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MEXICO EMISSIONS INVENTORY PROGRAM MANUALS

VOLUME IV - POINT SOURCE INVENTORY DEVELOPMENT

Prepared for:

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PREFACE

Air pollution can negatively impact public health when present in the atmosphere in sufficient quantities. Most rural areas rarely experience air quality problems, while elevated concentrations of air pollution are commonly found in many urban environments. Recently, urbanization and industrial activity throughout Mexico has increased, resulting in air quality concerns for several regions.

Air pollution results from a complex mix of, literally, thousands of sources, from industrial smoke stacks and motor vehicles, to the individual use of grooming products, household cleaners, and paints. Even plant and animal life can play an important role in the air pollution problem. Due to the complex nature of air pollution, detailed regional plans are needed to identify the emission sources and to develop methods for reducing the health impact from exposure to air pollution. Examples of air quality planning activities include:

- Application of air quality models;
- Examination of the sources emitting air pollution for emissions control analysis, where necessary;
- Development of emission projections to examine possible changes in future air quality;
- Analysis of emission trends; and
- Analysis of emissions transport from one region to another.

Development of fundamentally sound emissions inventories is a key aspect for each of these air quality planning functions.

Developing emission estimates to meet air quality planning needs requires continual development and refinement; “one time” inventory efforts are not conducive to the air quality planning process. For lasting benefit, an *inventory program* must be implemented so that accurate emission estimates can be developed for all important geographic regions, refined over time, and effectively applied in the air quality planning and monitoring process. Therefore, a set of inventory manuals is being developed that can be used throughout the country to help coordinate the development of consistent emission estimates. These manuals are intended for use by local, state, and federal staff, as well as by industry and private consultants. The purpose of these manuals is to assist in implementing the inventory program and in maintaining that program over time so that emissions inventories can be developed in periodic cycles and continually improved.

The manuals cover inventory program elements such as estimating emissions, program planning, database management, emissions validation, and other important topics. Figure 1 shows the complete series of manuals that will be developed to support a comprehensive inventory program. The main purpose of each manual is summarized below.

Volume I—Emissions Inventory Program Planning. This manual addresses the important planning issues that must be considered in an air emissions inventory program. Program planning is discussed not as an “up-front” activity, but rather as an ongoing process to ensure the long-term growth and success of an emissions inventory program. *Key Topics*: program purpose, inventory end uses, regulatory requirements, coordination at federal/state/local levels, staff and data management requirements, identifying and selecting special studies.

Volume II—Emissions Inventory Fundamentals. This manual presents the basic fundamentals of emissions inventory development and discusses inventory elements that apply to multiple source types (e.g., point and area) to avoid the need for repetition in multiple volumes. *Key Topics*: applicable regulations, rule effectiveness, rule penetration, pollutant

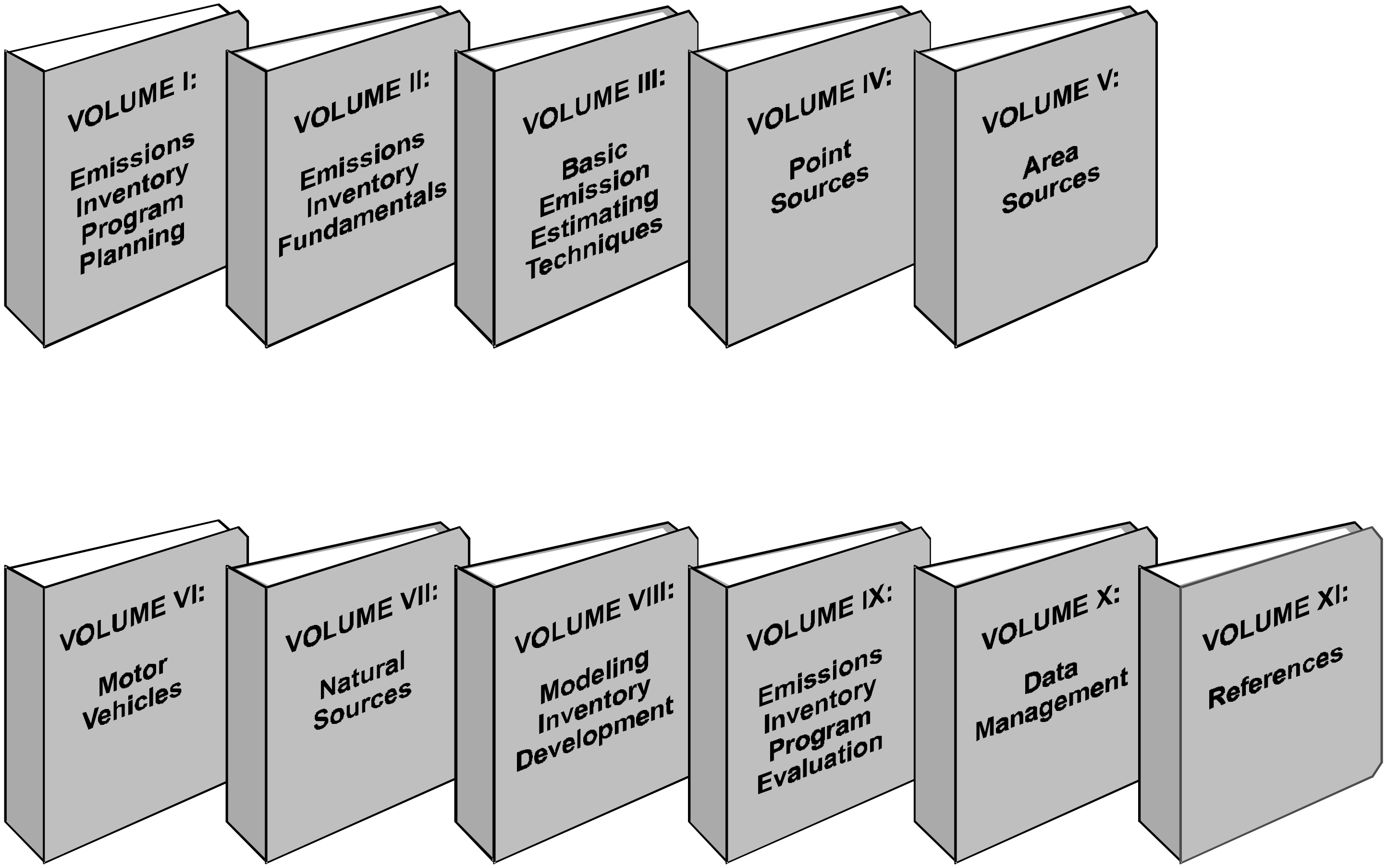

Figure 1. Mexico Emissions Inventory Program Manuals

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Figure 1

definitions (e.g., how to properly exclude nonreactive volatile compounds), point/area source delineation, point/area source reconciliation.

Volume III—Emissions Inventory Development: Basic Emission Estimating Techniques (EETs). This manual presents the basic EETs used to develop emission estimates, including examples and sample calculations. Inventory tools associated with each methodology are identified and included in Volume XI (References). *Key Topics*: source sampling, emissions models, surveying, emission factors, material balance, extrapolation.

Volume IV—Point Sources. This manual provides guidance for developing the point source emissions inventory. A cross-reference table is provided for each industry/device type combination (e.g., petroleum refining/combustion devices) with one or more of the basic EETs presented in Volume III. *Key Topics*: cross-reference table, stack parameters, control devices, design/process considerations, geographic differences and variability in Mexico, quality assurance/quality control (QA/QC), overlooked processes, data references, data collection forms.

Volume V—Area Sources (includes non-road mobile). This manual provides guidance for developing the area source emissions inventory. After the presentation of general area source information, a table is provided to cross-reference each area source category (e.g., asphalt application) with one or more of the basic EETs presented in Volume III. Then, source category-specific information is discussed for each source category defined in the table. *Key Topics*: area source categorization and definition, cross-reference table, control factors, geographic differences and variability in Mexico, QA/QC, data references, data collection forms (questionnaires).

Volume VI—Motor Vehicles. Because motor vehicles are inherently different from point and area sources, the available estimation methods and required data are also different. To estimate emissions from these complex sources, models are the preferred estimation tool. Many of these models utilize extensive test data applicable to a given country or region. This manual focuses primarily on the data development phase of estimating motor vehicle emissions. *Key Topics*: available estimation methods, primary/secondary/tertiary data and information, source categorization, emission factor sources, geographic variability within Mexico, QA/QC.

Volume VII—Natural Sources. This manual provides guidance for developing a natural source emissions inventory (i.e., biogenic volatile organic compounds [VOC] and soil oxides of nitrogen [NO_x]). In addition, this manual includes the theoretical aspects of emission calculations and discussion of specific models. *Key Topics*: source categorization and definition, emission mechanisms, basic emission algorithms, biomass determination, land use/land cover data development, temporal and meteorological adjustments, emission calculation approaches.

Volume VIII—Modeling Inventory Development. This manual provides guidance for developing inventory data for use in air quality models and addresses issues such as temporal allocation, spatial allocation, speciation, and projection of emission estimates. *Key Topics*: definition of modeling terms, seasonal adjustment, temporal allocation, spatial allocation, chemical speciation, projections (growth and control factors).

Volume IX—Emissions Inventory Program Evaluation. This manual consists of three parts: QA/QC, uncertainty analysis, and emissions verification. The QA/QC portion defines the overall QA/QC program and is written to complement source specific QA/QC procedures written into other manuals. The uncertainty analysis includes not only methods of assessing uncertainty in emission estimates, but also for assessing uncertainty in modeling values such as speciation profiles and emission projection factors. The emissions verification section describes various analyses that can be performed to examine the accuracy of the emission estimates. Examples include receptor modeling and trajectory analysis combined with specific data analysis techniques. *Key Topics*: description of concepts and definition of terms, inventory review protocol, completeness review, accuracy review, consistency review, recommended uncertainty EETs, applicable emission verification EETs.

Volume X—Data Management. This manual addresses the important needs associated with the data management element of the Mexico national emission inventory program. *Key Topics*: general-purpose data management systems and tools, specific-purpose software systems and tools, coding system, confidentiality, electronic submittal, frequency of updates, recordkeeping, Mexico-specific databases, reports.

Volume XI—References. This manual is a compendium of tools that can be used in emission inventory program development. Inventory tools referenced in the other manuals are included (i.e., hardcopy documents, electronic documents, and computer models).

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ACRONYMS

BBS	bulletin board system
Btu	British thermal unit
CAD	computer aided design
CD	control device
CEM	continuous emissions monitor
CHIEF	Clearing House for Inventories and Emission Factors
CO	carbon monoxide
dscfm	dry standard cubic feet per minute
dscm	dry standard cubic meter
DQI	data quality indicator
DQO	data quality objective
EET	emissions estimating techniques
EIIP	Emission Inventory Improvement Program
EP	emission point
ESP	electrostatic precipitators
EU	emission unit
FGR	flue gas recirculation
FIRE	Factor Information Retrieval System
GPS	global positioning system
hr	hour

INE	National Institute of Ecology
INEGI	Instituto Nacional de Estadística, Geografía e Informática
kg	kilogram
km	kilometer
L	liter
lb	pound
LEVD	Low Emission Vapor Degreaser
LPG	liquefied petroleum gas
m^3	cubic meter
Mg	megagram (i.e., 10^6g = 1 metric tonne)
mg	milligram
MW	molecular weight
NH_3	ammonia
NO_x	oxides of nitrogen
O_2	oxygen
OFA	overfire air
PM	particulate matter
PM_{10}	particulate matter of less than 10 microns
ppbv	parts per billion by volume
ppmv	parts per million by volume
psig	pounds per square inch - gauge
QA	quality assurance

QC	quality control
SNIFF	National Information System of Point Sources
SO_2	sulfur dioxide
SO_3	sulfur trioxide
SO_x	oxides of sulfur
SCC	Source Classification Code
ton	English ton (i.e., 2,000 lbs)
tonne	metric ton (i.e., 1,000 kg)
TSDF	treatment, storage, and disposal facility
UNAM	National Meteorological and Atmospheric Science Center at the National University
U.S.	United States
U.S. EPA	United States Environmental Protection Agency
UTM	universal transverse mercator
VOC	volatile organic compound

1.0 INTRODUCTION

Article 17 from the *Regulation of the General Law for the Ecological Equilibrium and Environmental Protection on Air Pollution Control and Prevention (Reglamento de la Ley General de Equilibrio Ecológico y la Protección al Ambiente en Materia de Prevención y Control de la Contaminación de la Atmósfera)* states that "entities responsible for the stationary sources of federal jurisdiction must present an inventory including their polluting emissions into the atmosphere." Article 112 from the *General Law for the Ecological Equilibrium and Environmental Protection (Reglamento de la Ley General de Equilibrio Ecológico y la Protección al Ambiente)* establishes that county and state governments must create and continuously update the emissions inventory, as well as prevent and control atmospheric pollution in their jurisdiction, including area, anthropogenic and other emission sources.

A series of documents is being prepared that will establish standard procedures for the preparation of point, area, mobile, and natural source emission inventories. The purpose of these documents is to provide cost-effective, reliable methods for developing inventories and improving the quality of emissions data collected and reported. These documents will also provide guidance on how to collect complete and accurate information on process technologies and air pollution control methods. The use of these standardized procedures will promote consistency in these activities among the emissions inventory reporting groups.

The emissions inventory procedures presented in this volume are specific to point sources. Point sources include facilities, plants, or activities for which individual source records are maintained in the inventory database. Volume IV is intended to familiarize the industrial sector and the federal, state, and municipal agencies with the basic concepts involved in preparing a point source emissions inventory. Volume III, *Basic Emission Estimating*

Techniques, provides an introduction to air pollutant emission estimation techniques and presents detailed examples to aid the reader in actual emission calculations.

Figure 1-1 illustrates the general point source development process and cross references these activities to the appropriate sections of this document. The National Institute of Ecology’s (INE) point source inventory development process, included as Appendix IV-A, shows that INE sometimes may accept responsibility for the emission calculations if they are not provided or well-documented by the facilities.

The remainder of this manual is organized as follows:

- Section 2.0 covers two important issues that must be addressed before getting started: the definition of a “point source” and the level of detail of the inventory.
- Section 3.0 includes brief descriptions of basic methodologies recommended for estimating emissions from point sources. Pollutant and emission source information is also included to assist the reader in selecting an appropriate technique for estimating point source emissions. Appendix IV-B provides useful conversion factors.
- Section 4.0 describes design and process considerations that could influence emissions (e.g., fuel characteristics or operating parameters) and also presents some point sources that are typically overlooked during inventory development. Appendix IV-C provides information about procedures and approaches for estimating emissions from fugitive component equipment leaks.
- Section 5.0 presents typical control device types and efficiencies.
- Section 6.0 describes the importance of reporting accurate stack parameter information within the inventory for use in developing modeling inventories.

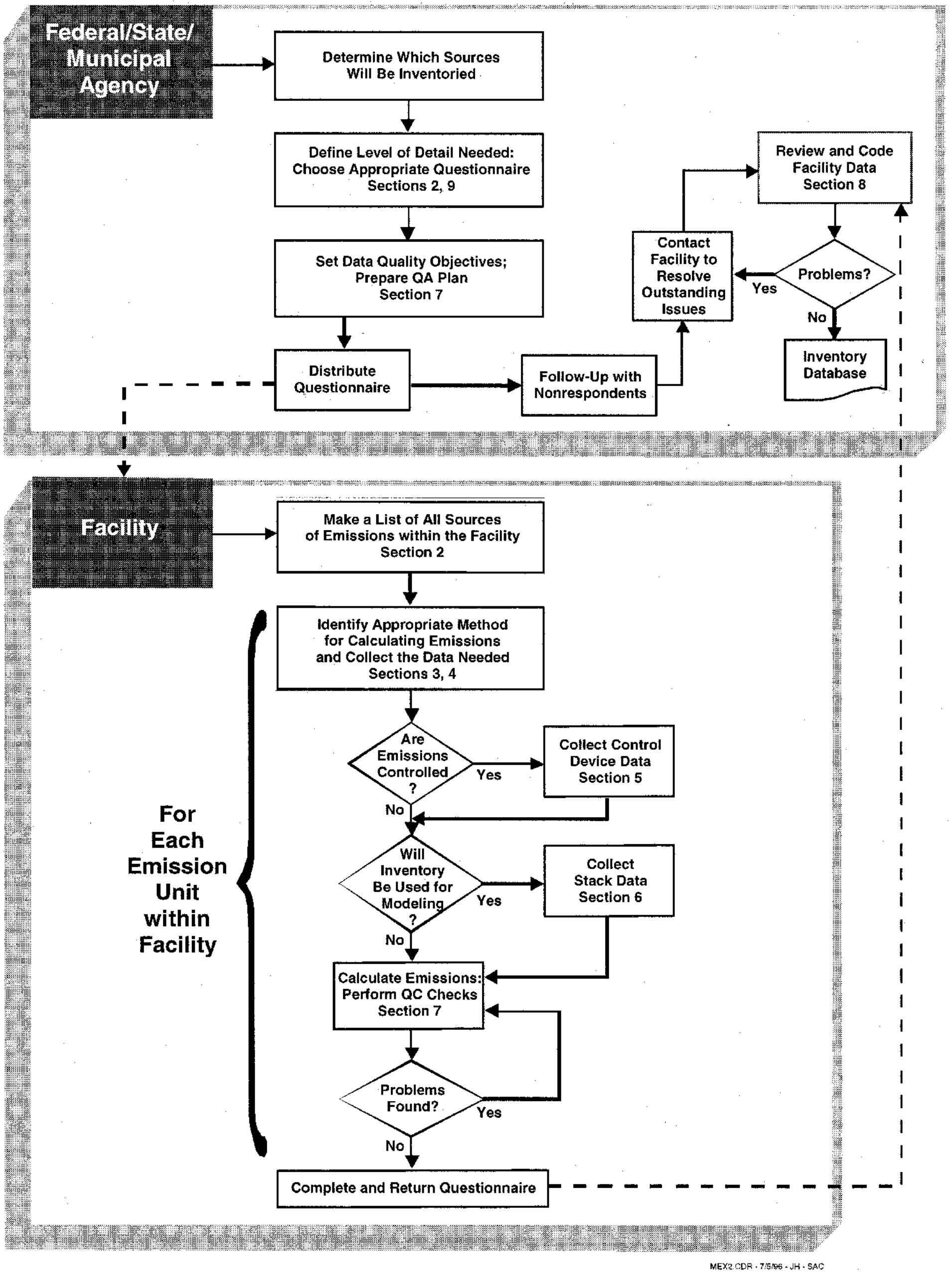

Figure 1-1. Point Source Inventory Development Process

- Section 7.0 discusses quality assurance/quality control (QA/QC) procedures. Data Quality Objectives (DQOs) for inventories are discussed as well as the methods for achieving these goals. An example QC checklist to aid the inventory preparer is included in Appendix IV-D.

- Section 8.0 describes available data coding procedures that should be used in the inventory to ensure that the data are reportable, manageable, and retrievable. Appendix IV-E provides a list and descriptions of source classification codes.

- Section 9.0 explains data collection procedures. INE’s existing industrial questionnaire and source-specific example data collection forms are included in Appendices IV-F and IV-G.

- Section 10.0 lists the references used to develop this document.

2.0 GETTING STARTED

The primary purpose of an air emissions inventory is to provide information to allow federal, state, and municipal air pollution control agencies to plan emissions control strategies and to manage air quality. The emissions inventory over time can be an indicator of changes in the air quality. Inventory areas are generally defined by political boundaries (e.g., municipalities and state boundaries).

Before beginning to develop a point source inventory, two important decisions must be made. First, a “point source” must be clearly defined (i.e., a point/area source delineation must be established). Second, the desired level of detail must be determined.

2.1 Point Source Definition

The division of sources of emissions into “point” and “area” sources is arbitrary but necessary to allow for the efficient collection of information needed to support air quality programs. This division has important implications for both the development of regulatory programs and the amount and type of information needed to support those programs.

Detailed information on every “point” at which emissions are discharged to the atmosphere is desirable. While this would allow a detailed understanding of the characteristics of each such point, there is no practical way that such information can be collected. An alternative approach is to collect information on a much simpler basis by aggregating related sources (e.g., all automobiles, all bakeries) into a single “area source.” The definition of point/area sources that specifies this division is thus a tradeoff between the needs of regulatory programs and the resources available to support the data requirements of those programs.

Treating all facilities as point sources may increase the accuracy of the inventory, but will require substantially more resources to compile and maintain the point source inventory.

In Mexico, point sources are defined in Article 6 of the *General Law for the Ecological Equilibrium and Environmental Protection* as any facility that is established in one place only, with the purpose of developing industrial or commercial processes, service works, or activities that generate or can generate air pollutant emissions.

"Fuente fija. Es toda instalación establecida en un solo lugar, que tenga como finalidad desarrollar operaciones o procesos industriales, comerciales, de servicios o actividades que generen o puedan generar emisiones contaminantes a la atmósfera."

As indicated in Article 11 of the *Regulation of the General Law for the Ecological Equilibrium and Environmental Protection on Air Pollution Control and Prevention* and Article 29 of the *General Law for the Ecological Equilibrium and Environmental Protection*, all sources of Federal jurisdiction are point sources. Sources of Federal jurisdiction include:

- All facilities, projects, or activities (industrial, commercial, or service) conducted by Federal Public Administration entities;
- Government controlled industries;
- Facilities located in the Federal District adjoining zone;
- Certain private industries (i.e., asbestos, chemical, petrochemical, iron and steel, paper, sugar, drink and beverage, cement, automobile, and electricity generation and transmission); and

- Sources affecting the ecological equilibrium in an adjoining state or country.

These facilities must solicit a permit to operate through the Secretary (SEMARNAP). In addition, they must annually submit emission estimates for the facility.

