few EPA Reference Test Methods exist for these compounds, which may come from the myriad sources covered in this document. However, test methods are available to allow reasonably reliable quantification of many compounds, and adequate test results are available to yield estimates of sufficient quality to be included in this document. Where such compounds are quantified herein with emission factors, they represent the actual mass of that compound emitted. Totals for PM or VOC, as appropriate, are inclusive of the component species unless otherwise noted. There are a limited number of gaseous hazardous or toxic compounds that may not be VOCs, and whenever they occur they will be identified separately.

The Emission Factor And Inventory Group produces a separate series of reports that focus on a number of the more significant HAPs and related sources. Titles of these documents generally follow the format of *Locating And Estimating Emissions From Sources Of . . . (Substance)*.

Examples Of Emission Factor Application -

Calculating carbon monoxide (CO) emissions from distillate oil combustion serves as an example of the simplest use of emission factors. Consider an industrial boiler that burns 90,000 liters of distillate oil per day. In Section 1.3 of AP-42, "Fuel Oil Combustion", the CO emission factor for industrial boilers burning distillate oil is 0.6 kilograms (kg) CO per 10³ liters of oil burned.

Then CO emissions

$$\begin{aligned} &= \text{CO emission factor} \times \text{distillate oil burned/day} \\ &= 0.6 \times 90 \\ &= \underline{54 \text{ kg/day}} \end{aligned}$$

In a more complex case, suppose a sulfuric acid (H₂SO₄) plant produces 200 Mg of 100 percent H₂SO₄ per day by converting sulfur dioxide (SO₂) into sulfur trioxide (SO₃) at 97.5 percent efficiency. In Section 8.10, "Sulfuric Acid", the SO₂ emission factors are listed according to SO₂-to-SO₃ conversion efficiencies in whole numbers. The reader is directed by footnote to an interpolation formula that may be used to obtain the emission factor for 97.5 percent SO₂-to-SO₃ conversion.

The emission factor for kg SO₂/Mg 100% H₂SO₄

$$\begin{aligned} &= 682 - [(6.82)(\% \text{ SO}_2\text{-to-SO}_3 \text{ conversion})] \\ &= 682 - [(6.82)(97.5)] \\ &= 682 - 665 \\ &= \underline{17 \text{ kg}} \end{aligned}$$

In the production of 200 Mg of 100 percent H₂SO₄ per day, SO₂ emissions are calculated thus:

$$\begin{aligned} \text{SO}_2 \text{ emissions} &= 17 \text{ kg SO}_2 \text{ emissions/Mg 100 percent H}_2\text{SO}_4 \times 200 \text{ Mg 100 percent} \\ &\quad \text{H}_2\text{SO}_4\text{/day} \\ &= \underline{3400 \text{ kg/day}} \end{aligned}$$

Emission Factor Ratings

Each AP-42 emission factor is given a rating from A through E, with A being the best. A factor's rating is a general indication of the reliability, or robustness, of that factor. This rating is assigned based on the estimated reliability of the tests used to develop the factor and on both the amount and the representative characteristics of those data. In general, factors based on many observations, or on more widely accepted test procedures, are assigned higher rankings. Conversely, a factor based on a single observation of questionable quality, or one extrapolated from another factor for a similar process, would probably be rated much lower. Because ratings are subjective and only indirectly consider the inherent scatter among the data used to calculate factors, the ratings should be seen only as approximations. AP-42 factor ratings do not imply statistical error bounds or confidence intervals about each emission factor. At most, a rating should be considered an indicator of the accuracy and precision of a given factor being used to estimate emissions from a large number of sources. This indicator is largely a reflection of the professional judgment of AP-42 authors and reviewers concerning the reliability of any estimates derived with these factors.

Because emission factors can be based on source tests, modeling, mass balance, or other information, factor ratings can vary greatly. Some factors have been through more rigorous quality assurance than others.

Two steps are involved in factor rating determination. The first step is an appraisal of data quality, the reliability of the basic emission data that will be used to develop the factor. The second step is an appraisal of the ability of the factor to stand as a national annual average emission factor for that source activity.

Test data quality is rated A through D, and ratings are thus assigned:

- A = Tests are performed by a sound methodology and are reported in enough detail for adequate validation.
- B = Tests are performed by a generally sound methodology, but lacking enough detail for adequate validation.
- C = Tests are based on an unproven or new methodology, or are lacking a significant amount of background information.
- D = Tests are based on a generally unacceptable method, but the method may provide an order-of-magnitude value for the source.

The quality rating of AP-42 data helps identify good data, even when it is not possible to extract a factor representative of a typical source in the category from those data. For example, the data from a given test may be good enough for a data quality rating of "A", but the test may be for a unique feed material, or the production specifications may be either more or less stringent than at the typical facility.

The AP-42 emission factor rating is an overall assessment of how good a factor is, based on both the quality of the test(s) or information that is the source of the factor and on how well the factor represents the emission source. Higher ratings are for factors based on many unbiased observations, or on widely accepted test procedures. For example, ten or more source tests on different randomly selected plants would likely be assigned an "A" rating if all tests are conducted using a single valid reference measurement method. Likewise, a single observation based on questionable methods of testing would be assigned an "E", and a factor extrapolated from higher-rated factors for similar processes would be assigned a "D" or an "E".

AP-42 emission factor quality ratings are thus assigned:

- A — Excellent. Factor is developed from A- and B-rated source test data taken from many randomly chosen facilities in the industry population. The source category population is sufficiently specific to minimize variability.
- B — Above average. Factor is developed from A- or B-rated test data from a "reasonable number" of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As with an A rating, the source category population is sufficiently specific to minimize variability.
- C — Average. Factor is developed from A-, B-, and/or C-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As with the A rating, the source category population is sufficiently specific to minimize variability.

- D — Below average. Factor is developed from A-, B- and/or C-rated test data from a small number of facilities, and there may be reason to suspect that these facilities do not represent a random sample of the industry. There also may be evidence of variability within the source population.
- E — Poor. Factor is developed from C- and D-rated test data, and there may be reason to suspect that the facilities tested do not represent a random sample of the industry. There also may be evidence of variability within the source category population.

Public Review Of Emission Factors

Since AP-42 emission factors may have effects on most aspects of air pollution control and air quality management including operating permit fees, compliance assessments, and SIP attainment emission inventories, these factors are always made available for public review and comment before publication. The Emission Factor And Inventory Group panel of public and peer reviewers includes representatives of affected industries, state and local air pollution agencies, and environmental groups. More information on AP-42 review procedures is available in the document, *Public Participation Procedures For EPA's Emission Estimation Guidance Materials*, EPA-454/R-94-022, July 1994. This publication is available on EFIG's *CHIEF* (Clearinghouse For Inventories And Emission Factors) electronic bulletin board (BB) and its *Fax CHIEF*, an automated facsimile machine. It is also available in conventional paper copy from the National Technical Information Service (NTIS). The Agency encourages all interested parties to take every opportunity to review factors and to provide information for factor quality improvement. Toward this objective, EFIG invites comments and questions about AP-42, and users are invited to submit any data or other information in accordance with this procedures document.

Other Ways To Obtain AP-42 Information And Updates

All or part of AP-42 can be downloaded either from the *CHIEF* BB or *Fax CHIEF*, and it is available on the *Air CHIEF* CD-ROM (Compact Disc - Read Only Memory). AP-42 is available in conventional paper copy from the Government Printing Office and NTIS, as well as through the *Fax CHIEF*.

The emission factors contained in AP-42 are available in the *Factor Information Retrieval System (FIRE)*. Also, software has been developed for emission models such as *TANKS*, *WATER7*, the *Surface Impoundment Modeling System (SIMS)*, and fugitive dust models. This software and the *FIRE* data base are available through the *CHIEF* BB. *FIRE* is also on the *Air CHIEF* compact disc. The *Fax CHIEF* and the *CHIEF* BB will always contain the latest factor information, as they are updated frequently, whereas *Air CHIEF*, the *FIRE* program, and printed AP-42 portions are routinely updated only once per year.

13.2.3 Heavy Construction Operations

13.2.3.1 General

Heavy construction is a source of dust emissions that may have substantial temporary impact on local air quality. Building and road construction are 2 examples of construction activities with high emissions potential. Emissions during the construction of a building or road can be associated with land clearing, drilling and blasting, ground excavation, cut and fill operations (i.e., earth moving), and construction of a particular facility itself. Dust emissions often vary substantially from day to day, depending on the level of activity, the specific operations, and the prevailing meteorological conditions. A large portion of the emissions results from equipment traffic over temporary roads at the construction site.