Certain companies that have a microindustry certificate may be exempt from the licensing and operating certificate requirements for point sources if their activities are exempted in the *Agreement by which Point sources considered to be Small Businesses (microindustries) in Terms of the Law of the matter Published 17 May 1990 are Exempted from the Requirement of obtaining an Operating License (el Acuerdo por el que se Exceptúan del Trámite para la Obtención de la Licencia de Funcionamiento, a las Fuentes Fijas consideradas como Empresas Microindustriales en los Términos de la Ley en la materia publicado el 17 de Mayo de 1990).*

Point sources could be specified in a number of other ways. These include defining a point source as follows (with all other sources included as area):

- Source of a given type (e.g., Fluidized Catalytic Cracking unit) or type <u>and</u> size (e.g., boiler with heat input > 10,000 British thermal unit [Btu]/hr);
- Source that emits more than a specific amount of emissions determined on some consistent basis;
- Every source (regardless of type, size or emissions) that is located in a facility of a given type (e.g., petroleum refinery) or type <u>and</u> size (e.g., steel foundry with steel production more than 1,000 tons/year); and
- Every source (regardless of type, size or emissions) that is located in a facility with more than a specified amount of emissions determined on some consistent basis.

Examples of a consistent basis for determining the amount of emissions includes actual (what was actually emitted in some prior time period), allowable (the maximum that could be emitted under regulatory limits), and potential (what would be emitted if operated full time without control equipment). In addition, these definitions can vary by regulatory region to account for different levels of severity of the air quality problem and/or the stringency of the regulatory program.

As an example, a specific basis has been set in the United States for areas that exceed the ozone and carbon monoxide ambient standards. In these areas, if a facility emits more than 100 tons per year of oxides of nitrogen (NO_x) or carbon monoxide (CO), or 10 tons per year of volatile organic compound (VOC), it must be included in the point source inventory. Individual states are encouraged to inventory sources below these cutoffs on an individual point basis. The decision to set a lower cutoff depends on a number of local factors, usually available resources to obtain and manage the data.

Environmental programs in the United States have often used the last definition (i.e., facility-wide emission thresholds) based on potential emissions. These sources are regulatorily defined as “stationary sources” and are subject to more stringent regulations than sources that emit less. The United States Environmental Protection Agency (U.S. EPA) has carried this regulatory definition into the realm of data management. U.S. EPA requires that state agencies submit data on the regulatory-defined stationary sources as “point sources,” all data on the remaining facilities must be submitted in aggregated form as “area sources.”

As the Mexico emissions inventory program evolves, the point source definition may be modified to add new significant sources that are identified or to eliminate insignificant sources. Again, the goal is to maximize the overall accuracy of the comprehensive emissions inventory (i.e., point, area, motor vehicle, and nature sources) within the allotted amount of resources available.

2.2 Level of Detail

Information on point sources is usually gathered by surveys. An example of point source surveying is shown in Figure 2-1. Point sources can be inventoried at the following three levels of detail (which are illustrated in Figure 2-2):

- Plant level, which denotes a plant or facility that could contain several pollutant-emitting activities;
- Point/stack level, where emissions to the ambient air occur; and
- Process/segment level, representing the emission unit operations of a source category.

The specific issues pertaining to each level are listed below. Whenever possible, emissions should be inventoried at the process/segment level in order to be able to support air quality activities such as regulation, compliance, and permitting. For example, identifying the processes and devices to which a future regulation might apply and then estimating the impact (i.e., costs and benefits) of that regulation would typically require estimating emissions for each process/device.

Another equally important reason for collecting data at this level of detail is that it provides the agency with the information required to verify the emissions estimates provided by the facility operators.

2.2.1 Plant Level

In a plant-level survey, the following issues apply:

- Each plant within the area should be identified and assigned a unique plant identification number (Refer to Section 8.0 of this document for information on assigning plant identification numbers);

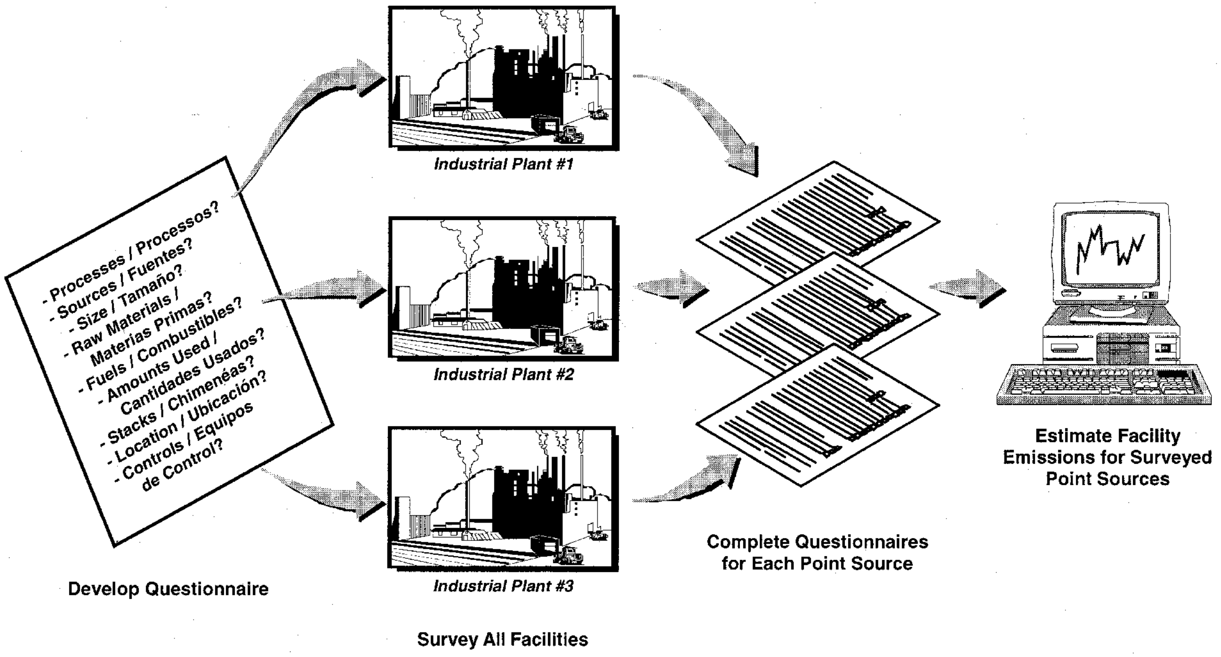

Figure 2-1. Example of Point Source Surveying

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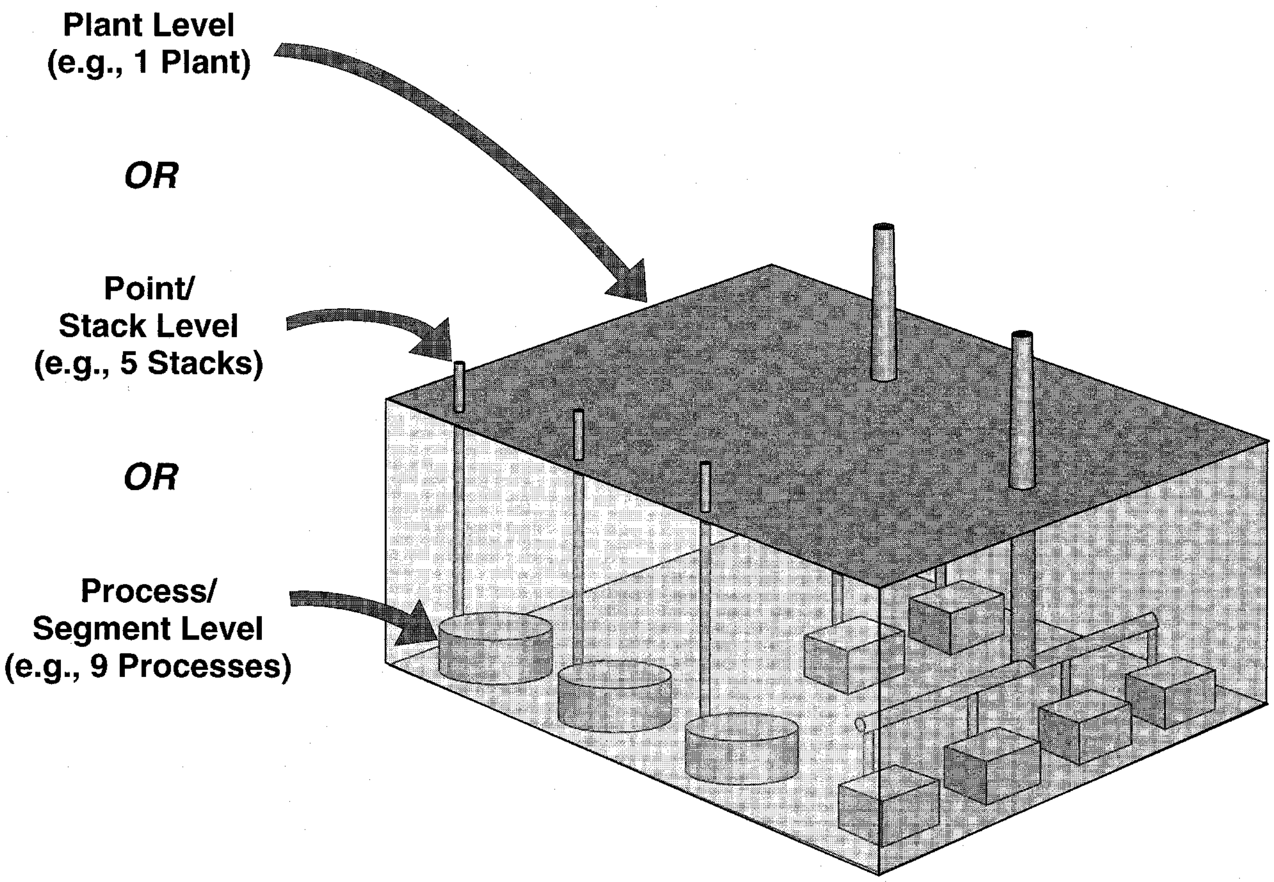

Figure 2-2. Different Point Source Inventory Levels

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- The plant should be further identified by geographic descriptors such as state, municipality, street and/or mailing address, and universal transverse mercator (UTM) map coordinates, or latitude/longitude (see Section 6.1); and

- A plant contact should be identified to facilitate communication and interaction with the plant.

2.2.2 Point/Stack Level

In a point/stack-level survey, the following issues apply:

- Each stack, vent, or other point of emission should be identified as an emission point within a plant;

- Each stack, vent or other point of emission should receive a unique identification number within the inventory (see Chapter 8.0 of this document); and

- The following information should be recorded for each emission point in a comprehensive inventory, as well as for modeling programs:

    - Location (latitude/longitude or UTM coordinates; see Section 6.1 of this document);

    - Height of the emission point (see Section 6.2 of this document);

    - Diameter of the emission point (see Section 6.3 of this document);

    - Emission rate;

    - Gas exit temperature (see Section 6.4 of this document); and

    - Gas exit velocity (see Section 6.5 of this document) or volumetric flow rate (see Section 6.6 of this document) from the emission point.

2.2.3 Process/Segment Level

A plant may include various processes or operations. The information necessary to establish an inventory at this level includes the following:

- Process identification information;
- Process level data (e.g., raw materials, process streams, and products properties);
- Operating rate data, including actual, maximum, and design operating rate or capacity;
- Fuel use and properties data (ash, sulfur, trace elements, heat content, etc.);
- Identification of all air pollution control equipment and their associated collection and control efficiencies (measured or design);
- Identification of the estimation method or reference used to develop each emissions estimate; and
- Final products information.

3.0 RECOMMENDED EMISSIONS ESTIMATION TECHNIQUES

This section presents a brief overview of the primary emission estimating techniques (EETs) applicable to point sources:

- Emission factors;
- Source tests;
- Material balance; and
- Emissions models.

For a more detailed description of these methods, please refer to Volume III: *Basic Emission Estimating Techniques*.

Following these descriptions, an Emission Estimation Technique Cross-Reference Table shows which EETs are recommended for the types of point sources commonly associated with various industrial sectors. Appendix IV-B of this manual contains conversion factors which may be useful when performing air emission calculations.

3.1 Emission Factors

An emission factor is a ratio that relates the quantity of pollutant released to the atmosphere to the activity level associated with the release of that pollutant. The activity level may be a production rate or a quantity of fuel burned, for example. If the emission factor and the corresponding activity level for a process are known, an estimate of the emissions can be produced. The use of emission factors is straightforward when the relationship between process data and emissions is direct and relatively uncomplicated. It should be noted that the use of facility-specific emission factors is preferred over the use of industry-averaged data. However, depending upon available resources, obtaining facility-specific data may not be cost effective. Figure 3-1 illustrates examples of emission factor units and applications.

One of the primary references for criteria pollutant emission factors for industrial sources is *AP-42*, which also contains emission factors for a limited number of toxic organic and inorganic pollutants (U.S. EPA, 1995a). An electronic database of emission factors can be found in the Factor Information Retrieval (FIRE) System, which contains the same criteria pollutant emission factors as *AP-42* (U.S. EPA, 1995b). In addition, toxic pollutant emission factors are presented for many source types. The FIRE system is available in electronic format from the Clearinghouse for Inventories and Emission Factors (CHIEF) Bulletin Board System (BBS), 95-919-541-5742. The FIRE system as well as *AP-42* may also be obtained from the Air CHIEF CD-ROM which can be requested through the Info CHIEF telephone line, 95-919-541-5285.

In order to calculate emissions using factors, various inputs to the estimation algorithm are required:

- Activity information for the process as specified by the relevant emission factor;
- Emission factors to translate activity information into uncontrolled or controlled emission estimates; and
- Capture and control device efficiencies if using an uncontrolled emission factor (“controlled” emission factors already take this into account).

The basic emission estimation algorithm for using an uncontrolled emission factor when a control device is in place is:

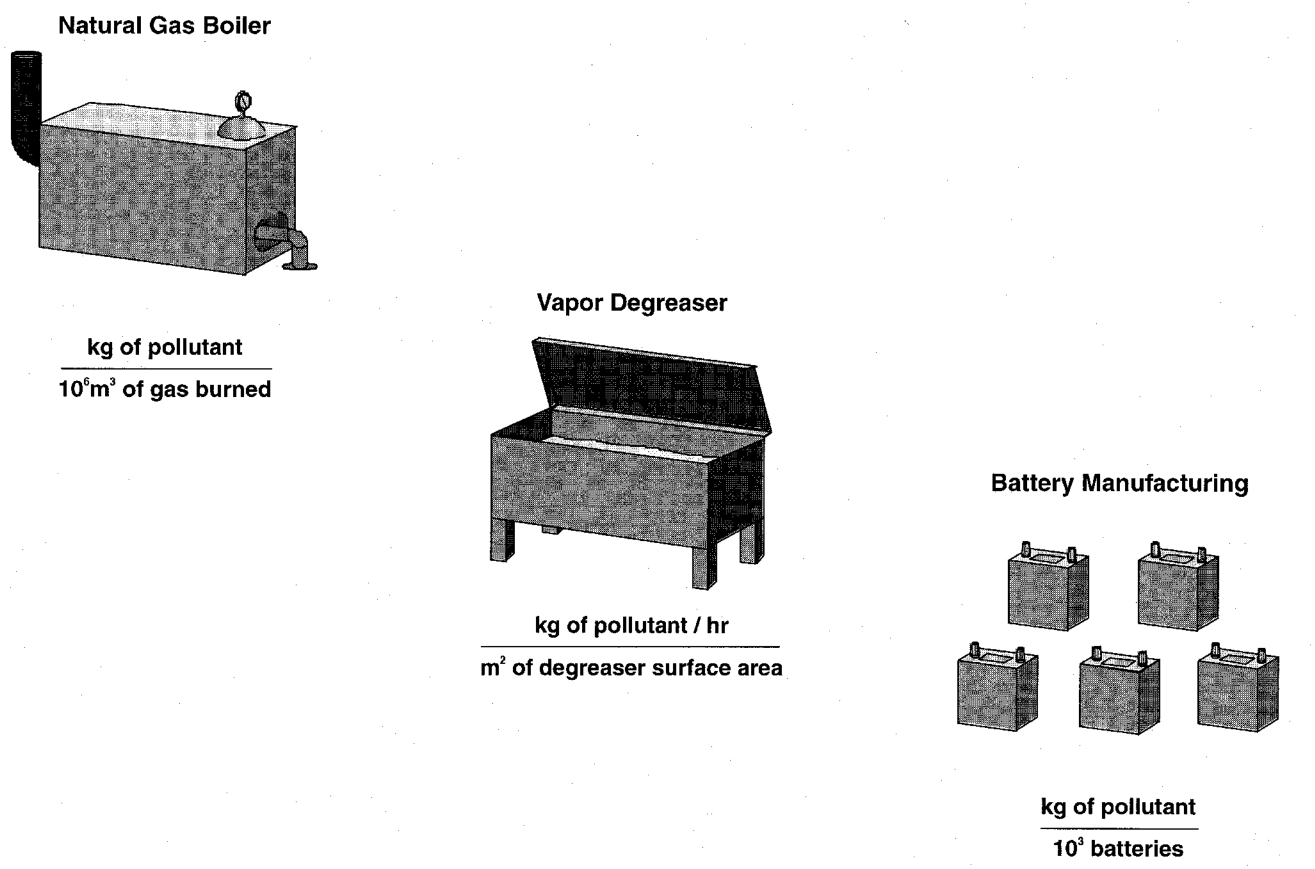

Figure 3-1. Examples of Emission Factor Units and Applications

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$$\mathbf{E = A \times EF \times (1 - ER/100)} \tag{3-1}$$

where:

E = emission estimate for source (at the process level)
A = activity level (such as throughput or material produced)
EF = “uncontrolled” emission factor (such as lb of pollutant emitted/ton of material processed)
ER = overall emission reduction efficiency, expressed in percent; equal to the capture device efficiency multiplied by the control device efficiency. If no control device present, ER = 0.

If the emission factor was developed with a control device in place, the emission factor already incorporates the control system effectiveness term (1-ER/100); therefore, the form of the algorithm is:

$$\mathbf{E = A \times EF} \tag{3-2}$$

where:

E = emission estimate for source (at the process level)
A = activity level (such as throughput or material produced)
EF = controlled emission factor (such as kilogram of pollutant emitted/Mg of material processed)

Equation 3-2 is also used when no control device is in place and the emission factor was developed from data generated from an uncontrolled system as shown in the following example:

Example 3-1:

Calculate the annual non-methane VOC emissions from a paint manufacturing facility that produced 200 Mg (metric tonnes) of paint in a year.

A_{paint} = 200 Mg/yr (From AP-42, Section 6.4)

EF_{VOC} = 15 kg/Mg

E_{VOC} = $A_{paint} \times EF_{VOC}$
= 200 x 15
= 3,000 kg/yr

Emission Factors - Issues to Consider

- Emissions calculated using emission factors for a given process are likely to differ from that facility's actual emissions because the estimate is less precise than source test measurements.

- The use of emission factors will produce higher emissions estimates than are actual for some sources and lower for others.

- Emission factors are often based on limited data, and may not truly represent the facility of interest.

- If emission factors are used to predict emissions from new or proposed sources, users should review the latest literature and technology to determine if such sources would likely exhibit emissions characteristics different from those of typical existing sources.

- In order to calculate emissions using emission factors, the following information is required:

    - Activity information for the process as specified by the relevant emission factor;

    - Emission factors to translate activity information into controlled or uncontrolled emission estimates; and

    - Capture device and control device efficiencies to provide the basis for estimating emissions to the atmosphere after passage through the control devices(s) if using an uncontrolled emission factor.

- The accuracy of the emission estimate is equally dependent upon the relative accuracy of each of these individual components. Errors introduced into any one of these components will affect the final emission estimate.

3.2 Source Tests

The source test is a common method of estimating process emissions. Source tests are short-term emission measurements taken at a stack or vent. Due to the substantial time and equipment involved, a source test requires more resources than an emission factor or material balance emission estimate. A source test measures pollutant concentration in the emission stream and the emission stream air flow rate.

The definition of source testing can be extended to include the use of continuous emissions monitors (CEM). This technology continuously removes a sample from the stack and analyses it for compounds of interest using the same principles as routine stack sampling. If CEM equipment are being used at a facility, the resulting data should be used to the greatest extent possible to prepare unit-specific emission estimates. The remainder of this section focuses on the use of traditional, short-term source test results to develop emission estimates.

Most source test reports summarize emissions for each pollutant by expressing them in terms of: (1) a mass loading rate (mass of pollutant emitted per unit of time); (2) an emission factor (mass of pollutant emitted per unit of process activity); or (3) a flue gas concentration (mass or number of moles of pollutant per some weight or volume of flue gas). Generally, when a mass loading rate or flue gas concentration is provided, the resulting emissions can easily be calculated with knowledge of operating parameters, as in the example below (U.S. EPA, 1993a):

Example 3-2:

A single-line paper coating plant has been subjected to an emission test for volatile organic compound (VOC) emissions. Since the coating solvent is primarily toluene, the emission concentrations were measured as toluene. The data averaged for three test runs are as follows:

Stack flow rate (Q_s) = 283 m^3/min
Emission concentration (C_e) = 96 ppm (as toluene)

Other information needed to complete the calculations include:
Plant operation = 16 hour/day, 312 days/year
Molecular weight of toluene (MW) = 92 g/gmole
Unit conversion factor (k) = 2.53×10^{-3} gmole-min/hr-ppm-m^3

The emission calculation begins with determination of the average mass loading rate (M_o):

M_o = $(k)(MW)(C_e)(Q_s)$
= $(2.53 \times 10^{-3})(92)(96)(283)$
= 6,324 g/hr
= 6.32 kg/hr

Total annual emissions = (6.32 kg/hr) (16 hr/day) (312 day/yr)
= 3.2×10^4 kg/yr

Note:

$$\left(\frac{1}{10^6}\right)\left(\frac{60\ \text{min}}{\text{hr}}\right)\left(\frac{\text{lb mole}}{379\ \text{ft}^3}\right)\left(\frac{35.31\ \text{ft}^3}{\text{m}^3}\right)\left(\frac{453.6\ \text{gmol}}{\text{lb mol}}\right) = 2.53 \times 10^{-3}$$

Sometimes, source test results may not be provided in the format that must be reported. The following examples show some of the data conversions that may be required.

Example 3-3: ppmv to kg/hr calculation

Given: Oxides of nitrogen (NO_x) measured at 100 parts-per-million volume (ppmv) in stack gas
Stack flow of 500 cubic meters (m^3) per minute

Required: kg/hr NO_x emitted in stack gas

Data: NO_x molecular weight (MW) = 46
Molar volume = 24.13 ℓ/kgmol @ 20°C
= 0.024 m^3/kgmol

$$\left(\frac{100\ \text{kgmol}\ NO_x}{10^6\ \text{kgmol}}\right)\left(\frac{46\ \text{kg}\ NO_x}{\text{kgmol}\ NO_x}\right)\left(\frac{\text{kgmol air}}{0.024\ m^3\ \text{air}}\right)\left(\frac{60\ x\ 500\ m^3\ \text{air}}{\text{hour}}\right) = 5{,}750\ \text{kg/hr}\ NO_x$$

Note: When computing mass emissions of NO_x, use the molecular weight of NO_2 (MW = 46) in the calculation. This is the standard convention, even though most NO_x is actually emitted from combustion sources as NO.

Example 3-4: Temperature correction: actual m^3/min to standard m^3/min (stack gas flow rate correction)

Given: Stack gas exit velocity measured at 10 m/s
Stack diameter = 0.8 m
Stack temperature = 80°C

Required: Stack gas flow in standard m^3/min (20°C reference temperature)

Conversion:

$$\text{Flow}_{20^\circ C} = \left(\text{Flow}_{x^\circ C}\right)\left(\frac{20^\circ C + 273.15}{X^\circ C + 273.15}\right)$$

$$\left(10\ \frac{m}{s}\right)\left(\pi\ \frac{(0.8)^2}{4}\ m^2\right)\left(\frac{60\ s}{\text{min}}\right)\left(\frac{293.15\ K}{353.15\ K}\right) = 250\ \text{standard}\ m^3/\text{min}$$

Note: For elevated temperature stack gas flows, it is generally necessary to correct for both temperature and water content (see Example 3-5).

Example 3-5: Water Vapor correction: actual m^3/min to dry standard m^3/min (stack gas flow rate correction)

Given: Wet stack gas flow rate from Example 3-4 = 250 standard m^3/min
Stack gas water vapor content = 2.1% (volume)

Required: Dry stack gas flow (dry standard m^3/min)

Conversion:

$$\text{Flow}_{\text{dry}} = \text{Flow}_{\text{wet}}\ [100\% - \%\ H_2O]$$

$$250 \text{ standard } m^3/\text{min } [1 - 0.021] = 245 \text{ dry standard } m^3/\text{min}$$

Example 3-6: Oxygen in flue gas correction (pollutant concentration correction)

Given: Particulate in stack gas = 20 mg/dry standard m^3 (dscm)
NO_x concentration in stack gas = 48 ppmv
Stack gas oxygen concentration = 4% (vol)

Required: Stack gas particulate and NO_x concentrations corrected to 7% oxygen.

Conversion:

$$\text{Conc}_{7\%} = \text{Conc}_{x\%} \left(\frac{21\% - 7\%}{21\% - X\%} \right)$$

$$\frac{20 \text{ mg PM}}{\text{dscm}} \left(\frac{21\% - 7\%}{21\% - 4\%} \right) = \frac{16.5 \text{ mg}}{\text{dscm}} \text{ PM @ } 7\%\ O_2$$

$$48 \text{ ppmv } NO_x \left(\frac{21\% - 7\%}{21\% - 4\%} \right) = 40 \text{ ppmv } NO_x \text{ @ } 7\%\ O_2$$

Source Tests - Issues to Consider

- Source tests typically provide better emission estimates than emission factors or material balances, if correctly applied.
- Source test data should be used for emission estimation purposes only if the data were obtained under conditions which are representative of operating conditions normally encountered at the source in question.
- Emission data from a one-time source test can be extrapolated to estimate annual emissions if the process stream does not vary and if the process is operated uniformly. If variability exists, multiple tests must be conducted, with knowledge of the process variation.
- If facility operation and test methods employed during the source test cannot be adequately characterized, the source test data should not be used.
- If a source test is used to estimate emissions for a process, test data gathered on-site for that process is generally preferred.
- The second choice is to use test data from similar equipment and processes on-site, or to use pooled source tests (tests taken from various similar facilities and averaged together) or test data taken from available literature.
- The reliability of the data may be affected by factors such as the number of tests conducted and the test methodology used.

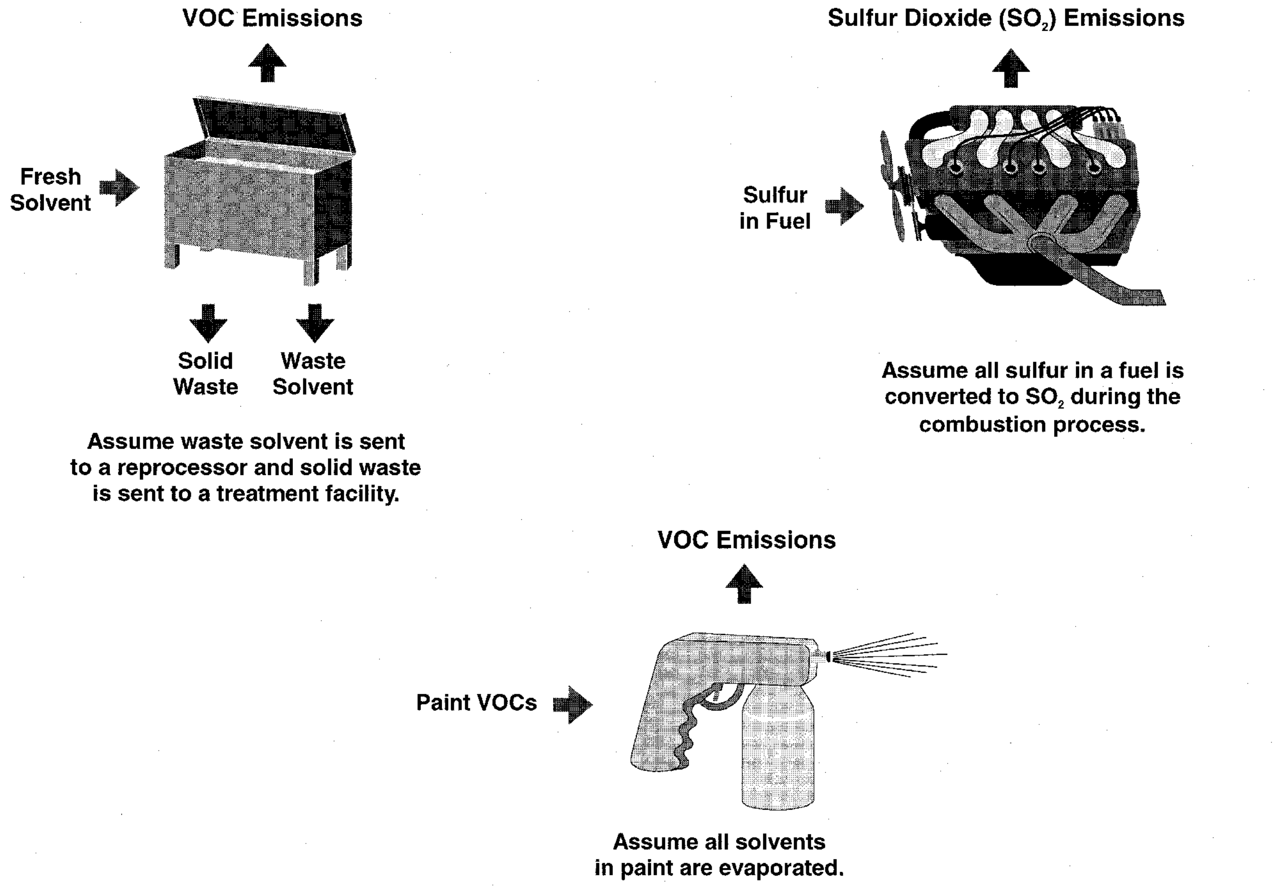
3.3 Material Balance

The material balance (also known as a mass balance) is a method commonly used for estimating emissions from many source categories. The basic assumption in the material balance method is that emissions are equal to the difference between the amount of material entering and exiting a process (allowing for fugitive losses, amount remaining in the final product, losses to wastewater, etc.). The material balance method can be used where source test data, emission factors, or other developed methods are not available. The material balance is most appropriate to use in cases where accurate measurements can be made of all but the air emission component, or when the emission estimate will be used for screening purposes if reasonable assumptions can be made about the fate of the compounds.

The use of a mass or material balance to determine total emissions from a process is usually simple and affordable. VOC emissions from solvent use (such as a coating operation) are often calculated using a material balance approach. In this case, the solvent sent to solid or hazardous waste disposal should be subtracted from total consumed:

$$\mathbf{Solvent_{total\ used}\ (liter) - Solvent_{waste}\ (liter) = Solvent_{emitted}\ (liter)} \qquad (3\text{-}3)$$

In the example above, the mass VOC/volume is multiplied by the volume of material used to give VOC emissions. Figure 3-2 illustrates examples of material balance.



Assume waste solvent is sent to a reprocessor and solid waste is sent to a treatment facility.

Assume all sulfur in a fuel is converted to SO_2 during the combustion process.

Assume all solvents in paint are evaporated.

Figure 3-2. Examples of Material Balances

MEX3.CDR - 7/5/96 - JH - SAC

Example 3-7:

Calculate annual PM emissions from a surface coating operation that uses 1,800 liters/yr of coatings. The average density of the coatings is 1.2 kg/liter and the average solids content is 35% by mass. The coating transfer efficiency is 40% and the control device efficiency is 95%.

PM_{in} = (1,800 liters/yr) x (1.2 kg/liter) x (35% PM)
= 756 kg/yr

$PM_{surface}$ = 756 kg/yr x 40%
= 302 kg/yr

$PM_{uncontrolled}$ = PM_{in} - $PM_{surface}$
= 756 - 302
= 454 kg/yr

$PM_{controlled}$ = 454 kg/yr x 95%
= 431 kg/yr

E_{PM} = PM_{in} - $PM_{surface}$ - $PM_{control}$
= 756 - 302 - 431
= 23 kg/yr

Material Balance - Issues to Consider

- The material balance method should not be used for processes where material is reacted to form products or the material otherwise undergoes significant chemical change unless the process is well-characterized.

- Because the emissions are estimated to be the difference between the material input and the known material output, a small percentage error in estimating the input or output can result in a large percentage error in the emission estimate. Therefore, material balances may be inappropriate when considering a small difference (i.e., loss) between two rather large input and output values.

3.4 Emissions Models

A more complex method, an emissions model, is used to estimate emissions when emissions are not directly related to any one parameter. Models usually are computer-based so that a large number of equations and interactions can be easily calculated. The data requirements for models vary but in most cases at least one physical parameter is needed from the source for which the model will be used to estimate emissions. Examples of models available are the TANKS3 and WATER8 models which are used to calculate VOC emissions from storage tanks and wastewater collection and treatment, respectively (EPA, 1993c and EPA, 1994). These models are available free of charge through the CHIEF BBS, 95-919-541-5742. For more detailed information on emissions models, refer to Section 4.1 of Volume III: *Basic Emission Estimating Techniques*.

Emissions Models - Issues to Consider

- Models generally require more data than emission factors.
- The data needed will be dependent upon the particular emission source as well as the model. Emission models for wastewater treatment operations, for example, may require wastewater flow rate, pollutant concentration, and temperature, while emission models for storage tanks may require tank capacity, dimensions, throughput, and vapor pressure.
- The accuracy of the emission estimate is dependent upon the accuracy of the individual components entered.

3.5 Emission Estimation Cross-Reference Table

Table 3-1 (located at the end of this section) recommends emission estimation techniques for several industrial categories and their emissions sources. Many facilities (e.g., chemical manufacturers) have numerous types of air pollutant emission sources including production processes, combustion devices, equipment leaks, storage tanks, and solvent usage as described below:

- Process emissions from facilities are those that directly result from production or manufacturing processes. The magnitude and type of process emissions vary with the type of production;
- Generators, boilers, and incinerators are common sources of gaseous and particulate emissions from combustion;
- Fugitive VOC emissions may be emitted from leaking production equipment including pump seals, valves, flanges, other connections, and open ended lines;
- Storage tanks may generate fugitive VOC emissions during transfer operations or during daily temperature changes; and
- Solvent usage for equipment or parts cleaning (i.e., degreasing) is another common source of fugitive VOC emissions.

Air pollutant emissions from the various emission sources at a facility may be estimated by different methods. The methods available for estimating emissions are dependent on the particular emission source. The selection of an estimation technique from the available methods requires consideration of the availability of data. If more data are needed to use a particular method, the costs have to be weighed against the desired quality of the emission estimate. Where risks of adverse environmental effects are high, more sophisticated and costly emission estimation methodologies such as source tests may be necessary. Conversely, where risks are low, less expensive estimation methods such as emission factors and emission models may be acceptable.

The rankings of methods in Table 3-1 are based on the industry, the magnitude of emissions, and the cost and quality of the emission estimate for specific combinations of emission sources and pollutants. A rank of “1" indicates that a method is the most preferred estimation technique. If a method does not have a ranking, then it is not available for that particular emission source and pollutant.

How to Use Table 3-1

- Identify the emission sources at your facility.
- Using Table 3-1, identify the EET for each emission source.
- If possible, use the most preferred EET to estimate emissions from a given source (ranked number 1).
- Review the corresponding subsection of Section 3.1 and the *Basic EET* manual (Volume III) to determine the data needed to use the preferred EET.
- If data and resources are not available to use the preferred EET, then use the next best technique (ranked 2 or 3 in Table 3-1) to estimate emissions.

Table 3-1

Recommended Emission Estimating Techniques for Source Categories

Source Category	Emission Source	Pollutant(s)	Estimation Techniques[a]				Comments
			Emission Factor	Source Tests	Material Balance	Emission Models	
Electric Utility	Combustion	CO	2	1			
		NO_x	2	1			
		SO_x	3	1	2[b]		
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			
Chemical Manufacturing	Process	VOC	2	1			
		NH_3	2	1			
	Combustion	CO	2	1			
		NO_x	2	1			
		SO_x	3	1	2[b]		
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			
	Equipment Leaks	VOC	1	2			
	Storage Tanks	VOC			2	1	
	Wastewater Treatment	VOC	2		3	1	
	Solvent Usage	VOC			1		

Table 3-1

Continued

Source Category	Emission Source	Pollutant(s)	Estimation Techniques[a]				Comments
			Emission Factor	Source Tests	Material Balance	Emission Models	
Petroleum Refining	Process	VOC	2	1			
	Combustion	CO	2	1			
		NO_x	2	1			
		SO_x	3	1	2[b]		
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			
	Equipment Leaks	VOC	1	2			
	Storage Tanks	VOC			2	1	
	Wastewater Treatment	VOC	2		3	1	
	Solvent Usage	VOC			1		Solvents used for equipment maintenance.
Primary Metal Production	Process (non-combustion)	VOC	2	1			
		SO_x	3	1	2[b]		
		PM	2	1			
	Combustion	CO	2	1			
		NO_x	2	1			
		SO_x	3	1	2[b]		
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			
	Fugitive Dust	PM	1				Storage piles, haul roads, etc.

Table 3-1

(Continued)

Source Category	Emission Source	Pollutant(s)	Estimation Techniques[a]				Comments
			Emission Factor	Source Tests	Material Balance	Emission Models	
Secondary Metal	Process (non-combustion)	VOC	2	1			Includes charging, refining, and casting.
		PM	2	1			
	Combustion	CO	2	1			Emissions may be generated from charge materials in addition to combustion fuels.
		NO_x	2	1			
		SO_x	3	1	2[b]		
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			
	Fugitive Dust	PM	1				Storage piles, haul roads, etc.

Table 3-1

(Continued)

Source Category	Emission Source	Pollutant(s)	Estimation Techniques[a]				Comments
			Emission Factor	Source Tests	Material Balance	Emission Models	
Cement Production	Combustion	CO	2	1			
		SO_x	3	1	2[b]		
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			
	Fugitive	PM	1				Storage piles and driving surfaces dust.
	Process	PM	2	1			Dryer operations.
Miscellaneous Mineral Products (e.g., lime and aggregate kilns)	Process	PM	2	1			Crushing and grinding operations.
	Combustion	CO	2	1			
		NO_x	2	1			
		SO_x	3	1	2[b]		
		VOC	2	1			
		PM	2	1			
	Combustion	NH_3[c]	2	1			
	Fugitive	PM	1				Storage piles and driving surfaces dust.

Table 3-1

(Continued)

Source Category	Emission Source	Pollutant(s)	Estimation Techniques[a]				Comments
			Emission Factor	Source Tests	Material Balance	Emission Models	
Automotive Industry	Process	VOC	2	1			
	Combustion	CO	2	1			
		NO_x	2	1			
		SO_x	3	1	2[b]		
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			
	Solvent Usage	VOC			1		Cleaning operations.
Wood Pulping Operations	Process	VOC	2	1			Digesters, evaporators, oxidation towers, etc.
		SO_x	2	1			
		PM	2	1			
	Combustion	CO	2	1			
		NO_x	2	1			
		SO_x	2	1	3[b]		
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			

Table 3-1

(Continued)

Source Category	Emission Source	Pollutant(s)	Estimation Techniques[a]				Comments
			Emission Factor	Source Tests	Material Balance	Emission Models	
Oil and Gas Production	Process	VOC	2	1			
	Fugitive (including equipment leaks)	VOC	1	2			Pipeline valves and seals and other fugitive.
	Combustion	CO	2	1			
		NO_x	2	1			
		SO_x	3	1	2[b]		
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			
	Storage Tanks	VOC			2	1	
Printing and Publishing	Process	VOC	2	1	3		
	Fugitive	VOC			1		Equipment cleaning.
Surface Coating	Process	VOC	2	3	1		Use mass balance if no VOC control device.
		PM	1				
	Degreasing	VOC	2		1		
	Fugitive	VOC			1		Equipment cleaning.
Bulk Fuel Terminals	Loading	VOC	1		2		Mass balance used for VOC from spills.
	Storage Tanks	VOC	2			1	
	Equipment Leaks	VOC	1	2			

Table 3-1

(Continued)

Source Category	Emission Source	Pollutant(s)	Estimation Techniques[a]				Comments
			Emission Factor	Source Tests	Material Balance	Emission Models	
Mining and Quarrying	Process	PM	1				
	Fugitive	PM	1				Storage piles and road surface dust.
Wood Products Manufacture	Process	VOC	2		1		
		PM	1	2			
	Combustion	CO	2	1			
		NO_x	2	1			
		SO_x	2	1	3[b]		
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			
	Storage Tanks	VOC				1	
Sugar Production	Process	PM	1				
	Combustion	CO	2	1			
		NO_x	2	1			
		SO_x	2	1	3[b]		
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			
	Fugitive	VOC			1		

Table 3-1

(Continued)

Source Category	Emission Source	Pollutant(s)	Estimation Techniques[a]				Comments
			Emission Factor	Source Tests	Material Balance	Emission Models	
Tanning and Leather Finishing	Process	VOC			1		
	Combustion	CO	2	1			
		NO_x	2	1			
		SO_x	2	1	3[b]		
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			
Glass Production	Melting Furnace	CO	2	1			Includes combustion emissions.
		NO_x	2	1			
		SO_x	2	1			
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			
	Process	PM	2	1			Raw material blending and transport.
		VOC	2	1			Forming and finishing.

Table 3-1

(Continued)

Source Category	Emission Source	Pollutant(s)	Estimation Techniques[a]				Comments
			Emission Factor	Source Tests	Material Balance	Emission Models	
Rubber and Plastic Parts	Process	VOC	2	1			
	Combustion	CO	2	1			
		NO_x	2	1			
		SO_x	2	1	3[b]		
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			
Fabricated Metal Products	Process	PM	2	1			
	Combustion	CO	2	1			
		NO_x	2	1			
		SO_x	2	1	3[b]		
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			
Textile Products	Process	VOC	2	1	3		VOC from finishing operations.
		PM	2	1			Lint from mechanical operations.
	Combustion	CO	2	1			
		NO_x	2	1			
		SO_x	2	1	3[b]		
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			

Table 3-1

(Continued)

Source Category	Emission Source	Pollutant(s)	Estimation Techniques[a]				Comments
			Emission Factor	Source Tests	Material Balance	Emission Models	
Solid Waste Disposal	Landfill Gas	VOC				1	
	Municipal Waste Combustors	CO	2	1			
		NO_x	2	1			
		SO_x	2	1			
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			
	Open Burning Dump	CO	1				
		NO_x	1				
		SO_x	1				
		VOC	1				
		PM	1				
		NH_3	1				
Miscellaneous Industrial Activities and Processes	Process Emissions	CO	2	1	3		The emissions estimation method selected will be dependent on the particular industry. Generally, source tests provide the most accurate estimates; however, other methods may be more practical.
		NO_x	2	1	3		
		SO_x	2	1	3		

Table 3-1

(Continued)

Source Category	Emission Source	Pollutant(s)	Estimation Techniques[a]				Comments
			Emission Factor	Source Tests	Material Balance	Emission Models	
Miscellaneous Industrial Activities and Processes (Cont.)	Process Emissions	VOC	2	1	3		
		PM	2	1	3		
	Combustion Emissions	CO	2	1			
		NO_x	2	1			
		SO_x	2	1	3[b]		
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			
	Fugitive	VOC			1		Solvent cleaning is a common VOC source.
Government Facilities	Combustion	CO	2	1			Typically includes space heating, as well as combustion for process operations.
		NO_x	2	1			
		SO_x	2	1	3[b]		
		VOC	2	1			
		PM	2	1			
		NH_3[c]	2	1			
	Fugitive	VOC			1		Typically includes solvent cleaning.