The temporary nature of construction differentiates it from other fugitive dust sources as to estimation and control of emissions. Construction consists of a series of different operations, each with its own duration and potential for dust generation. In other words, emissions from any single construction site can be expected (1) to have a definable beginning and an end and (2) to vary substantially over different phases of the construction process. This is in contrast to most other fugitive dust sources, where emissions are either relatively steady or follow a discernable annual cycle. Furthermore, there is often a need to estimate areawide construction emissions, without regard to the actual plans of any individual construction project. For these reasons, following are methods by which either areawide or site-specific emissions may be estimated.

13.2.3.2 Emissions And Correction Parameters

The quantity of dust emissions from construction operations is proportional to the area of land being worked and to the level of construction activity. By analogy to the parameter dependence observed for other similar fugitive dust sources,¹ one can expect emissions from heavy construction operations to be positively correlated with the silt content of the soil (that is, particles smaller than 75 micrometers [μm] in diameter), as well as with the speed and weight of the average vehicle, and to be negatively correlated with the soil moisture content.

13.2.3.3 Emission Factors

Only 1 set of field studies has been performed that attempts to relate the emissions from construction directly to an emission factor.¹⁻² Based on field measurements of total suspended particulate (TSP) concentrations surrounding apartment and shopping center construction projects, the approximate emission factors for construction activity operations are:

$$E = 2.69 \text{ megagrams (Mg)/hectare/month of activity}$$

$$E = 1.2 \text{ tons/acre/month of activity}$$

These values are most useful for developing estimates of overall emissions from construction scattered throughout a geographical area. The value is most applicable to construction operations with: (1) medium activity level, (2) moderate silt contents, and (3) semiarid climate. Test data were not sufficient to derive the specific dependence of dust emissions on correction parameters. Because the above emission factor is referenced to TSP, use of this factor to estimate particulate matter (PM) no greater than 10 μm in aerodynamic diameter (PM-10) emissions will result in conservatively high

estimates. Also, because derivation of the factor assumes that construction activity occurs 30 days per month, the above estimate is somewhat conservatively high for TSP as well.

Although the equation above represents a relatively straightforward means of preparing an areawide emission inventory, at least 2 features limit its usefulness for specific construction sites. First, the conservative nature of the emission factor may result in too high an estimate for PM-10 to be of much use for a specific site under consideration. Second, the equation provides neither information about which particular construction activities have the greatest emission potential nor guidance for developing an effective dust control plan.

For these reasons, it is strongly recommended that when emissions are to be estimated for a particular construction site, the construction process be broken down into component operations. (Note that many general contractors typically employ planning and scheduling tools, such as critical path method [CPM], that make use of different sequential operations to allocate resources.) This approach to emission estimation uses a unit or phase method to consider the more basic dust sources of vehicle travel and material handling. That is to say, the construction project is viewed as consisting of several operations, each involving traffic and material movements, and emission factors from other AP-42 sections are used to generate estimates. Table 13.2.3-1 displays the dust sources involved with construction, along with the recommended emission factors.³

In addition to the on-site activities shown in Table 13.2.3-1, substantial emissions are possible because of material tracked out from the site and deposited on adjacent paved streets. Because all traffic passing the site (i. e., not just that associated with the construction) can resuspend the deposited material, this "secondary" source of emissions may be far more important than all the dust sources actually within the construction site. Furthermore, this secondary source will be present during all construction operations. Persons developing construction site emission estimates must consider the potential for increased adjacent emissions from off-site paved roadways (see Section 13.2.1, "Paved Roads"). High wind events also can lead to emissions from cleared land and material stockpiles. Section 13.2.5, "Industrial Wind Erosion", presents an estimation methodology that can be used for such sources at construction sites.

13.2.3.4 Control Measures⁴

Because of the relatively short-term nature of construction activities, some control measures are more cost effective than others. Wet suppression and wind speed reduction are 2 common methods used to control open dust sources at construction sites, because a source of water and material for wind barriers tend to be readily available on a construction site. However, several other forms of dust control are available.

Table 13.2.3-2 displays each of the preferred control measures, by dust source.³⁻⁴ Because most of the controls listed in the table modify independent variables in the emission factor models, the effectiveness can be calculated by comparing controlled and uncontrolled emission estimates from Table 13.2.3-1. Additional guidance on controls is provided in the AP-42 sections from which the recommended emission factors were taken, as well as in other documents, such as Reference 4.