Table 3-1

(Continued)

Source Category	Emission Source	Pollutant(s)	Estimation Techniques[a]				Comments
			Emission Factor	Source Tests	Material Balance	Emission Models	
Food and Agriculture	Process	VOC	1	2			Includes alfalfa dehydration, grain elevators, beer production, etc.
		PM	1	2			
	Combustion Emissions	CO	2	1			
		NO_x	2	1			
		SO_x	2	1	3[b]		
		VOC	2	1			
		PM	2	1			
		NH_3	2	1			
Asphalt Plants	Process	PM	2	1			Aggregate handling operations.
	Combustion Emissions	CO	2	1			
		NO_x	2	1			
		SO_x	2	1	3[b]		
		VOC	2	1			
		PM	2	1			
		NH_3	2	1			

[a] Emission estimation techniques are discussed briefly in Section 2.1 and in detail in *Volume III: Basic Emissions Estimating Techniques*. The numeric values indicate the order of preference that should be considered when selecting an estimation technique, number 1 being the most preferred.

[b] Based on fuel sulfur analysis from supplier.

[c] Ammonia slip from SCR used as a NO_x control method.

CO = carbon monoxide
NH_3 = ammonia
NO_x = oxides of nitrogen
PM = particulate matter
SO_x = oxides of sulfur
VOC = volatile organic compound

4.0 SPECIAL CONSIDERATIONS INFLUENCING EMISSIONS

Variability in processes, equipment, and raw materials used within the inventory region can lead to variability in emissions. In addition, some emission sources are frequently overlooked and inadvertantly excluded from inventory efforts. These two special considerations affecting point source inventory development are addressed below.

4.1 Design and Process Variability

Many factors can influence emissions. This section presents some of the factors that may vary from device to device or from region to region. **The inventory developer should be aware of these factors and should try to collect device-specific or region-specific data whenever possible.**

4.1.1 Combustion Characteristics

Combustion products from fuel burning can include partially oxidized hydrocarbons, carbon monoxide (CO), sulfur dioxide (SO_2), sulfur trioxide (SO_3), oxides of nitrogen (NO_x), acids such as hydrochloric acid, organohalides, and particulates. The generation of combustion products is strongly influenced by fuel type, furnace type, firing configuration, and boiler operating conditions. Although a detailed discussion on boiler operations is not presented here, some general observations are included to assist in understanding the relative impact of various boilers and fuel types on air emissions.

Fuel Properties: The four primary classifications of coal are lignite, anthracite, bituminous, and subbitumimous. Fuel is ranked based on standard methods referred to as "proximate" and "ultimate" analyses. Proximate analyses report fuel composition in broad categories such as moisture content and ash content. Ultimate analyses provide an estimate of the carbon, hydrogen, sulfur, oxygen, nitrogen, and water content of the fuel. An ultimate analysis is used to compute combustion air requirements and can be used to calculate fuel factors (F_d) for determining exhaust flow rates. Generally, boiler size, firing configuration, and operation has little effect on the percent conversion of fuel sulfur to sulfur oxides, so fuel analysis is typically a valid means of predicting emissions of sulfur oxides. Example 4-1 shows how fuel analysis can be used to estimate SO_2 emissions.

Example 4-1:

This example shows how SO_2 emissions can be calculated from oil combustion based on fuel analysis data.

Emissions of SO_2 may be calculated using the following equation:

$$E = Q_f \text{ x Pollutant concentration in fuel x } (MW_p/MW_f)$$

where:
E = Emissions
Q_f = Fuel Flow rate
MW_p = Molecular weight of pollutant emitted (g/gmole)
MW_f = Molecular weight of pollutant fuel (g/gmole)

For this example:

Q_f = 2.09×10^4 kg/hr
Percent sulfur (%S) in fuel = 1.17
MW of SO_2 = 64
MW of Sulfur(S) = 32
E_{SO2} = Q_f x Pollutant concentration in fuel x (MW_p/MW_f)
= $(2.09 \times 10^4)(1.17/100)(64/32)$
= 489.3 kg/hr

In addition, the Norma Mexicana (Mexican Official Standard) NOM-086-ECOL-1994 defines the environmental protection specifications for liquid and gaseous fossil fuels used in stationary and mobile sources (SEMARNAP, 1994). Specifications for natural gas and petroleum products such as gasoline, diesel, fuel oil, and liquified petroleum gas (LPG) being used in the various geographical regions are defined in this standard. Fuel specifications have been defined for critical zones, such as Mexico City, Guadalajara, and Monterrey Metropolitan zones and North Boundary zone.

Table 4-1 presents a list of fuel types, their applicability based on geographical regions, and the fuel specification reference in NOM-086-ECOL-1994 where detailed information on fuel characteristics (including sulfur content, Reid vapor pressure, ash content, etc.) can be found. The specifications defined in NOM-086-ECOL-1994 can be used to develop emission estimates if more specific information on fuel properties cannot be obtained from PEMEX or government agencies.

Operating Conditions: By contrast, NO_x formation is highly dependent on boiler conditions, especially temperature and air/fuel ratios near the burner. NO_x formation is produced by two mechanisms: 1) conversion of fuel-bound nitrogen and 2) oxidation of molecular nitrogen from combustion air (referred to as thermal NO_x formation). Thermal NO_x formation is highly temperature dependent and becomes rapid as temperatures exceed 1,649°C (Buonicore, 1992). Lower operating temperatures result in decreased thermal NO_x production. Shorter residence time also lowers thermal NO_x generated by oil- and coal-fired boilers. Nitrogen oxide emissions from the tangential-fired oil boilers are typically lower than those from horizontally opposed units. Many boilers employ combustion modifications to reduce NO_x emissions. These include staged combustion, off-stoichiometric firing, flue gas recirculation (FGR), and low-NO_x burners with overfire air (OFA). These control strategies can reduce NO_x emissions by 5 or 50 percent (Buonicore, 1992).

Table 4-1

Applicability by Geographical Regions and Specification Reference in NOM-086-ECOL-1994 for Fuel Types

Fuel	Fuel Specification Table Number in NOM-086-ECOL-1994	Applicability by Geographical Regions
Gasoline (Magna Sin)	Table 1	Country-wide, except Mexico City Metropolitan Zone (ZMCM-Zona Metropolitana de la Ciudad de Mexico) and North Boundary Zone (ZFN-Zona Fronteriza Norte) through 1997[a]
Gasoline (Magna Sin Zona Fronteriza Norte)	Table 2 and Annex 1, 2, and 3 of Table 2	North Boundary Zone Distribution influence area of the following marketing terminals: • Ciudad Juárez and Tijuana • West Zone (including Cananea, Ciudad Obregon, Guaymas, Hermosillo, Magdalena and Nogales in Sonora, and Ensenada, Rosarito and Mexicali in Baja California • North Zone (including Avalos and Monclova in Coahuila; and Nuevo Laredo and Reynosa in Tamaulipas.
Gasoline (Magna Sin Zonas Metropolitanas)	Table 3	Mexico City Metropolitan Zone through 1997. In 1998, Mexico City, Guadalajara, and Monterrey Metropolitan Zones.
Gasoline (Nova Plus)	Table 4	Country-wide, except Mexico City Metropolitan Zone through 1997[b]
Gasoline (Nova Plus-Zonas Metropolitanas)	Table 5	Mexico City Metropolitan Zone through 1997. In 1998, Mexico City, Guadalajara, and Monterrey Metropolitan Zones.

Table 4-1

(Continued)

Fuel	Fuel Specification Table Number in NOM-086-ECOL-1994	Applicability by Geographical Regions
Diesel (Diesel Sin)	Table 6	Mexico City, Guadalajara, and Monterrey Metropolitan Zones.
Low Sulfur Diesel (Diesel Desulfurado)	Table 7	Country-wide
Diesel (Diesel Industrial)	Table 8	Country-wide. Exclusively for use in open-flame flares
Fuel Oil (Gasoleo Industrial)	Table 9	Country-wide, except Mexico City Metropolitan Zone. Not available after December 31, 1997. Exclusively for use in open-flame combustion.
Heavy Fuel Oil (Combustóleo Pesado)	Table 10	Country-wide
Natural Gas (Gas Natural)	Table 11	Country-wide
Liquefied Petroleum Gas-LPG (Gas LP)	Table 12	Country-wide
Aviation gasoline (Turbosina) or Aviation turbine fuel	Table 13	Country-wide

[a] In 1998, applicable country-wide except Metropolitan zones of Mexico City, Guadalajara, and Monterrey, and ZFN.

[b] In 1998, applicable country-wide except Metropolitan zones of Mexico City, Guadalajara, and Monterrey.

4.1.2 Raw Materials

In addition to the effects that fuel properties can have on emission estimates, physical and chemical properties of other raw materials used by a point source may also influence emissions. For example, the material density is often used to convert the volume of material used to a mass of material used. As another example, the material VOC content (i.e., g/L) is often used to estimate emissions from surface coating operations.

The physical and chemical properties of some raw materials may vary throughout Mexico. For instance, the “maquiladora” industry, principally located in the northern border zone, began in the 1960's as part of a plan to bring international industrial facilities to Mexico. The plan allowed foreign companies to bring equipment, components, and raw materials into Mexico without paying tariff barriers. Therefore, many of the raw materials used by the maquiladoras may be imported and may be different from the raw materials used in other regions of Mexico.

4.1.3 Operating Practices

Operating practices may vary in different regions of Mexico and potentially impact the development of emission estimates. For example, many of the technologies, production standards, and operating practices of the maquiladoras are imported and reflect foreign industrial practices. In general, the foreign industrial plants are more automated, whereas Mexican industry traditionally tends to use more manual processes and is often more artisan based. These differences may result in different emission estimates. For example, automated surface coating equipment generally can apply a thinner and more even layer of paint with less overspray than if manual, hand-held paint spray equipment are used.

4.1.4 Age of Equipment

In Mexico, the manufacturing sector is comprised of a small number of large national consortia and foreign companies (2,481 in 1992) and a large number of micro (101, 226), small (20,734), and medium (3,338) companies. In general, the large manufacturing facilities have implemented clean and competitive production processes and use modern equipment. On the other hand, the smaller companies operate with older equipment and technologies and are considered to be high energy-consumers that may be significant polluters, despite their smaller size.

The age of equipment can influence the development of emission estimates in a couple of ways. First, newer equipment may employ a newer technology that was designed to reduce emissions. For example, recently designed Low Emission Vapor Degreasers (LEVDs) use new technologies such as full vacuum or sealed degreasing chambers to significantly reduce emissions compared to a conventional, open-top degreaser. Second, the age of equipment should be considered when selecting an emission factor for an emission source. In order for the emission factor to be applicable, the age of the equipment inventoried should be similar to the age of equipment tested to develop the emission factor.

4.1.5 Meteorological and Climatological Data

Meteorological and climatological information are needed when estimating emissions from certain emission sources. For example, parameters such as annual average ambient temperature and wind speed are required by the emission estimating equations for storage tanks. As another example, the quantity of fuel combusted for heating or air-conditioning purposes will generally vary based on climate.

Region-specific climatological information should be obtained from reports developed by the National Institute of Statistics, Geography and Computer Science (INEGI) or by the National Meteorological and Atmospheric Science Center at the National University (UNAM).

4.2 Typically Overlooked Emission Sources

Some processes that routinely emit atmospheric pollutants are often overlooked in emissions inventories. Inventory preparers should be aware of these processes and should include emissions from the following sources:

- In-process fuel-fired equipment;
- Fugitive components;
- Control devices;
- Miscellaneous solvent use;
- On-site vehicles
- Process additives
- Storage piles; and
- Material handling.

The responsibility for properly recording this information is given to the emissions inventory preparer. Examples of the typically overlooked processes and ambiguities about equipment classifications are discussed below.

4.2.1 In-Process Fuel-Fired Equipment

Many industrial processes use fuel-fired equipment or indirect-fired equipment as part of a given manufacturing process. For example, cement kilns use fuel-fired dryers to dry the product. Another example of in-process fuel use is natural gas-fired dryers for coating operations. **Emissions from in-process fuel use are estimated using the same techniques used to estimate emissions from combustion sources and should be included in the inventory**.

4.2.2 Fugitive Emission Sources

There are several potential sources of equipment leak emissions associated with the oil and gas, petroleum refining, and petroleum product distribution industries. Components such as pumps, valves, pressure relief valves, flanges, agitators, and compressors are potential sources that can leak due to seal failure. Fugitive component emissions occur from process equipment whenever the liquid or gas stream leaks. These emissions generally occur randomly and are difficult to predict. In addition, these emissions may be intermittent and vary in intensity over time. Therefore, measurements of equipment leak emissions actually represent a “snapshot” of the leaking process. Other sources, such as open-ended lines, and sampling connections may leak to the atmosphere for reasons other than faulty seals. The majority of data collected in the United States for estimating equipment leak emissions has been from the synthetic organic chemical manufacturing industry, petroleum refineries, petroleum marketing terminals, gas processing plants, and oil and gas production facilities for total organic compounds and non-methane organic compounds.

The *Protocol for Equipment Leak Emission Estimates* document (U.S. EPA, 1995c) is a good reference for information about procedures and approaches for estimating emissions from equipment leaks. Available approaches for estimating emissions from equipment leaks range from the simple (multiplying equipment counts by average emission factors) to the complex (developing unit-specific correlations of mass emission rates and screening values). Several pages of this document which describe the average emission factor approach and the screening ranges approach are presented as Appendix IV-C.**

In addition to equipment leaks from fugitive components, there are other miscellaneous fugitive emissions that may or may not be regularly identified as a “point source” associated with a given process or industry. Emission inventory specialists use published lists to begin a point source list which is further developed based on personal observations. Examples of fugitive process emissions that may be added include metallurgical fumes from welding or soldering, particulate emissions from metal-working operations, or ammonia emissions from reproduction (e.g., blueprinting) services.

The inventory development must diligently search for fugitive sources of emissions and include them in the inventory to prevent the underestimation of emissions.

4.2.3 Control Devices

Care must be taken when accounting for the influence that control devices have on emissions. Though control devices are generally used to reduce emissions, it may be possible that they are also emission sources. The best example is the use of selective reduction to control combustion emissions. Selective reduction is used to control NO_x emissions, but may result in ammonia emissions due to “ammonia slip,” that is, excess ammonia that is unreacted and that is directly released.

4.2.4 Miscellaneous Solvent Usage

Solvents are often used to spot clean pieces of equipment prior to surface coating or other manufacturing processes. In addition to degreasing vats where the components are actually submerged into the solvent, solvent cleaners may be applied by hand using small brushes or rags. **Emissions occur when these solvents evaporate and should be quantified using the material balance technique. These emissions should be included in the emissions inventory**.

4.2.5 On-site Vehicle Emissions

Large industrial complexes may have vehicle fleets used on-site to transport materials, products, or personnel within a facility. The vehicles themselves are sources of combustion related pollutants - NO_x and CO in particular. Also, if the roads used within the facility are not paved, particulate matter may be stirred up from the road surface. **The regulatory agency should decide if on-site vehicle emissions should be included in the point source inventory. Emissions from this source are usually estimated using emission factors**.

4.2.6 Process Additives

Any chemicals added to a production or control process have the potential to be emitted. Examples of these types of sources include ammonia injected into flue gas to control NO_x and catalysts used in chemical reaction processes. **Emissions from these processes are estimated using source tests, emission factors, or material balance techniques and should be included in the inventory**.

4.2.7 Storage Piles

Storage piles may be a source of particulate matter emissions if not properly covered and otherwise controlled. Materials typically found in storage piles include coal at power plants, rocks at concrete and/or asphalt production facilities, and other materials stored in bulk. **These sources have the potential to generate significant PM emissions and should be included in the emissions inventory. PM emissions from these sources are estimated using emission factors or models**.

4.2.8 Materials Handling

Materials transported via truck or rail which are not covered may also produce particulate matter emissions. Within a facility, materials such as coal may be transported via conveyor belts or pneumatic transport systems which result in fugitive particulate emissions. **As with storage piles, emissions from these sources are usually estimated using emission factors or models and should be included in any emissions inventory**.

5.0 AIR POLLUTION CONTROL DEVICES

To properly estimate emissions, the effectiveness of an existing control device must be applied in the emission calculations. Control devices for reducing particulate and volatile organic compound (VOC) emissions generally employ physical collection or combustion processes. Sulfur oxides and nitrogen oxides are more often controlled by chemical transformation. Control devices for carbon monoxide are typically not used by stationary sources. Ammonia emissions may be controlled by physical, combustion, or chemical processes. A basic description of the techniques typically used by industry to control particulate matter of less than 10 microns (PM_{10}), VOCs, sulfur dioxide (SO_2), oxides of nitrogen (NO_x), and hazardous air pollutants can be found in the *Control Technologies for Hazardous Air Pollutants Handbook* (U.S. EPA, 1991).

5.1 Control Effectiveness

The control device efficiency is the percentage of the air pollutant that is removed from the emission stream before release to the atmosphere. In addition to control device efficiency, emissions will be determined by capture efficiency of a system. The capture efficiency indicates the percentage of the emission stream that is taken into the control system. Overall control effectiveness is a product of the capture device efficiency and the control device efficiency. Consequently, estimates of efficiencies for capture devices and control devices are needed for accurate emissions estimates.

Example 5-1:

If you have a highly efficient afterburner (to reduce VOC emissions) that achieves 99% destruction, and the capture system achieves 80% capture efficiency, then the total VOC reduction efficiency is only 79.2%.

Control Effectiveness = control device efficiency (%) x capture efficiency (%)
= 99/100 x 80/100
= 79.2%

5.1.1 Capture Efficiency

The capture efficiency is defined as the fraction of pollutant emitted from the processing point that is actually gathered by baffles, hoods, or other capturing devices, and routed to the control device. Capture efficiency can be estimated by tests preformed at the facility for which emissions are being estimated. Often, capture device efficiency is estimated on the basis of tests performed on similar equipment at other facilities. Alternatively, capture efficiency can be estimated from manufacturer’s specifications or literature values. In the absence of capture efficiency data, estimates may be based on engineering judgement (e.g., all of the pollutants from an enclosed emission source are ducted to the control device).

5.1.2 Control Device Efficiency

Three different ways to determine control device efficiency are presented below in order of preference.

Source Test: Control device efficiency may be determined for specific equipment and operating conditions by source tests measuring pollutant concentrations before and after application of the control device.

However, because of possible variation in control device operation with process, control device malfunction, and deterioration over time, the measurement is subject to the potential limitations of all source tests.

Manufacturer Specification: A second method of obtaining a control efficiency is to use the manufacturer's design specification or guaranteed performance specification.

However, the design collection efficiency reported by manufacturers is the efficiency obtainable under optimum conditions and may not represent actual conditions. In addition, a control device may be improperly sized for effective control of the process under consideration. Some assessment of design efficiency will be required to adjust for these source conditions.

Literature Values: When test data or manufacturer's specifications are not available for estimating control efficiency of a specific control device, literature values may be used. Table 5-1 lists control devices commonly used at stationary point sources, applicable pollutants controlled, and their typical control efficiencies.

While Table 5-1 may be used for rough estimates of control device efficiencies, control efficiency will be affected by the specific operating conditions. Consequently, control efficiency estimates may not be precisely applicable to specific control devices. Knowledge of the process and engineering judgement must be used in addition to the estimate.

Control device efficiency estimates will also need to be adjusted for downtime or control device condition (e.g., degradation of fabric filter bags). If control devices are shut down periodically for maintenance or by upset conditions, the emissions released in a given hour may far exceed those released in the controlled mode over many hours of operation. Failure to

Table 5-1

Typical Control Devices and Control Efficiencies (%)[a]

	Pollutant			
Device/Technique	**Particulate Matter**	**VOC**	**SO_x**	**NO_x**
Cyclone	80-90 +			
Fabric Filter	80-99 +			
Electrostatic Precipitator	95-99 +			
Scrubber	80-95	--	80-98	--[b]
Absorption		90-99	--	--[b]
Adsorption		50-99	--[b]	--[b]
Condensation	--	50-95		
Thermal Incineration	--	95-99 +		
Catalytic Incineration		95-99 +		--
Selective Catalytic Reduction				40-90
Selective Noncatalytic Reduction				40-60

Sources: Emission Inventory Improvement Program (EIIP), July 1995a and Nevers, 1995.

[a] Efficiencies are estimates only. Specific knowledge of the actual process and device is required for a more accurate efficiency estimate.

[b] Experimental control technique.

-- = Data not available.
SO_x = oxides of sulfur
NO_x = oxides of nitrogen
VOC = volatile organic compound

account for excess emissions resulting from downtime and deteriorated efficiency can be a large source of error in an emission estimate.

5.2 Control Device Descriptions

Brief descriptions of some common control devices and techniques are presented in this section. Further detail can be found in *Air Pollution Control, A Design Approach* (Cooper and Alley, 1994). For additional information on control device advantages/disadvantages, cost, consult *Control Technologies for Hazardous Air Pollutants* (U.S. EPA, June 1991), *OAQPS Control Cost Manual* (U.S. EPA, 1990), and *Air Pollution Engineering Manual* (Buonicore 1992).

5.2.1 Cyclone

The cyclone (also known as a “mechanical collector”) is a particulate control device that uses gravity, inertia, and impaction to remove particles from a ducted stream. Large diameter cyclones are often used as primary cleaners to remove the bulk of heavier particles before from an air stream before entering a secondary cleaner (EIIP, 1995b).

5.2.2 Fabric Filter

Fabric filter systems (often called baghouses) filter particles through filtering elements (bags). Particles are caught on the surface of the bags, while the cleaned air stream passes through. Fabric filters can achieve the highest particulate collection efficiency of all particulate control devices (EIIP, 1995b).

5.2.3 Electrostatic Precipitator

Electrostatic precipitators (ESPs) are used to control particulate emissions. ESPs employ electrical forces to remove particles from the gas stream onto collecting plates. The accumulated particles are then knocked or washed off the plates and into collecting hoppers (EIIP, 1995b).

5.2.4 Scrubber

Scrubbers are used to remove particulate matter and sulfur oxides. Wet scrubbers utilize water to remove particles by direct contact from an air stream. Sulfur oxides may be controlled with alkaline liquids in wet or dry scrubbers.

5.2.5 Absorption

Absorption is an operation in which components of a gas mixture are transferred into a liquid. This process can be physical, when the absorbed compound simply dissolves in the solvent, or chemical, when a reaction occurs (U.S. EPA, 1991). In a majority of pollution control applications, the liquid is water and the process is sometimes referred to as scrubbing or washing (Cooper, 1994). The type of equipment most often used for gas/liquid contact operations is the packed tower. The gas stream enters the bottom of the column and passes upward through a wetted packed bed. The liquid enters the top of the column and is uniformly distributed over the column packing. Mass transfer from the gas to the liquid phase occurs across the gas-liquid interface provided by the wetted surface of the tower packing (Cooper, 1994).

5.2.6 Adsorption

An adsorber system controls VOC by selectively adsorbing the compounds on a surface, or bed, that is typically carbon. Adsorbed VOC are removed from the carbon bed in the process of desorption by heating the carbon, typically using steam, or by reducing the pressure of the system. These systems include fixed beds and moving beds, which are also known as fluidized beds. Some fluidized systems have also been designed for SO_2 adsorption (Nevers, 1995; U.S. EPA, 1991; Cooper, 1994).

5.2.7 Condensation

Condensation is a separation technique in which VOC are separated from a gas through saturation followed by a phase change to a liquid. Two techniques may be used to produce the VOC phase change: (1) increase the system pressure at a given temperature; or (2) reduce the system temperature at a constant pressure. The two most common types of condensers used are surface and contact condensers (U.S. EPA, 1991).

5.2.8 Incineration

Thermal incineration is a widely used control technique that oxidizes VOC at high temperatures. These devices are capable of high control efficiencies (e.g., greater than 99 percent VOC destruction). Catalysts may be used to help oxidize the VOC in catalytic incinerator systems (U.S. EPA, 1991).

5.2.9 Selective Reduction

Selective catalytic reduction is an add-on technology that controls nitrogen oxides by reacting them catalytically with ammonia to form nitrogen and water. Selective noncatalytic reduction technologies use a reducing agent to reduce the nitrogen oxides to nitrogen and water (EIIP, 1995a; EIIP, 1995b).

6.0 STACK PARAMETERS

Stack data are needed if the inventory is being used for air quality modeling. This includes the obvious smokestacks or chimneys, as well as less obvious vents, pipes, or other openings that exhaust air pollutants. Depending on the model and the modeling objective, stacks may be treated individually or may be grouped. The remainder of this chapter discusses the stack parameters. See *Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised* for more discussion on the requirements for modeling inventories (U.S. EPA, 1992).

The stack parameters usually required for modeling are:

- Location;
- Height;
- Diameter;
- Temperature;
- Velocity; and/or
- Volumetric flow rate.

In a large facility, compiling parameters for all stacks may pose a significant data collection challenge. It is often possible to treat groups of similar stacks as a single stack.

6.1 Stack Location

The location of each stack is identified by geographic coordinates such as latitude and longitude, or universal transverse mercator (UTM) coordinates. For dispersion modeling, the stack locations should be accurate to within 10 meters. For regional modeling, less accuracy may be tolerable. The stack locations can be determined by several different methods which are briefly described below.

6.1.1 Global Positioning System (GPS)

A GPS can be used to determine a location very accurately. Numerous GPS satellites currently in orbit around the earth function as known reference points; they broadcast satellite identity, position, and time. By making distance measurements to four or more satellites, the location of a GPS receiver on the ground can be determined using trilateration.

A good GPS is costly, with survey grade GPS receivers ranging from U.S. $10,000 to $30,000. A survey grade GPS receiver has a 1 cm to 1 meter accuracy depending on whether an FM receiver is used for differential correction or post-processing is performed from a base station fixed over a known point. Accuracy also depends on the occupation times over a location to be surveyed (10 minutes to 1 hour for cm accuracy).

Resource grade GPS receivers cost U.S. $600-4,000 and have a 1 to 10 meter accuracy. Recreational grade receivers cost U.S. $200-600 with 100 meter accuracy. The accuracy of these two grades of GPS receivers may not be adequate for certain point source inventory efforts with a small inventory domain or where micro-analysis is needed.

6.1.2 Survey Data/CAD Maps

If the site has been surveyed, the locations of specific stacks can sometimes be determined from the survey maps or computer aided design (CAD) files. At least two benchmarks must be located within the surveyed area; however, the more benchmarks within the area, the more accurate the stack can be located. The survey locations are then calibrated according to the benchmarks. The Instituto Nacional de Estadística, Geografía e Informática

(INEGI) [National Institute of Statistics, Geography and Computer Science] standards and procedures should be followed for identifying benchmarks.

6.1.3 Topographic Maps

The least accurate method for locating stacks is to use a topographic map to locate the plant. If the plant has more than one stack, it is unlikely that this method can be used to accurately locate each individual stack. However, this level of detail is generally not required for large-scale, regional modeling (see discussion in 6.1, above, on dealing with groups of stacks).

6.2 Stack Height

The stack height is measured from the ground. The most common inventory error for this parameter is in measuring the height above the roof rather than above ground. Three methods of determining stack height are described briefly below.

6.2.1 Clinometer

A clinometer is a simple device that can be used to measure the height of an object. The distance from the person taking the measurement to the base of the stack is also needed to complete the calculations. Accuracy varies and primarily depends on:

- How accurate the measurement to the base is; and
- Precision of the clinometer.

Figure 6-1 illustrates the use of a clinometer. In this figure, the stack is located at the edge of the building, so measurement of the distance to the base is not obstructed. If the stack is positioned near the middle of the building, it may be more accurate to measure building

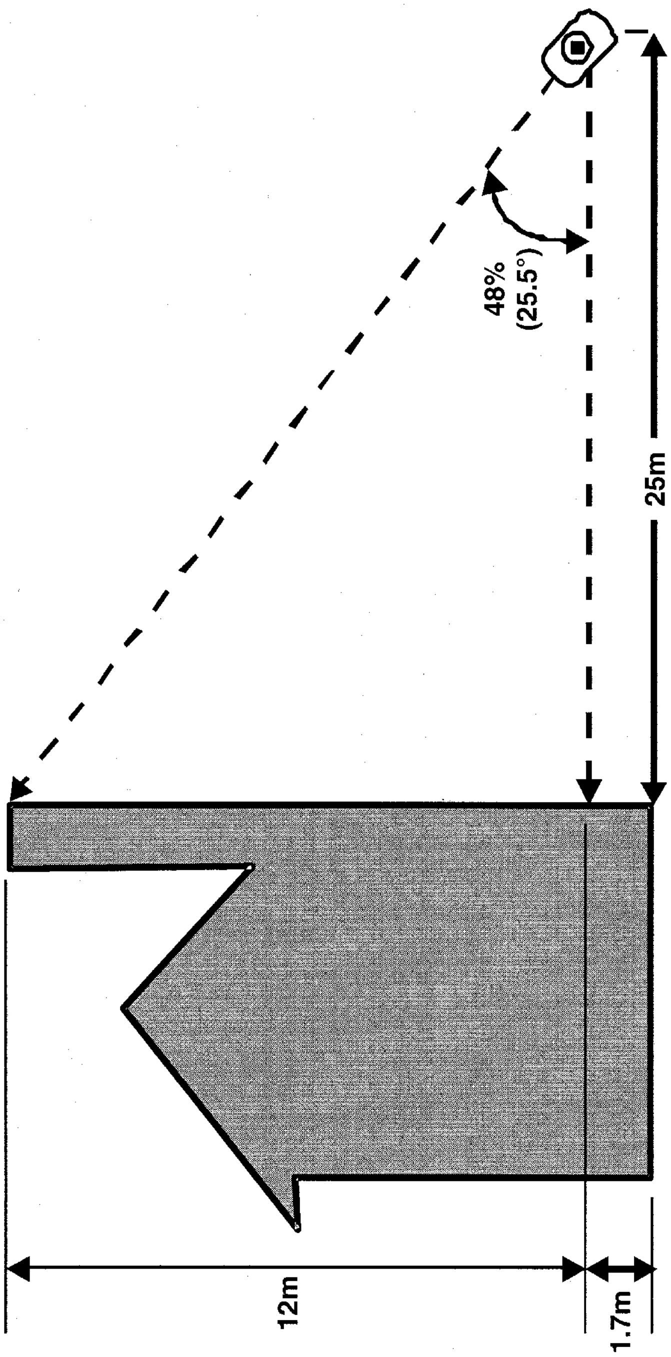


Figure 6-1. Using a Clinometer to Measure Stack Height

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height and stack height above the roof (using a clinometer) and add the two measurements together.

The clinometer reading is given as a percentage of the distance to the base. In the example shown in Figure 6-1, the stack height (from eye-level) is:

$$48/100 \times 25 = 12.0 \text{ m} \qquad (6\text{-}1)$$

The eye's height from the ground (1.7 m) is added to give a total height of 13.7 m.

6.2.2 Direct Measurement

If the stack is not too tall, the measurement can be made directly. Generally, it is easiest to drop a measuring tape from the roof to the ground to measure building height; then the height of the stack from the roof to the top of the stack is measured. The total height is equal to the sum of these two measurements.

6.2.3 Architectural/Engineering Drawings

If blue prints or other building schematics are available, the stack heights may be taken directly from them. However, verify the height (using one of the other two methods or by estimation) if possible.

6.3 Stack Diameter

The exit diameter or inner diameter of the stack are the parameters of interest. The inner diameter should be measured directly. If blueprints or drawings are used, verify the reasonableness of the values shown. This is a very important variable because it affects the exit velocity calculation and should, therefore, be measured as accurately as possible.

If the stack is not round, the diameter is calculated from the area of the stack. For example, the area (A) of a rectangular vent is calculated by measuring the length of the two (unequal) sides, and multiplying them together. The area of a circle is πr^2 (where r is the radius or 1/2 of the diameter). The effective diameter (d) therefore, is calculated as:

$$\mathbf{d} = \mathbf{2 \times \sqrt{A/\pi}} \tag{6-2}$$

6.4 Temperature

The temperature of the gases at the point where they leave the stack is another important variable. In most models, the exit temperature affects the height of the plume rise. This value should be measured just inside the top of the stack.

Remember that if the stack is very tall, the gases will cool significantly as they rise. Most exit temperatures for some specific processes fall within a typical range but temperatures outside those ranges are also possible. For example, wet scrubbers (or other controls) may significantly reduce temperatures from combustion processes.

6.5 Exit Velocity

This is the exit velocity of the stack gases. It is usually calculated from the stack diameter and volumetric flow rate as follows:

$$\textbf{Exit velocity (m/s)} = \frac{\textbf{flow rate (m}^3\textbf{/s)}}{\textbf{area of stack (m}^2\textbf{)}} \tag{6-3}$$

The area of the stack is calculated using the stack diameter at the point of exit (see Section 6.3 above).

6.6 Volumetric Flow Rate

The volumetric flow rate is the volume of gases exiting a stack or other emission point per unit of time (e.g., m^3/s).

The flow rate is not used directly for modeling. However, it is more commonly available (i.e., measured or in manufacturers’ specifications for exhaust fans) than is exit velocity. Therefore, the actual volumetric flow rate is typically used to calculate velocity (see Section 6.5). If the flow rate has been converted to a standard (or sometimes expressed as “normal” flow rate), it should be converted back to actual flow.

7.0 QUALITY ASSURANCE/ QUALITY CONTROL

Quality assurance activities are essential to the development of comprehensive, high-quality emission inventories for any purpose. The development of a reasonable and comprehensive emissions inventory requires the implementation of quality assurance/quality control (QA/QC) procedures throughout the entire inventory process. For more information on QA/QC, uncertainty, and emissions verification, see Emission Inventory Improvement Program (EIIP) Volume VI: *Quality Assurance Procedures for the Emission Inventory Improvement Program*, external draft (EIIP, 1995c).

Quality assurance is an integrated system of activities involving planning, QC, quality assessment, reporting, and quality improvements which are designed to help ensure that the inventory meets the data quality goals or objectives established prior to developing the inventory. Quality control is the overall system of routine technical activities that are designed to measure and control the quality of the inventory as it is being developed. The main objective of QA/QC for emissions inventories is the development of accurate, useful, and reliable data.

Figure 7-1 shows the basic steps involved in INE's point source inventory QA/QC procedures. The INE auditor randomly selects a facility to QA/QC from a strategic set of industrial sectors. The auditor obtains a copy of the industrial questionnaire (Encuesta Industrial) that the facility submitted to INE and performs a "general revision". This general revision consists of reviewing the submitted data for completeness and reasonableness. After that, the auditor makes a list of the SNIFF codes that the auditor thinks should be assigned to the data submitted on the questionnaire. Then, the SNIFF codes assigned by the auditor are compared with the codes that INE's coders actually assigned when they entered the questionnaire data into the SNIFF data files, and modifications are made, if necessary.

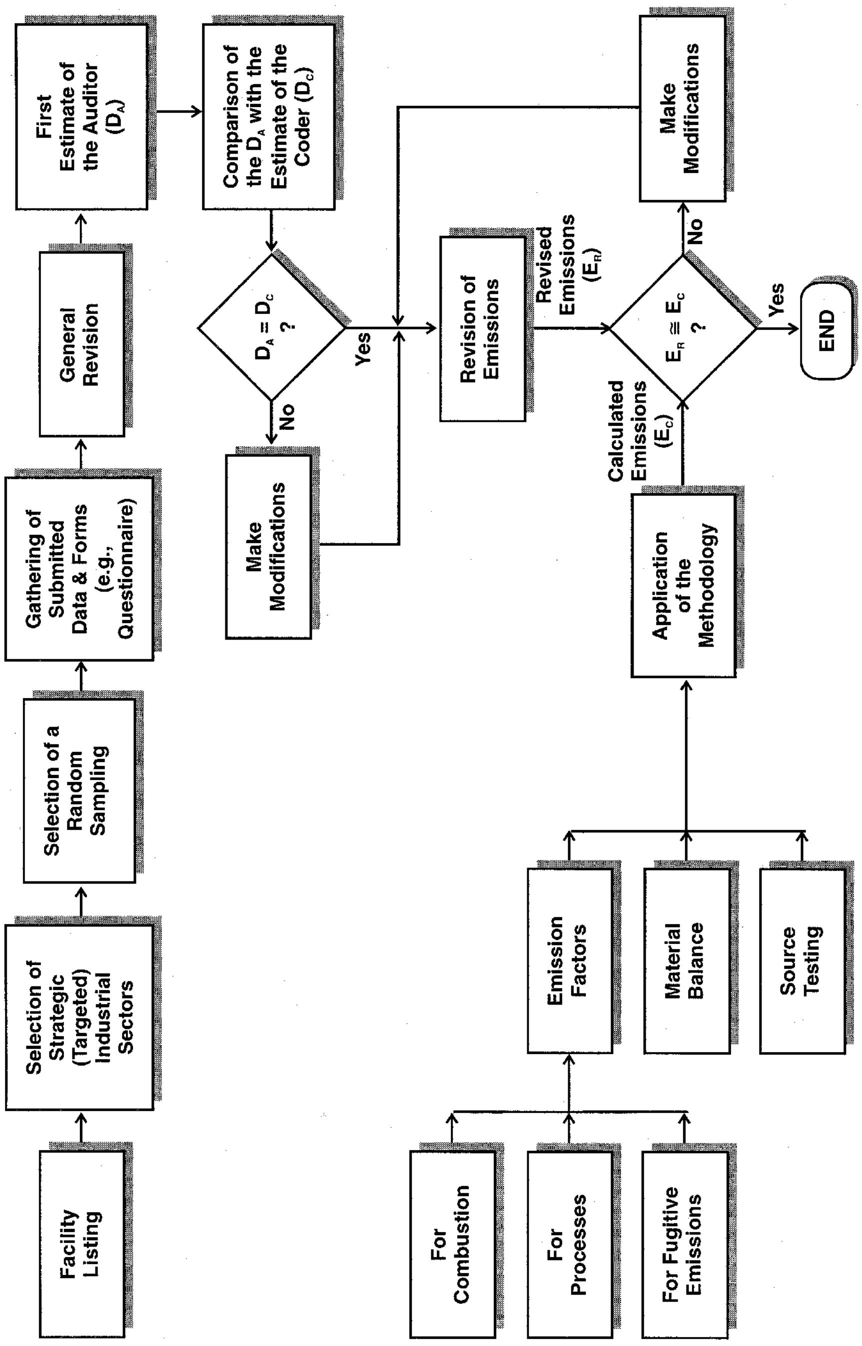

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Figure 7-1. INE's Point Source Inventory QA/QC Procedures

Next, the auditor looks at the “revised emissions” reported by the facility on the questionnaire and compares them to emissions calculated using a standard methodology. For example, a facility might submit an emissions estimate based on source test data on the questionnaire. This estimate might be compared to an emission estimate developed by the auditor based on the fuel usage and emission factors from AP-42. If the results from these two approaches are reasonably consistent, then the QA/QC procedure is complete. If not, then more QA/QC activities (e.g., follow-up call to facility, auditor review of source test results) must be performed until the auditor is satisfied that the emission estimate submitted to SNIFF is reasonable.

An example QC checklist for stationary point sources is included in Appendix IV-D. This checklist, designed for an inventory of ozone precursors, includes questions concerning completeness, use of approved methods, and reasonableness.

7.1 Statement of Data Quality Objectives

The first step in planning any inventory is to define the purpose and intended use of the inventory. This information will, in turn, be used to determine the data quality objectives (DQOs) for the inventory as well as the QA/QC requirements.

DQOs are statements of the level of uncertainty a decision maker is willing to accept. Their purpose is to ensure that the final data will be sufficient for its intended use. DQO statements must identify the end use or intended purpose of the data and the level of uncertainty anticipated in the emissions estimates.

It is very important to recognize that DQOs are method-specific; they are based on what is possible for a given methodology and the quality of the data available. The inventory preparers should look at the historical data. What problems have they had in the past that limited inventory quality? Can these problems be overcome for this effort? If this inventory is for a source or region that has never been inventoried, information and experiences from similar efforts should be studied.

DQOs should be planned in advance and written down. A complete DQO statement should address:

- Accuracy (or uncertainty) of emission estimates;
- Completeness;
- Representativeness; and
- Comparability.

Despite the best intentions of inventory preparers, the development effort is often constrained by schedules, resource limitations, and lack of data. The DQOs for the inventory should be realistic and need to account for any factors that will limit inventory quality. The important thing is that some thought be given in advance to the desired quality of the product.

Table 7-1 lists six important quality goals for inventories and gives general methods for achieving these goals.

7.2 Data Quality Indicators

Having determined the DQOs, the next, and often more difficult, step is to identify the data quality indicators (DQIs) that will be used to measure the progress towards each DQO. Quantitative measures (such as confidence limits, numerical ranking systems, or letter grades) are preferable. However, implementing these is also more difficult. An alternative is to use qualitative DQIs, which may simply be a critical discussion of the inventory’s strengths and limitations. Ultimately, the appropriate QA/QC will depend upon the methods employed for the inventory. See Section 7.3 for method specific QA/QC guidance.

Table 7-1

Methods for Achieving Emissions Inventory Data Quality Objectives

Data Quality Objectives	Methods
Ensure correct implementation of INE guidance.	• Review inventory documentation, comparing actual procedures used to those required.
Where INE guidance was not used or unavailable, assess bias by evaluating the reasonableness of the approach used.	• Technical review of approach used. • Compare with results from other methods.
Ensure accuracy of input data.	• Check accuracy of transcription of data. • Check any conversion factors used. • Assess reasonableness of assumptions used to calculate input data. • Verify that the data source was current and the best available.
Ensure accuracy of calculations.	• Reconstruct a representative sample (or all) by hand.
Assess comparability and representativeness of inventory.	• Compare emissions to those from similar inventories. • Cross-check activity data by comparing it to surrogates.
Assess completeness of inventory.	• Compare list of source categories or emission points to those listed in INE guidance. • Cross-check against other published inventories, business directories, etc.

7.3 QA/QC Procedures for Specific Emission Estimation Methods

The following sections contain detailed descriptions of QA/QC procedures for specific emission estimation techniques including source tests, emission factors, material balance, and emission models.

7.3.1 Source Tests

Thorough descriptions of stack sampling procedures, source sampling tools and equipment, identification and handling of samples, laboratory analysis, use of the sampling data, and preparation of reports are available in several references, such as the *Guidelines for Assessing and Reporting Data Quality for Environmental Measurements* (U.S. EPA, 1983) or *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III. Stationary Source Specific Methods* (U.S. EPA, 1984). These documents also contain a detailed discussion on the accuracy calculations required and interpretations of data, specific criteria for unacceptable data, and indications that a system is out-of-control. In addition to referencing the QA Handbook, a QA Plan should be developed by the team conducting the test prior to each specific field test.