Table 13.2.3-1. RECOMMENDED EMISSION FACTORS FOR CONSTRUCTION OPERATIONS^a

Construction Phase	Dust-generating Activities	Recommended Emission Factor	Comments	Rating Adjustment ^b
I. Demolition and debris removal	1. Demolition of buildings or other (natural) obstacles such as trees, boulders, etc.			
	a. Mechanical dismemberment ("headache ball") of existing structures	NA		—
	b. Implosion of existing structures	NA		—
	c. Drilling and blasting of soil	Drilling factor in Table 11.9-4 Blasting factor NA		-1
	d. General land clearing	Dozer equation (overburden) in Tables 11.9-1 and 11.9-2	Blasting factor in Tables 11.9-1 and 11.9-2 not considered appropriate for general construction activities	NA -1/-2 ^c
	2. Loading of debris into trucks	Material handling emission factor equation in Section 13.2.4		-0/-1 ^c
	3. Truck transport of debris	Unpaved road emission factor in Section 13.2.2, or paved road emission factor in Section 13.2.1		-0/-1 ^c
	4. Truck unloading of debris	Material handling emission factor equation in Section 13.2.4	May occur offsite	-0/-1 ^c

Table 13.2.3-1 (cont.).

Construction Phase	Dust-generating Activities	Recommended Emission Factor	Comments	Rating Adjustment ^b
II. Site Preparation (earth moving)	1. Bulldozing	Dozer equation (overburden) in Tables 11.9-1 and 11.9-2		-1/-2 ^c
	2. Scrapers unloading topsoil	Scraper unloading factor in Table 11.9-4		-1
	3. Scrapers in travel	Scraper (travel mode) expression in Tables 11.9-1 and 11.9-2		-0/-1 ^c
	4. Scrapers removing topsoil	5.7 kg/vehicle kilometer traveled (VKT) (20.2 lb/vehicle mile traveled [VMT])		E ^d
	5. Loading of excavated material into trucks	Material handling emission factor equation in Section 13.2.4		-0/-1 ^c
	6. Truck dumping of fill material, road base, or other materials	Material handling emission factor equation in Section 13.2.4	May occur offsite	-0/-1 ^c
	7. Compacting	Dozer equation in Tables 11.9-1 and 11.9-2	Emission factor downgraded because of differences in operating equipment	-1/-2 ^c
	8. Motor grading	Grading equation in Tables 11.9-1 and 11.9-2		-1/-2 ^c

Table 13.2.3-1 (cont.).

Construction Phase	Dust-generating Activities	Recommended Emission Factor	Comments	Rating Adjustment ^b
III. General Construction	1. Vehicular traffic	Unpaved road emission factor in Section 13.2.2, or paved road emission factor in Section 13.2.1		-0/-1 ^c -0/-1 ^c
	2. Portable plants			
	a. Crushing	Factors for similar material/operations in Section 11.19.2		-1/-2 ^c
	b. Screening	Factors for similar material/operations in Section 11.19.2		-1/-2 ^c
	c. Material transfers	Material handling emission factor equation in Section 13.2.4		-0/-1 ^c
3. Other operations	Factors for similar material/operations in the Mineral Products Industry, Chapter 11 of this document		—	

^a NA = not applicable.

^b Refers to how many additional letters the emission factor should be downrated (beyond the guidance given in the other sections of AP-42) for application to construction activities. For example, "-2" means that an A-rated factor should be considered of C quality in estimating construction emissions. All emission factors assumed to have site-specific input values; otherwise, additional downgrading of one letter should be employed. Note that no rating can be lower than E.

^c First value for cases with independent variables within range given in AP-42 section; second value for cases with at least 1 variable outside the range.

^d Rating for emission factor given. Reference 5.

^e In the event that individual operations cannot be identified, one may very conservatively overestimate PM-10 emissions by using Equation 1.

Table 13.2.3-2. CONTROL OPTIONS FOR GENERAL CONSTRUCTION
OPEN SOURCES OF PM-10

Emission Source	Recommended Control Method(s)
Debris handling	Wind speed reduction Wet suppression ^a
Truck transport ^b	Wet suppression Paving Chemical stabilization ^c
Bulldozers	Wet suppression ^d
Pan scrapers	Wet suppression of travel routes
Cut/fill material handling	Wind speed reduction Wet suppression
Cut/fill haulage	Wet suppression Paving Chemical stabilization
General construction	Wind speed reduction Wet suppression Early paving of permanent roads

^a Dust control plans should contain precautions against watering programs that confound trackout problems.

^b Loads could be covered to avoid loss of material in transport, especially if material is transported offsite.

^c Chemical stabilization usually cost-effective for relatively long-term or semipermanent unpaved roads.

^d Excavated materials may already be moist and not require additional wetting. Furthermore, most soils are associated with an "optimum moisture" for compaction.

References For Section 13.2.3

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