A systems audit should be conducted on-site as a qualitative review of the various aspects of a total sampling and/or analytical system to assess its overall effectiveness. The systems audit should represent an objective evaluation of each system with respect to strengths, weaknesses, and potential problem areas. The audit provides an evaluation of the adequacy of the overall measurement system(s) to provide data of known quality which are sufficient, in terms of quantity and quality, to meet the program objectives.

The acceptance criteria and limits and values for each control parameter associated with manual sampling methods, such as dry gas meter calibration and leak rates, are summarized in Table 7-2. QA/QC procedures associated with CEMs (e.g., multi-point

Table 7-2

Summary of Manual Sampling Methods Acceptance Criteria and Control Limits

Parameter or Criteria	Control Limit and Values
Isokinetics TSP	100 ± 10%
Isokinetics PM_{10}	100 ± 20%
DP_{50} Calculated Cut Size	9 - 11 μg
Final Leak Rate (after each port)	≤0.02 acfm or 4% of sampling rate, whichever is less
Dry Gas Meter Calibration	Post average factor ( ) agree ± 5% of pre-factor
Individual Correction Factors (Y_i)	Agree within 2% of average factor
Average Correction Factor	1.00 ± 1%
Intermediate Dry Gas Meter	Calibrated every 6 months against standard
Analytical Balance (Top Loader)	0.1 g of National Bureau of Standards Class S Weights
Filter Constant Weight	Two weighings agree ± 0.5 mg

Source: EIIP, Volume VI, Table 9-2.

calibration of instruments, zeroing of instruments, calculation of drift, etc.) are contained in the specific reference methods (40 CFR, Part 60, Appendix A).

7.3.1.1 Error Analyses

The purpose of an error analysis is to identify the sources of error, to evaluate the relative magnitude of each error component in the results, and ultimately to minimize error by focusing on QA/QC efforts where they will have the most impact.

The emission rates of a particular pollutant are the product of stack gas and sampling measurements such as concentration (g/dscm) and emission rate (kg/hr) data. The magnitude of error in a concentration or emission rate caused by a measurement error can be calculated. Relative error can be defined as:

$$\textbf{Relative Error} = \textbf{(Observed - True)/True} \times \textbf{100} \qquad (7\text{-}1)$$

Table 7-3 illustrates how errors in stack gas measurements can affect the final concentrations and emission values. The resulting errors in concentrations and emission rates are caused from a hypothetical +10 percent isolated measurement error in various stack gas and sampling measurements. The following sections show in more detail how a measurement error can affect the parameter being measured during stack sampling.

7.3.1.2 Flow versus Stack Diameter

The following equation calculates the error in stack gas flow rate caused by a measurement error in stack diameter:

Table 7-3

Sensitivity of Emissions Test Results to Hypothetical Errors in Manual Measurements

Measurement	**Error Caused by +10% Error in Measurement**	
	Concentration Error[a] (%)	**Emission Rate Error[b] (%)**
D_s, Stack Diameter (meters)	0	21.0
p, Velocity Pressure (in H_2O)	0	4.9
P_{static}, Static Pressure (in H_2O)	0	0.03
P_{bar}, Barometric Pressure (in Hg)	-9.0	-3.8
T_s, Stack Temperature (°F)	0	-1.8
T_m, Meter Temperature (°F)	1.6	1.5
O_2, Oxygen Measurement (%V)	0	-0.03
CO_2, Carbon Dioxide Measurement (%V)	0	-0.3
H_2O, Water Entrainment (g)	0	-0.9
V, Meter Volume (m^3)	-9.1	-8.3
H, Meter Pressure (in H_2O)	-0.05	-0.04
Y, Meter Calibration	-9.1	-8.3
Pollutant Analysis (μg)	10.0	10.0

[a] Concentration of pollutant in stack gas. For example, a 10% error in the measured stack diameter has no affect on the reported concentration.

[b] Rate of emissions in mass per unit time or activity. For example, a 10% error in the measured stack diameter results in a 21% error in the estimated emission rate.

Source: EIIP, Volume VI, Table 9-4.

$$\mathbf{E_R = (2E_M + E_M^2)} \qquad (7\text{-}2)$$

where:

E_R = the resulting flow rate error (fraction)
E_M = the diameter measurement error (fraction)

For example, if E_M = 10%, then

$$E_R = (2 \text{ x } 0.1 + 0.1^2)$$

7.3.1.3 Flow versus Velocity Pressure

The following equation calculates the error in stack gas flow rate caused by a measurement error in velocity pressure:

$$\mathbf{E_R = \sqrt{(1 + E_M)} - 1} \qquad (7\text{-}3)$$

For example, if E_M = 10%, then

$$E_R = \sqrt{(1 + 0.1)} - 1$$
$$= 0.049 \quad 4.9\%$$

Therefore, a 10 percent error in velocity pressure measurement results in a 4.9 percent error in flow measurement.

7.3.2 Emission Factors

Data used to develop emission factors available in *AP-42* or the Factor Information Retrieval System (FIRE) system, for example, are obtained from source tests, material balance studies, and engineering estimates. The data are acquired through technical papers and reports, actual test results and reports, and personal communication.

Each emission factor published in *AP-42* or FIRE receives a quality rating, which serves as an assessment of the confidence the generator of that value places in the accuracy of the emission factor. When using existing emission factors, the user should be familiar with the criteria for assigning data quality ratings and emission factor ratings as described in the document *Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections* (U.S. EPA, 1993b). The inventory preparer should review the data and emission factor ratings associated with the major sources in the inventory. If emission estimates for a major source have been developed using data or emission factors with a low rating, further attempts should be made to obtain site-specific or region-specific data.

The criteria for assigning the data quality ratings to source tests are as follows:

- A-rated test(s) was performed by a sound methodology and reported in enough detail for adequate validation. These tests are not necessarily U.S. EPA reference test methods, although such reference methods are certainly to be used as a guide;
- B-rated test(s) was performed by a generally sound methodology but lacked enough detail for adequate validation;
- C-rated test(s) was based on a nonvalidated or draft methodology or lacked a significant amount of background data; and
- D-rated test(s) was based on a generally unacceptable method but may provide an order-of-magnitude value for the source.

Once the data quality ratings for the source tests are assigned, these ratings along with the number of source tests available for a given emission point are evaluated. Because of the almost impossible task of assigning a meaningful confidence limit to industry-specific variables (*e.g.*, sample size versus sample population, industry and facility variability, method of measurement), the use of a statistical confidence interval for establishing a representative emission factor for each source category is usually not practical. Therefore, some subjective quality rating is necessary. The following emission factor quality ratings are used for the emission factors found in *AP-42*, FIRE, or any U.S. EPA published document:

A - Excellent - The emission factor was developed only from A-rated test data taken from many randomly chosen facilities in the industry population. The source category is specific enough to minimize variability within the source category population.

B - Above Average - The emission factor was developed only from A-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 is specific enough to minimize variability within the source category population.

C - Average - The emission factor was developed only from A- and 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 the A-rating, the source category is specific enough to minimize variability within the source category population.

D - Below Average - The emission factor was developed only from A- and B-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 category population.

E - Poor - The emission factor was 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.

U - Unrated or Unratable - The emission factor was developed from suspect data with no supporting documentation to accurately apply an “A” through “E” rating. A “U” rating may be applied in the following circumstances (FIRE):

U1 - Mass Balance (for example, estimating air emissions based on raw material input, product recovery efficiency, and percent control).

U2 - Source test deficiencies (such as inadequate quality assurance/quality control, questionable source test methods, only one source test).

U3 - Technology transfer.

U4 - Engineering judgement.

U5 - Lack of supporting documentation.

7.3.3 Material Balance

If a mass balance method is used to estimate emissions, the preparer should:

- Ensure that all assumptions made are reasonable;
- Ensure that all end points and pathways are identified and quantified;
- Ensure that all data are accurate (consumption, etc.); and
- Check that the emissions are reasonable (compared to the previous years results or other reference points).

7.3.4 Emission Models

If a model is used to estimate emissions, the preparer should:

- Verify the accuracy of input data;

- Verify that all software used has been quality assured;

- Where possible, model results should be verified with a manual calculation, otherwise, results should be compared to results from an alternative method; and

- Check that the emissions results are reasonable (compared to the previous years results or other reference points).

8.0 DATA CODING PROCEDURES

Data coding is an integral part of an emissions inventory. Using unique codes for inventory data will ensure that the data are properly maintained and retrievable. For example, each facility should be assigned a unique identification number (see Section 8.2). In order to track inventories for review or update, the information must be coded in a unique way as to allow for easy retrieval.

Also, in order to share or transfer data to other users, the information must be in a consistent and recognizable format. All agency inventory activities should be coordinated so that submittal and update procedures flow smoothly for each inventory. A useful data coding system should allow for the following:

- Identification of the type of data included; and
- Storage and retrieval of specific data.

8.1 Facility Identification Codes

In order to track and update a facility's inventory, a unique facility identification code should be assigned to each plant. Suggestions for assigning these codes are as follows:

- Use a predetermined number of characters in the code (such as one letter, followed by four numbers);
- Keep the facility identification code short (less data entry time and less likelihood of data entry errors); and
- The use of a letter within the code significantly increases the number of unique combinations you can have.

Within a facility, each emission unit (EU), emission point (EP), and control device (CD) should be identified with a unique code such as EU1, EP1, EP2, and CD1, CD2, and so on.

8.2 SNIFF Data Coding Procedures

Currently, information gathered through the INE's industrial questionnaire is integrated in the National Information System of Point Sources (SNIFF) database. The parameters, quantity of codes, and number of informational fields available in SNIFF are identified in Table 8-1.

The codes used for data entered into SNIFF were specifically developed by INE for the Emissions Inventory Program and are contained in internal INE code catalogs. Data coding and entry are usually performed by the INE personnel. In order to obtain a copy of the code catalog, you must submit a request to the INE's Subdirectorate of Emissions Inventory.

As the inventory process in Mexico becomes further developed and the electronic reporting and storing of data becomes more sophisticated, a more precise and descriptive method for identifying industrial activity will be required. For example, the Source Classification Code (SCC) system, described in Section 8.3, introduces an expanded concept of applying unique identification codes to individual processes.

8.3 Source Classification Codes (SCCs)

Many databases use SCC codes to link emissions data to specific technology types. Each SCC represents a unique process or function within a source category that is logically associated with a point of air pollution emissions. With an appropriate SCC, a process can be accurately identified for retrieval purposes.

Table 8-1

Identifying Features of the SNIFF Code System

Parameter	Approximate Number of Codes	Number of Fields
Location	by district, state and municipality	3
Activity of the company (industrial sector)	450[a]	1
Process type	396	1 (only the principal process)
Machinery and equipment	350	5 (one for each process phase)
Raw materials	2,000	6
Products	22,000	7
Fuels	13	1
Fuel Units	28	1
Pollutants	100[b]	5
Control devices	170	10 (2 for each process phase)
Control device capacity	22	1

[a] The classification system that is used by SNIFF to identify industrial activities has 7 digits. The first 2 digits correspond to the level of severity or potential for air pollution from a given industrial branch (01 for the group of the largest emittors, 02 for the next largest emittors, and 03 for the minor emittors or those that are considered to be area sources). The following 2 digits identify the industrial branch or sector (0101 for electric utility plants, 0102 for petroleum refineries and petrochemical plants, 0103 for chemical processes, etc.), and the last 3 digits correspond to the subsector within the industrial branch (0103002 for fabrication of ammonia and its derivatives, 0102004 for fabrication of nitric acid, etc.).

[b] Only criteria pollutants are reported.

The SCCs are divided into four levels of identification: Levels I, II, III, and IV, consisting of 1, 2, 3, and 2 digits, respectively. Level I identifies the category of the process with a one digit number as shown in Table 8-2. The second level (II) of identification is a 2-digit code that signifies the major industry group. For example, Industrial Processes (Level I, code 3) are subdivided into chemical manufacturing (3-01), food/agricultural (3-02), primary metals (3-03), etc. The third level, a 3-digit number, indicates the major product, raw material, fuel, or piece of equipment. The fourth level of classification, a 2-digit number, identifies different operations at the point source. As an example, the assignment of an SCC for an electric utility burning pulverized bituminous coal in a wet bottom furnace is shown in Figure 8-1.

In some cases, “General” appears as a fourth-level SCC process description. This indicates that the process or series of processes have been identified and simplified into a “black box” or group of activities rather than a complex assortment of related emissions sources. Normally, “General” SCCs are replaced by more specific SCCs when more detailed information about the process becomes available.

The term “Other Not Classified” is a fourth-level SCC process description that can be used to represent activities that exist but for which no specific SCC has been defined. These “Other Not Classified” SCCs are usually represented by codes ending in “99". If these codes are used, then the emissions inventory specialist is strongly urged to enter into a comment field an appropriate entry that more fully describes the emissions discharged.

A complete numerical listing of SCCs is available for downloading from the Clearinghouse for Inventories and Emission Factors (CHIEF) bulletin board system (BBS) 95-919-541-5742 (which is a modem access line) and from the Factor Information Retrieval (FIRE) System database. A hardcopy of the SCC listing is included in Appendix IV-E of this document.

Table 8-2

Level I SCC Categories

Level I Values	Process Category	Category Description
1	External Combustion Sources	Boilers and space heaters
2	Internal Combustion Sources	Turbines and reciprocating engines
3	Industrial Processes	All industrial processes other than evaporation sources, and combustion for steam or power, and disposal of solid waste
4	Evaporation Sources	Surface coating operations, petroleum storage, and printing operations
5	Solid Waste Disposal	Incineration of wastes, wastewater treatment, landfills, treatment, storage, and disposal facility (TSDF) processes

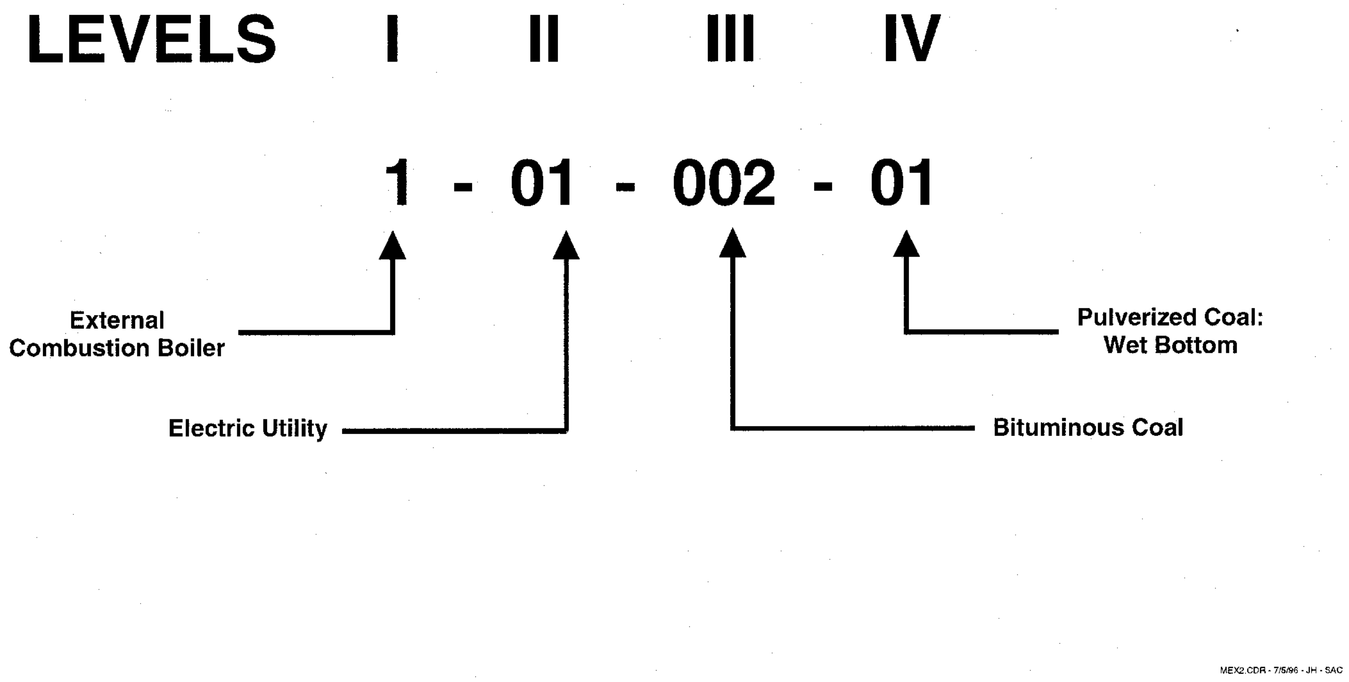

Figure 8-1. SCC for Electric Utility Burning Pulverized Bituminous Coal in a Wet Bottom Furnace

9.0 DATA COLLECTION

Data collection should be done efficiently to obtain the information required to calculate emissions. Using data collection forms or questionnaires are the most efficient means of gathering information. Once completed, the forms themselves may be kept as background documentation for emissions inventory development. Data collection forms may be generic enough to be used at any facility, or may be developed individually for each industry or device type. A detailed discussion for surveying facilities is presented in Section 5 of Volume III: *Basic Emission Estimating Techniques*.

9.1 General Questionnaire

A general questionnaire is merely a collection of process-specific questionnaires. It is best used if the mailing list is long, if the agency is unfamiliar with many of the sources on the list, or if agency resources are limited.

Developing a questionnaire involves the following:

- Establish a suitable format and make it as simple and functional as possible;
- Identify and write the appropriate questions;
- Develop a cover letter and instructions for filling out the questionnaire;
- Design the questionnaire for the person who will be asked to complete it; consider the technical background and experience level of the person who will complete the questionnaire;
- Design the questionnaire to be understood by persons without specialized technical training;
- Space the questions for readability with sufficient area for complete responses;

- Make the questionnaire as short as possible; lengthy questionnaires can be intimidating;
- Use terminology that will be familiar to the recipient;
- Ensure that each question is self-explanatory or accompanied by clear directions;
- Solicit all necessary information on the questionnaire, thus avoiding later requests for additional data;
- Consider the ultimate use of the data when determining the information to request on the questionnaire;
- Collect any additional data needed for subsequent application of a photochemical model at this time;
- Request process information in addition to general source information such as location, ownership, and nature of business;
- Obtain appropriate activity levels (such as indicators of production and fuel consumption) for each type of source; and
- Obtain control device information to estimate controlled emissions and to determine potential reductions in emissions for applying various control strategies.

In accordance with Article 17 of the *Regulation in Matters of the Prevention and Control of Atmospheric Pollution*, those responsible for the point sources under federal jurisdiction that emit odors, gases, solid particulates or liquids to the atmosphere should present an inventory of their containment emissions to the atmosphere. INE has developed two point source questionnaires to collect this information. The data that are obtained from the industrial questionnaire (Formato LF-CO) and the microindustry questionnaire (Formato IE-MI) are integrated in the SNIFF database (see Section 8.2). Appendix IV-F contains these questionnaires.

9.2 Industry-specific Questionnaire

Ideally, a questionnaire sent to any facility would be industry-specific and would only address information pertaining to the industry of interest. If sufficient resources are available to design an industry-specific questionnaire, it may be advantageous to do so. Advantages and disadvantages to using industry-specific questionnaires are listed below:

Advantages

- Questionnaires are generally shorter because questions not applicable to the particular industry are not included; and
- Can use industry-specific terminology that is familiar to those working in a particular industry which enhances communication, reduces confusion and increases inventory accuracy.

Disadvantages

- The design of many industry-specific questionnaires can require significant resources;
- The returned questionnaires must be processed individually because of the variations in format for different industries; and
- Industry-specific questionnaires may be incorrectly sent to some sources because of limited prior knowledge of the operations at these sources.

9.3 Device Level Data Collection Forms

Appendix IV-G contains examples of device specific data collection forms for surface coating operations, boilers, and fugitive equipment leaks. These forms may be distributed blank, or may be filled in by the regulatory agency using previously gathered information about the source. This approach is appropriate for periodic (monthly, annual, etc.) updates of a source’s emissions inventory.

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APPENDIX IV-A

INE'S POINT SOURCE INVENTORY DEVELOPMENT PROCESS

APPENDIX IV-B

MISCELLANEOUS DATA AND CONVERSION FACTORS

SOME USEFUL WEIGHTS AND MEASURES

Unit Of Measure	Equivalent	
grain	0.002	ounces
gram	0.04	ounces
ounce	28.35	grams
kilogram	2.21	pounds
pound	0.45	kilograms
pound (troy)	12	ounces
ton (short)	2000	pounds
ton (long)	2240	pounds
ton (metric)	2200	pounds
ton (shipping)	40	feet^3
centimeter	0.39	inches
inch	2.54	centimeters
foot	30.48	centimeters
meter	1.09	yards
yard	0.91	meters
mile	1.61	kilometers
centimeter^2	0.16	inches^2
inch^2	6.45	centimeters^2
foot^2	0.09	meters^2
meter^2	1.2	yards^2
yard^2	0.84	meters^2
mile^2	2.59	kilometers^2
centimeter^3	0.061	inches^3
inch^3	16.39	centimeters^3
foot^3	283.17	centimeters^3
foot^3	1728	inches^3

SOME USEFUL WEIGHTS AND MEASURES (cont.)

Unit Of Measure	Equivalent	
$meter^3$	1.31	$yards^3$
$yard^3$	0.77	$meters^3$
cord	128	$feet^3$
cord	4	$meters^3$
peck	8	quarts
bushel (dry)	4	pecks
bushel	2150.4	$inches^3$
gallon (U. S.)	231	$inches^3$
barrel	31.5	gallons
hogshead	2	barrels
township	36	$miles^2$
hectare	2.5	acres

MISCELLANEOUS DATA

One cubic foot of anthracite coal weighs about 53 pounds.

One cubic foot of bituminous coal weighs from 47 to 50 pounds.

One ton of coal is equivalent to two cords of wood for steam purposes.

A gallon of water (U. S. Standard) weighs 8.33 pounds and contains 231 cubic inches.

There are 9 square feet of heating surface to each square foot of grate surface.

A cubic foot of water contains 7.5 gallons and 1728 cubic inches, and weighs 62.5 lbs.

Each nominal horsepower of a boiler requires 30 to 35 pounds of water per hour.

A horsepower is equivalent to raising 33,000 pounds one foot per minute, or 550 pounds one foot per second.

To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by 0.434.

TYPICAL PARAMETERS OF VARIOUS FUELS[a]

Type Of Fuel	Heating Value		Sulfur % (by weight)	Ash % (by weight)
	kcal	Btu		
Solid Fuels				
Bituminous Coal	7,200/kg	13,000/lb	0.6-5.4	4-20
Anthracite Coal	6,810/kg	12,300/lb	0.5-1.0	7.0-16.0
Lignite (@ 35% moisture)	3,990/kg	7,200/lb	0.7	6.2
Wood (@ 40% moisture)	2,880/kg	5,200/lb	N	1-3
Bagasse (@ 50% moisture)	2,220/kg	4,000/lb	N	1-2
Bark (@ 50% moisture)	2,492/kg	4,500/lb	N	1-3[b]
Coke, Byproduct	7,380/kg	13,300/lb	0.5-1.0	0.5-5.0
Liquid Fuels				
Residual Oil	$9.98 \times 10^6/m^3$	150,000/gal	0.5-4.0	0.05-0.1
Distillate Oil	$9.30 \times 10^6/m^3$	140,000/gal	0.2-1.0	N
Diesel	$9.12 \times 10^6/m^3$	137,000/gal	0.4	N
Gasoline	$8.62 \times 10^6/m^3$	130,000/gal	0.03-0.04	N
Kerosene	$8.32 \times 10^6/m^3$	135,000/gal	0.02-0.05	N
Liquid Petroleum Gas	$6.25 \times 10^6/m^3$	94,000/gal	N	N
Gaseous Fuels				
Natural Gas	$9,341/m^3$	1,050/SCF	N	N
Coke Oven Gas	$5,249/m^3$	590/SCF	0.5-2.0	N
Blast Furnace Gas	$890/m^3$	100/SCF	N	N

[a] N = negligible.

[b] Ash content may be considerably higher when sand, dirt, etc., are present.

THERMAL EQUIVALENTS FOR VARIOUS FUELS

Type Of Fuel	kcal	Btu (gross)
Solid fuels		
Bituminous coal	(5.8 to 7.8) x 10^6/Mg	(21.0 to 28.0) x 10^6/ton
Anthracite coal	7.03 x 10^6/Mg	25.3 x 10^6/ton
Lignite	4.45 x 10^6/Mg	16.0 x 10^6/ton
Wood	1.47 x 10^6/m^3	21.0 x 10^6/cord
Liquid fuels		
Residual fuel oil	10 x 10^3/liter	6.3 x 10^6/bbl
Distillate fuel oil	9.35 x 10^3/liter	5.9 x 10^6/bbl
Gaseous fuels		
Natural gas	9,350/m^3	1,050/ft^3
Liquefied petroleum gas		
Butane	6,480/liter	97,400/gal
Propane	6,030/liter	90,500/gal

WEIGHTS OF SELECTED SUBSTANCES

Type Of Substance	g/liter	lb/gal
Asphalt	1030	8.57
Butane, liquid at 60°F	579	4.84
Crude oil	850	7.08
Distillate oil	845	7.05
Gasoline	739	6.17
Propane, liquid at 60°F	507	4.24
Residual oil	944	7.88
Water	1000	8.4

DENSITIES OF SELECTED SUBSTANCES

Substance	Density	
Fuels		
Crude Oil	874 kg/m^3	7.3 lb/gal
Residual Oil	944 kg/m^3	7.88 lb/gal
Distillate Oil	845 kg/m^3	7.05 lb/gal
Gasoline	739 kg/m^3	6.17 lb/gal
Natural Gas	673 kg/m^3	1 lb/23.8 ft^3
Butane	579 kg/m^3	4.84 lb/gal (liquid)
Propane	507 kg/m^3	4.24 lb/gal (liquid)
Wood (Air dried)		
Elm	561 kg/m^3	35 lb/ft^3
Fir, Douglas	513 kg/m^3	32 lb/ft^3
Fir, Balsam	400 kg/m^3	25 lb/ft^3
Hemlock	465 kg/m^3	29 lb/ft^3
Hickory	769 kg/m^3	48 lb/ft^3
Maple, Sugar	689 kg/m^3	43 lb/ft^3
Maple, White	529 kg/m^3	33 lb/ft^3
Oak, Red	673 kg/m^3	42 lb/ft^3
Oak, White	769 kg/m^3	48 lb/ft^3
Pine, Southern	641 kg/m^3	40 lb/ft^3
Agricultural Products		
Corn	25.4 kg/bu	56 lb/bu
Milo	25.4 kg/bu	56 lb/bu
Oats	14.5 kg/bu	32 lb/bu
Barley	21.8 kg/bu	48 lb/bu
Wheat	27.2 kg/bu	60 lb/bu
Cotton	226 kg/bale	500 lb/bale
Mineral Products		
Brick	2.95 kg/brick	6.5 lb/brick
Cement	170 kg/bbl	375 lb/bbl

DENSITIES OF SELECTED SUBSTANCES (cont.)

Substance	Density	
Cement	1483 kg/m^3	2500 lb/yd^3
Concrete	2373 kg/m^3	4000 lb/yd^3
Glass, Common	2595 kg/m^3	162 lb/ft^3
Gravel, Dry Packed	1600 - 1920 kg/m^3	100 - 120 lb/ft^3
Gravel, Wet	2020 kg/m^3	126 lb/ft^3
Gypsum, Calcined	880 - 960 kg/m^3	55 - 60 lb/ft^3
Lime, Pebble	850 - 1025 kg/m^3	53 - 64 lb/ft^3
Sand, Gravel (Dry, loose)	1440 - 1680 kg/m^3	90 - 105 lb/ft^3

CONVERSION FACTORS

The table of conversion factors on the following pages contains factors for converting English to metric units and metric to English units as well as factors to manipulate units within the same system. The factors are arranged alphabetically by unit within the following property groups.

-Area
-Density
-Energy
-Force
-Length
-Mass
-Pressure
-Velocity
-Volume
-Volumetric Rate

To convert a number from one unit to another:

1. Locate the unit in which the number is currently expressed in the left-hand column of the table;

2. Find the desired unit in the center column; and

3. Multiply the number by the corresponding conversion factor in the right-hand column.

CONVERSION FACTORS[a]

To Convert From	To	Multiply By
Area		
Acres	Sq feet	4.356×10^{4}
Acres	Sq kilometers	4.0469×10^{-3}
Acres	Sq meters	4.0469×10^{3}
Acres	Sq miles (statute)	1.5625×10^{-3}
Acres	Sq yards	4.84×10^{3}
Sq feet	Acres	2.2957×10^{-5}
Sq feet	Sq cm	929.03
Sq feet	Sq inches	144.0
Sq feet	Sq meters	0.092903
Sq feet	Sq miles	3.587×10^{-8}
Sq feet	Sq yards	0.111111
Sq inches	Sq feet	6.9444×10^{-3}
Sq inches	Sq meters	6.4516×10^{-4}
Sq inches	Sq mm	645.16
Sq kilometers	Acres	247.1
Sq kilometers	Sq feet	1.0764×10^{7}
Sq kilometers	Sq meters	1.0×10^{6}
Sq kilometers	Sq miles	0.386102
Sq kilometers	Sq yards	1.196×10^{6}
Sq meters	Sq cm	1.0×10^{4}
Sq meters	Sq feet	10.764
Sq meters	Sq inches	1.55×10^{3}
Sq meters	Sq kilometers	1.0×10^{-6}
Sq meters	Sq miles	3.861×10^{-7}
Sq meters	Sq mm	1.0×10^{6}
Sq meters	Sq yards	1.196
Sq miles	Acres	640.0
Sq miles	Sq feet	2.7878×10^{7}
Sq miles	Sq kilometers	2.590

CONVERSION FACTORS (cont.)[a]

To Convert From	To	Multiply By
Sq miles	Sq meters	2.59×10^6
Sq miles	Sq yards	3.0976×10^6
Sq yards	Acres	2.0661×10^{-4}
Sq yards	Sq cm	8.3613×10^3
Sq yards	Sq ft	9.0
Sq yards	Sq inches	1.296×10^3
Sq yards	Sq meters	0.83613
Sq yards	Sq miles	3.2283×10^{-7}
Density		
Dynes/cu cm	Grams/cu cm	1.0197×10^{-3}
Grains/cu foot	Grams/cu meter	2.28835
Grams/cu cm	Dynes/cu cm	980.665
Grams/cu cm	Grains/milliliter	15.433
Grams/cu cm	Grams/milliliter	1.0
Grams/cu cm	Pounds/cu inch	1.162
Grams/cu cm	Pounds/cu foot	62.428
Grams/cu cm	Pounds/cu inch	0.036127
Grams/cu cm	Pounds/gal (Brit.)	10.022
Grams/cu cm	Pounds/gal (U. S., dry)	9.7111
Grams/cu cm	Pounds/gal (U. S., liq.)	8.3454
Grams/cu meter	Grains/cu foot	0.4370
Grams/liter	Pounds/gal (U. S.)	8.345×10^{-3}
Kilograms/cu meter	Grams/cu cm	0.001
Kilograms/cu meter	Pounds/cu ft	0.0624
Kilograms/cu meter	Pounds/cu in	3.613×10^{-5}
Pounds/cu foot	Grams/cu cm	0.016018
Pounds/cu foot	kg/cu meter	16.018
Pounds/cu inch	Grams/cu cm	27.68
Pounds/cu inch	Grams/liter	27.681
Pounds/cu inch	kg/cu meter	2.768×10^4

CONVERSION FACTORS (cont.)[a]

To Convert From	To	Multiply By
Pounds/gal (U. S., liq.)	Grams/cu cm	0.1198
Pounds/gal (U. S., liq.)	Pounds/cu ft	7.4805
Energy		
Btu	Cal. gm (IST.)	251.83
Btu	Ergs	1.05435×10^{10}
Btu	Foot-pounds	777.65
Btu	Hp-hours	3.9275×10^{-4}
Btu	Joules (Int.)	1054.2
Btu	kg-meters	107.51
Btu	Kw-hours (Int.)	2.9283×10^{-4}
Btu/hr	Cal. kg/hr	0.252
Btu/hr	Ergs/sec	2.929×10^{6}
Btu/hr	Foot-pounds/hr	777.65
Btu/hr	Horsepower (mechanical)	3.9275×10^{-4}
Btu/hr	Horsepower (boiler)	2.9856×10^{-5}
Btu/hr	Horsepower (electric)	3.926×10^{-4}
Btu/hr	Horsepower (metric)	3.982×10^{-4}
Btu/hr	Kilowatts	2.929×10^{-4}
Btu/lb	Foot-pounds/lb	777.65
Btu/lb	Hp-hr/lb	3.9275×10^{-4}
Btu/lb	Joules/gram	2.3244
Calories, kg (mean)	Btu (IST.)	3.9714
Calories, kg (mean)	Ergs	4.190×10^{10}
Calories, kg (mean)	Foot-pounds	3.0904×10^{3}
Calories, kg (mean)	Hp-hours	1.561×10^{-3}
Calories, kg (mean)	Joules	4.190×10^{3}
Calories, kg (mean)	kg-meters	427.26
Calories, kg (mean)	kW-hours (Int.)	1.1637×10^{-3}
Ergs	Btu	9.4845×10^{-11}
Ergs	Foot-poundals	2.373×10^{-6}

CONVERSION FACTORS (cont.)[a]

To Convert From	To	Multiply By
Ergs	Foot-pounds	7.3756×10^{-8}
Ergs	Joules (Int.)	9.99835×10^{-8}
Ergs	kW-hours	2.7778×10^{-14}
Ergs	kg-meters	1.0197×10^{-8}
Foot-pounds	Btu (IST.)	1.2851×10^{-3}
Foot-pounds	Cal. kg (IST.)	3.2384×10^{-4}
Foot-pounds	Ergs	1.3558×10^{7}
Foot-pounds	Foot-poundals	32.174
Foot-pounds	Hp-hours	5.0505×10^{-7}
Foot-pounds	Joules	1.3558
Foot-pounds	kg-meters	0.138255
Foot-pounds	kW-hours (Int.)	3.76554×10^{-7}
Foot-pounds	Newton-meters	1.3558
Foot-pounds/hr	Btu/min	2.1432×10^{-5}
Foot-pounds/hr	Ergs/min	2.2597×10^{5}
Foot-pounds/hr	Horsepower (mechanical)	5.0505×10^{-7}
Foot-pounds/hr	Horsepower (metric)	5.121×10^{-7}
Foot-pounds/hr	Kilowatts	3.766×10^{-7}
Horsepower (mechanical)	Btu (mean)/hr	2.5425×10^{3}
Horsepower (mechanical)	Ergs/sec	7.457×10^{9}
Horsepower (mechanical)	Foot-pounds/hr	1.980×10^{6}
Horsepower (mechanical)	Horsepower (boiler)	0.07602
Horsepower (mechanical)	Horsepower (electric)	0.9996
Horsepower (mechanical)	Horsepower (metric)	1.0139
Horsepower (mechanical)	Joules/sec	745.70
Horsepower (mechanical)	Kilowatts (Int.)	0.74558
Horsepower (boiler)	Btu (mean)/hr	3.3446×10^{4}
Horsepower (boiler)	Ergs/sec	9.8095×10^{10}
Horsepower (boiler)	Foot-pounds/min	4.341×10^{5}
Horsepower (boiler)	Horsepower (mechanical)	13.155

CONVERSION FACTORS (cont.)[a]

To Convert From	To	Multiply By
Horsepower (boiler)	Horsepower (electric)	13.15
Horsepower (boiler)	Horsepower (metric)	13.337
Horsepower (boiler)	Joules/sec	9.8095×10^{3}
Horsepower (boiler)	Kilowatts	9.8095
Horsepower (electric)	Btu (mean)/hr	2.5435×10^{3}
Horsepower (electric)	Cal. kg/hr	641.87
Horsepower (electric)	Ergs/sec	7.46×10^{9}
Horsepower (electric)	Foot-pounds/min	3.3013×10^{4}
Horsepower (electric)	Horsepower (boiler)	0.07605
Horsepower (electric)	Horsepower (metric)	1.0143
Horsepower (electric)	Joules/sec	746.0
Horsepower (electric)	Kilowatts	0.746
Horsepower (metric)	Btu (mean)/hr	2.5077×10^{3}
Horsepower (metric)	Ergs/sec	7.355×10^{9}
Horsepower (metric)	Foot-pounds/min	3.255×10^{4}
Horsepower (metric)	Horsepower (mechanical)	0.98632
Horsepower (metric)	Horsepower (boiler)	0.07498
Horsepower (metric)	Horsepower (electric)	0.9859
Horsepower (metric)	kg-meters/sec	75.0
Horsepower (metric)	Kilowatts	0.7355
Horsepower-hours	Btu (mean)	2.5425×10^{3}
Horsepower-hours	Foot-pounds	1.98×10^{6}
Horsepower-hours	Joules	2.6845×10^{6}
Horsepower-hours	kg-meters	2.73745×10^{5}
Horsepower-hours	kW-hours	0.7457
Joules (Int.)	Btu (IST.)	9.4799×10^{-4}
Joules (Int.)	Ergs	1.0002×10^{7}
Joules (Int.)	Foot-poundals	12.734
Joules (Int.)	Foot-pounds	0.73768
Joules (Int.)	kW-hours	2.778×10^{-7}

CONVERSION FACTORS (cont.)[a]

To Convert From	To	Multiply By
Joules (Int.)/sec	Btu (mean)/min	0.05683
Joules (Int.)/sec	Cal. kg/min	0.01434
Joules (Int.)/sec	Horsepower	1.341×10^{-3}
Kilogram-meters	Btu (mean)	9.2878×10^{-3}
Kilogram-meters	Cal. kg (mean)	2.3405×10^{-3}
Kilogram-meters	Ergs	9.80665×10^{7}
Kilogram-meters	Foot-poundals	232.715
Kilogram-meters	Foot-pounds	7.233
Kilogram-meters	Hp-hours	3.653×10^{-6}
Kilogram-meters	Joules (Int.)	9.805
Kilogram-meters	kW-hours	2.724×10^{-6}
Kilogram-meters/sec	Watts	9.80665
Kilowatts (Int.)	Btu (IST.)/hr	3.413×10^{3}
Kilowatts (Int.)	Cal. kg (IST.)/hr	860.0
Kilowatts (Int.)	Ergs/sec	1.0002×10^{10}
Kilowatts (Int.)	Foot-poundals/min	1.424×10^{6}
Kilowatts (Int.)	Foot-pounds/min	4.4261×10^{4}
Kilowatts (Int.)	Horsepower (mechanical)	1.341
Kilowatts (Int.)	Horsepower (boiler)	0.10196
Kilowatts (Int.)	Horsepower (electric)	1.3407
Kilowatts (Int.)	Horsepower (metric)	1.3599
Kilowatts (Int.)	Joules (Int.)/hr	3.6×10^{6}
Kilowatts (Int.)	kg-meters/hr	3.6716×10^{5}
Kilowatt-hours (Int.)	Btu (mean)	3.41×10^{3}
Kilowatt-hours (Int.)	Foot-pounds	2.6557×10^{6}
Kilowatt-hours (Int.)	Hp-hours	1.341
Kilowatt-hours (Int.)	Joules (Int.)	3.6×10^{6}
Kilowatt-hours (Int.)	kg-meters	3.6716×10^{5}
Newton-meters	Gram-cm	1.01972×10^{4}
Newton-meters	kg-meters	0.101972

CONVERSION FACTORS (cont.)[a]

To Convert From	To	Multiply By
Newton-meters	Pound-feet	0.73756
Force		
Dynes	Newtons	1.0×10^{-5}
Dynes	Poundals	7.233×10^{-5}
Dynes	Pounds	2.248×10^{-6}
Newtons	Dynes	1.0×10^{-5}
Newtons	Pounds (avdp.)	0.22481
Poundals	Dynes	1.383×10^{4}
Poundals	Newtons	0.1383
Poundals	Pounds (avdp.)	0.03108
Pounds (avdp.)	Dynes	4.448×10^{5}
Pounds (avdp.)	Newtons	4.448
Pounds (avdp.)	Poundals	32.174
Length		
Feet	Centimeters	30.48
Feet	Inches	12
Feet	Kilometers	3.048×10^{-4}
Feet	Meters	0.3048
Feet	Miles (statute)	1.894×10^{-4}
Inches	Centimeters	2.540
Inches	Feet	0.08333
Inches	Kilometers	2.54×10^{-5}
Inches	Meters	0.0254
Kilometers	Feet	3.2808×10^{3}
Kilometers	Meters	1000
Kilometers	Miles (statute)	0.62137
Kilometers	Yards	1.0936×10^{3}
Meters	Feet	3.2808
Meters	Inches	39.370
Micrometers	Angstrom units	1.0×10^{4}

CONVERSION FACTORS (cont.)[a]

To Convert From	To	Multiply By
Micrometers	Centimeters	1.0×10^{-3}
Micrometers	Feet	3.2808×10^{-6}
Micrometers	Inches	3.9370×10^{-5}
Micrometers	Meters	1.0×10^{-6}
Micrometers	Millimeters	0.001
Micrometers	Nanometers	1000
Miles (statute)	Feet	5280
Miles (statute)	Kilometers	1.6093
Miles (statute)	Meters	1.6093×10^{3}
Miles (statute)	Yards	1760
Millimeters	Angstrom units	1.0×10^{7}
Millimeters	Centimeters	0.1
Millimeters	Inches	0.03937
Millimeters	Meters	0.001
Millimeters	Micrometers	1000
Millimeters	Mils	39.37
Nanometers	Angstrom units	10
Nanometers	Centimeters	1.0×10^{-7}
Nanometers	Inches	3.937×10^{-8}
Nanometers	Micrometers	0.001
Nanometers	Millimeters	1.0×10^{-6}
Yards	Centimeters	91.44
Yards	Meters	0.9144
Mass		
Grains	Grams	0.064799
Grains	Milligrams	64.799
Grains	Pounds (apoth. or troy)	1.7361×10^{-4}
Grains	Pounds (avdp.)	1.4286×10^{-4}
Grains	Tons (metric)	6.4799×10^{-8}
Grams	Dynes	980.67

CONVERSION FACTORS (cont.)[a]

To Convert From	To	Multiply By
Grams	Grains	15.432
Grams	Kilograms	0.001
Grams	Micrograms	1×10^{6}
Grams	Pounds (avdp.)	2.205×10^{-3}
Grams	Tons, metric (megagrams)	1×10^{-6}
Kilograms	Grains	1.5432×10^{4}
Kilograms	Poundals	70.932
Kilograms	Pounds (apoth. or troy)	2.679
Kilograms	Pounds (avdp.)	2.2046
Kilograms	Tons (long)	9.842×10^{-4}
Kilograms	Tons (metric)	0.001
Kilograms	Tons (short)	1.1023×10^{-3}
Megagrams	Tons (metric)	1.0
Milligrams	Grains	0.01543
Milligrams	Grams	1.0×10^{-3}
Milligrams	Ounces (apoth. or troy)	3.215×10^{-5}
Milligrams	Ounces (avdp.)	3.527×10^{-5}
Milligrams	Pounds (apoth. or troy)	2.679×10^{-6}
Milligrams	Pounds (avdp.)	2.2046×10^{-6}
Ounces (apoth. or troy)	Grains	480
Ounces (apoth. or troy)	Grams	31.103
Ounces (apoth. or troy)	Ounces (avdp.)	1.097
Ounces (avdp.)	Grains	437.5
Ounces (avdp.)	Grams	28.350
Ounces (avdp.)	Ounces (apoth. or troy)	0.9115
Ounces (avdp.)	Pounds (apoth. or troy)	0.075955
Ounces (avdp.)	Pounds (avdp.)	0.0625
Pounds (avdp.)	Poundals	32.174
Pounds (avdp.)	Pounds (apoth. or troy)	1.2153
Pounds (avdp.)	Tons (long)	4.4643×10^{-4}

CONVERSION FACTORS (cont.)[a]

To Convert From	To	Multiply By
Pounds (avdp.)	Tons (metric)	4.5359×10^{-4}
Pounds (avdp.)	Tons (short)	5.0×10^{-4}
Pounds (avdp.)	Grains	7000
Pounds (avdp.)	Grams	453.59
Pounds (avdp.)	Ounces (apoth. or troy)	14.583
Pounds (avdp.)	Ounces (avdp.)	16
Tons (long)	Kilograms	1.016×10^3
Tons (long)	Pounds (apoth. or troy)	2.722×10^3
Tons (long)	Pounds (avdp.)	2.240×10^3
Tons (long)	Tons (metric)	1.016
Tons (long)	Tons (short)	1.12
Tons (metric)	Grams	1.0×10^6
Tons (metric)	Megagrams	1.0
Tons (metric)	Pounds (apoth. or troy)	2.6792×10^3
Tons (metric)	Pounds (avdp.)	2.2046×10^3
Tons (metric)	Tons (long)	0.9842
Tons (metric)	Tons (short)	1.1023
Tons (short)	Kilograms	907.18
Tons (short)	Pounds (apoth. or troy)	2.4301×10^3
Tons (short)	Pounds (avdp.)	2000
Tons (short)	Tons (long)	0.8929
Tons (short)	Tons (metric)	0.9072
Pressure		
Atmospheres	cm of H_2O (4°C)	1.033×10^3
Atmospheres	Ft of H_2O (39.2°F)	33.8995
Atmospheres	In. of Hg (32°F)	29.9213
Atmospheres	kg/sq cm	1.033
Atmospheres	mm of Hg (0°C)	760
Atmospheres	Pounds/sq inch	14.696
Inches of Hg (60°F)	Atmospheres	0.03333

CONVERSION FACTORS (cont.)[a]

To Convert From	To	Multiply By
Inches of Hg (60°F)	Grams/sq cm	34.434
Inches of Hg (60°F)	mm of Hg (60°F)	25.4
Inches of Hg (60°F)	Pounds/sq ft	70.527
Inches of H_2O (4°C)	Atmospheres	2.458×10^{-3}
Inches of H_2O (4°C)	In. of Hg (32°F)	0.07355
Inches of H_2O (4°C)	kg/sq meter	25.399
Inches of H_2O (4°C)	Pounds/sq ft	5.2022
Inches of H_2O (4°C)	Pounds/sq inch	0.036126
Kilograms/sq cm	Atmospheres	0.96784
Kilograms/sq cm	cm of Hg (0°C)	73.556
Kilograms/sq cm	Ft of H_2O (39.2°F)	32.809
Kilograms/sq cm	In. of Hg (32°F)	28.959
Kilograms/sq cm	Pounds/sq inch	14.223
Millimeters of Hg (0°C)	Atmospheres	1.3158×10^{-3}
Millimeters of Hg (0°C)	Grams/sq cm	1.3595
Millimeters of Hg (0°C)	Pounds/sq inch	0.019337
Pounds/sq inch	Atmospheres	0.06805
Pounds/sq inch	cm of Hg (0°C)	5.1715
Pounds/sq inch	cm of H_2O (4°C)	70.309
Pounds/sq inch	In. of Hg (32°F)	2.036
Pounds/sq inch	In. of H_2O (39.2°F)	27.681
Pounds/sq inch	kg/sq cm	0.07031
Pounds/sq inch	mm of Hg (0°C)	51.715
Velocity		
Centimeters/sec	Feet/min	1.9685
Centimeters/sec	Feet/sec	0.0328
Centimeters/sec	Kilometers/hr	0.036
Centimeters/sec	Meters/min	0.6
Centimeters/sec	Miles/hr	0.02237

CONVERSION FACTORS (cont.)[a]

To Convert From	To	Multiply By
Feet/minute	cm/sec	0.508
Feet/minute	Kilometers/hr	0.01829
Feet/minute	Meters/min	0.3048
Feet/minute	Meters/sec	5.08×10^{-3}
Feet/minute	Miles/hr	0.01136
Feet/sec	cm/sec	30.48
Feet/sec	Kilometers/hr	1.0973
Feet/sec	Meters/min	18.288
Feet/sec	Miles/hr	0.6818
Kilometers/hr	cm/sec	27.778
Kilometers/hr	Feet/hr	3.2808×10^{3}
Kilometers/hr	Feet/min	54.681
Kilometers/hr	Meters/sec	0.27778
Kilometers/hr	Miles (statute)/hr	0.62137
Meters/min	cm/sec	1.6667
Meters/min	Feet/min	3.2808
Meters/min	Feet/sec	0.05468
Meters/min	Kilometers/hr	0.06
Miles/hr	cm/sec	44.704
Miles/hr	Feet/hr	5280
Miles/hr	Feet/min	88
Miles/hr	Feet/sec	1.4667
Miles/hr	Kilometers/hr	1.6093
Miles/hr	Meters/min	26.822
Volume		
Barrels (petroleum, U. S.)	Cu feet	5.6146
Barrels (petroleum, U. S.)	Gallons (U. S.)	42
Barrels (petroleum, U. S.)	Liters	158.98
Barrels (U. S., liq.)	Cu feet	4.2109
Barrels (U. S., liq.)	Cu inches	7.2765×10^{3}

CONVERSION FACTORS (cont.)[a]

To Convert From	To	Multiply By
Barrels (U. S., liq.)	Cu meters	0.1192
Barrels (U. S., liq.)	Gallons (U. S., liq.)	31.5
Barrels (U. S., liq.)	Liters	119.24
Cubic centimeters	Cu feet	3.5315×10^{-5}
Cubic centimeters	Cu inches	0.06102
Cubic centimeters	Cu meters	1.0×10^{-6}
Cubic centimeters	Cu yards	1.308×10^{-6}
Cubic centimeters	Gallons (U. S., liq.)	2.642×10^{-4}
Cubic centimeters	Quarts (U. S., liq.)	1.0567×10^{-3}
Cubic feet	Cu centimeters	2.8317×10^{4}
Cubic feet	Cu meters	0.028317
Cubic feet	Gallons (U. S., liq.)	7.4805
Cubic feet	Liters	28.317
Cubic inches	Cu cm	16.387
Cubic inches	Cu feet	5.787×10^{-4}
Cubic inches	Cu meters	1.6387×10^{-5}
Cubic inches	Cu yards	2.1433×10^{-5}
Cubic inches	Gallons (U. S., liq.)	4.329×10^{-3}
Cubic inches	Liters	0.01639
Cubic inches	Quarts (U. S., liq.)	0.01732
Cubic meters	Barrels (U. S., liq.)	8.3864
Cubic meters	Cu cm	1.0×10^{6}
Cubic meters	Cu feet	35.315
Cubic meters	Cu inches	6.1024×10^{4}
Cubic meters	Cu yards	1.308
Cubic meters	Gallons (U. S., liq.)	264.17
Cubic meters	Liters	1000
Cubic yards	Bushels (Brit.)	21.022
Cubic yards	Bushels (U. S.)	21.696
Cubic yards	Cu cm	7.6455×10^{5}

CONVERSION FACTORS (cont.)[a]

To Convert From	To	Multiply By
Cubic yards	Cu feet	27
Cubic yards	Cu inches	4.6656×10^4
Cubic yards	Cu meters	0.76455
Cubic yards	Gallons	168.18
Cubic yards	Gallons	173.57
Cubic yards	Gallons	201.97
Cubic yards	Liters	764.55
Cubic yards	Quarts	672.71
Cubic yards	Quarts	694.28
Cubic yards	Quarts	807.90
Gallons (U. S., liq.)	Barrels (U. S., liq.)	0.03175
Gallons (U. S., liq.)	Barrels (petroleum, U. S.)	0.02381
Gallons (U. S., liq.)	Bushels (U. S.)	0.10742
Gallons (U. S., liq.)	Cu centimeters	3.7854×10^3
Gallons (U. S., liq.)	Cu feet	0.13368
Gallons (U. S., liq.)	Cu inches	231
Gallons (U. S., liq.)	Cu meters	3.7854×10^{-3}
Gallons (U. S., liq.)	Cu yards	4.951×10^{-3}
Gallons (U. S., liq.)	Gallons (wine)	1.0
Gallons (U. S., liq.)	Liters	3.7854
Gallons (U. S., liq.)	Ounces (U. S., fluid)	128.0
Gallons (U. S., liq.)	Pints (U. S., liq.)	8.0
Gallons (U. S., liq.)	Quarts (U. S., liq.)	4.0
Liters	Cu centimeters	1000
Liters	Cu feet	0.035315
Liters	Cu inches	61.024
Liters	Cu meters	0.001
Liters	Gallons (U. S., liq.)	0.2642
Liters	Ounces (U. S., fluid)	33.814

CONVERSION FACTORS (cont.)[a]

To Convert From	To	Multiply By
Volumetric Rate		
Cu ft/min	Cu cm/sec	471.95
Cu ft/min	Cu ft /hr	60. 0
Cu ft/min	Gal (U. S.)/min	7.4805
Cu ft/min	Liters/sec	0.47193
Cu meters/min	Gal (U. S.)/min	264.17
Cu meters/min	Liters/min	999.97
Gallons (U. S.)/hr	Cu ft/hr	0.13368
Gallons (U. S.)/hr	Cu meters/min	6.309×10^{-5}
Gallons (U. S.)/hr	Cu yd/min	8.2519×10^{-5}
Gallons (U. S.)/hr	Liters/hr	3.7854
Liters/min	Cu ft/min	0.0353
Liters/min	Gal (U. S., liq.)/min	0.2642

[a] Where appropriate, the conversion factors appearing in this table have been rounded to four to six significant figures for ease in use. The accuracy of these numbers is considered suitable for use with emissions data; if a more accurate number is required, tables containing exact factors should be consulted.

CONVERSION FACTORS FOR COMMON AIR POLLUTION MEASUREMENTS

AIRBORNE PARTICULATE MATTER

To Convert From	To	Multiply By
Milligrams/cu m	Grams/cu ft	283.2×10^{-6}
	Grams/cu m	0.001
	Micrograms/cu m	1000.0
	Micrograms/cu ft	28.32
	Pounds/1000 cu ft	62.43×10^{-6}
Grams/cu ft	Milligrams/cu m	35.3145×10^{3}
	Grams/cu m	35.314
	Micrograms/cu m	35.314×10^{6}
	Micrograms/cu ft	1.0×10^{6}
	Pounds/1000 cu ft	2.2046
Grams/cu m	Milligrams/cu m	1000.0
	Grams/cu ft	0.02832
	Micrograms/cu m	1.0×10^{6}
	Micrograms/cu ft	28.317×10^{3}
	Pounds/1000 cu ft	0.06243
Micrograms/cu m	Milligrams/cu m	0.001
	Grams/cu ft	28.317×10^{-9}
	Grams/cu m	1.0×10^{-6}
	Micrograms/cu ft	0.02832
	Pounds/1000 cu ft	62.43×10^{-9}
Micrograms/cu ft	Milligrams/cu m	35.314×10^{-3}
	Grams/cu ft	1.0×10^{-6}
	Grams/cu m	35.314×10^{-6}
	Micrograms/cu m	35.314
	Pounds/1000 cu ft	2.2046×10^{-6}
Pounds/1000 cu ft	Milligrams/cu m	16.018×10^{3}
	Grams/cu ft	0.35314
	Micrograms/cu m	16.018×10^{6}
	Grams/cu m	16.018
	Micrograms/cu ft	353.14×10^{3}

CONVERSION FACTORS FOR COMMON AIR POLLUTION MEASUREMENTS (cont.).

SAMPLING PRESSURE

To Convert From	To	Multiply By
Millimeters of mercury (0°C)	Inches of water (60°F)	0.5358
Inches of mercury (0°C)	Inches of water (60°F)	13.609
	Millimeters of mercury (0°C)	1.8663
Inches of water (60°F)	Inches of mercury (0°C)	73.48×10^{-3}

CONVERSION FACTORS FOR COMMON AIR POLLUTION MEASUREMENTS (cont.).

ATMOSPHERIC GASES

To Convert From	To	Multiply By
Milligrams/cu m	Micrograms/cu m	1000.0
	Micrograms/liter	1.0
	ppm by volume (20°C)	24.04/M
	ppm by weight	0.8347
	Pounds/cu ft	62.43×10^{-9}
Micrograms/cu m	Milligrams/cu m	0.001
	Micrograms/liter	0.001
	ppm by volume (20°C)	0.02404/M
	ppm by weight	834.7×10^{-6}
	Pounds/cu ft	62.43×10^{-12}
Micrograms/liter	Milligrams/cu m	1.0
	Micrograms/cu m	1000.0
	ppm by volume (20°C)	24.04/M
	ppm by weight	0.8347
	Pounds/cu ft	62.43×10^{-9}
ppm by volume (20°C)	Milligrams/cu m	M/24.04
	Micrograms/cu m	M/0.02404
	Micrograms/liter	M/24.04
	ppm by weight	M/28.8
	Pounds/cu ft	$M/385.1 \times 10^{6}$
ppm by weight	Milligrams/cu m	1.198
	Micrograms/cu m	1.198×10^{-3}
	Micrograms/liter	1.198
	ppm by volume (20°C)	28.8/M
	Pounds/cu ft	7.48×10^{-6}
Pounds/cu ft	Milligrams/cu m	16.018×10^{6}
	Micrograms/cu m	16.018×10^{9}
	Micrograms/liter	16.018×10^{6}
	ppm by volume (20°C)	$385.1 \times 10^{6}/M$
	ppm by weight	133.7×10^{3}

M = Molecular weight of gas.

CONVERSION FACTORS FOR COMMON AIR POLLUTION MEASUREMENTS (cont.).

VELOCITY

To Convert From	To	Multiply By
Meters/sec	Kilometers/hr	3.6
	Feet/sec	3.281
	Miles/hr	2.237
Kilometers/hr	Meters/sec	0.2778
	Feet/sec	0.9113
	Miles/hr	0.6214
Feet/sec	Meters/sec	0.3048
	Kilometers/hr	1.09728
	Miles/hr	0.6818
Miles/hr	Meters/sec	0.4470
	Kilometers/hr	1.6093
	Feet/sec	1.4667

ATMOSPHERIC PRESSURE

To Convert From	To	Multiply By
Atmospheres	Millimeters of mercury	760.0
	Inches of mercury	29.92
	Millibars	1013.2
Millimeters of mercury	Atmospheres	1.316×10^{-3}
	Inches of mercury	39.37×10^{-3}
	Millibars	1.333
Inches of mercury	Atmospheres	0.03333
	Millimeters of mercury	25.4005
	Millibars	33.35
Millibars	Atmospheres	0.00987
	Millimeters of mercury	0.75
	Inches of mercury	0.30

CONVERSION FACTORS FOR COMMON AIR POLLUTION MEASUREMENTS (cont.).

VOLUME EMISSIONS

To Convert From	To	Multiply By
Cubic m/min	Cubic ft/min	35.314
Cubic ft/min	Cubic m/min	0.0283

BOILER CONVERSION FACTORS

1 Megawatt = 10.5 x 10^6 BTU/hr
(8 to 14 x 10^6 BTU/hr)

1 Megawatt = 8 x 10^3 lb steam/hr
(6 to 11 x 10^3 lb steam/hr)

1 BHP = 34.5 lb steam/hr

1 BHP = 45 x 10^3 BTU/hr
(40 to 50 x 10^3 BTU/hr)

1 lb steam/hr = 1.4 x 10^3 BTU/hr
(1.2 to 1.7 x 10^3 BTU/hr)

NOTES: In the relationships,

Megawatt is the net electric power production of a steam electric power plant.

BHP is boiler horsepower.

Lb steam/hr is the steam production rate of the boiler.

BTU/hr is the heat input rate to the boiler (based on the gross or high heating value of the fuel burned).

For less efficient (generally older and/or smaller) boiler operations, use the higher values expressed. For more efficient operations (generally newer and/or larger), use the lower vlaues.

VOLUME	cu. in.	ml.	liters	ounces (U. S. fl.)	gallons (U. S.)	barrels (U. S.)	cu. ft.
Cubic inches	....	16.3868	.0163868	0.5541	4.3290x10^{-3}	1.37429x10^{-4}	5.78704x10^{-4}
Milliliters	0.061024	....	0.001	0.03381	2.6418x10^{-4}	8.387x10^{-6}	3.5316x10^{-5}
Liters	61.024	1000	....	33.8147	0.26418	8.387x10^{-3}	0.035316
Ounces (U. S. fl.)	1.80469	29.5729	0.029573	....	7.8125x10^{-3}	2.48x10^{-4}	1.0443x10^{-3}
Gallons (U. S.)*..	231	3785.3	3.7853	128	....	0.031746	0.13368
Barrels (U. S.)...	7276.5	1.1924x10^5	119.2369	4032.0	31.5	....	4.2109
Cubic feet	1728	2.8316x10^4	28.316	957.568	7.481	0.23743	....

[1] U. S. gallon of water at 16.7°C (62°F) weighs 3.780 kg. or 8.337 pounds (avoir.)

MASS	grams	kilograms	ounces (avoir.)	pounds (avoir.)	grains	tons (U. S.)	milligrams
Grams	....	0.001	3.527x10^{-2}	2.205x10^{-3}	15.432	1.102x10^{-6}	1000
Kilograms	1000	....	35.274	2.2046	15432	1.102x10^{-3}	1x10^6
Ounces (avoir.)...	28.350	0.028350	....	0.0625	437.5	3.125x10^{-5}	2.8350x10^4
Pounds (avoir.)*..	453.59	0.45359	16.0	....	7000	5.0x10^{-4}	4.5359x10^5
Grains	0.06480	6.480x10^{-5}	2.286x10^{-3}	1.429x10^{-4}	....	7.142x10^{-8}	64.799
Tons (U. S.)	9.072x10^5	907.19	3.200x10^4	2000	1.4x10^7	....	9.0718x10^8
Milligrams	0.001	1x10^{-6}	3.527x10^{-5}	2.205x10^{-6}	0.015432	1.102x10^{-9}	....

*Mass of 27.692 cubic inches water weighed in air at 4.0°C, 760 mm mercury pressure.

WORK AND ENERGY	g. cal.	kg. cal.	ergs	Joules	BTU	ft. lb.	kg. meters	L-Atm	HP Hours	ft. poundals	KWH	WH
Gram Calories (mean)...........	....	0.001	4.186×10^{7}	4.186	3.9680×10^{-3}	3.0874	0.42685	0.041311	1.5593×10^{-6}	99.334	1.1628×10^{-6}	1.1628×10^{-3}
Kilogram Calories.	1000	....	4.186×10^{10}	4186	3.9680	3087.4	426.85	41.311	1.5593×10^{-3}	99334	1.1628×10^{-3}	1.1628
Ergs	2.3889×10^{-8}	2.3889×10^{-11}	....	1×10^{-7}	9.4805×10^{-11}	7.3756×10^{-8}	1.0197×10^{-8}	9.8689×10^{-10}	3.7251×10^{-14}	2.3730×10^{-6}	2.7778×10^{-14}	2.7778×10^{-11}
Joules	0.23889	2.3889×10^{-4}	1×10^{7}	....	9.4805×10^{-4}	0.73756	0.10197	9.8689×10^{-3}	3.7251×10^{-7}	23.730	2.7778×10^{-7}	2.7778×10^{-4}
BTU (mean)	251.98	0.25198	1.0548×10^{10}	1054.8	....	777.98	107.56	10.409	3.9292×10^{-4}	2.5030×10^{4}	2.930×10^{-4}	0.2930
Foot Pounds	0.32389	3.2389×10^{-4}	1.35582×10^{7}	1.3558	1.2854×10^{-3}	....	0.13825	0.013381	5.0505×10^{-7}	32.174	3.7662×10^{-7}	3.7662×10^{-4}
Kilogram meters ..	2.3427	2.3427×10^{-3}	9.8066×10^{7}	9.8066	9.2967×10^{-3}	7.2330	....	0.096781	3.6529×10^{-6}	232.71	2.7241×10^{-6}	2.7241×10^{-3}
Liter Atmospheres (normal)	24.206	2.4206×10^{-2}	1.0133×10^{9}	101.328	0.09606	74.735	10.333	....	3.7745×10^{-5}	2404.5	2.8164×10^{-5}	2.8164×10^{-2}
Horsepower Hours .	6.4130×10^{5}	641.30	2.6845×10^{13}	2.6845×10^{6}	2454.0	1.9800×10^{6}	2.7374×10^{5}	26494	....	6.3705×10^{7}	0.7457	745.7
Foot poundals	0.010067	10.067×10^{-6}	4.21402×10^{5}	0.04214	3.9952×10^{-5}	0.031081	4.2972×10^{-3}	4.1558×10^{-4}	1.5697×10^{-8}	....	1.17055×10^{-8}	1.17055×10^{-5}
Kilowatt Hours ...	8.6001×10^{5}	860.01	3.6000×10^{13}	3.6000×10^{6}	3413.0	2.6552×10^{6}	3.6709×10^{-5}	3.5529×10^{6}	1.3440	8.5430×10^{7}	....	1000
Watt Hours	860.01	0.86001	3.6000×10^{10}	3600	3.4130	2655.3	367.09	3.5529×10^{3}	1.3410×10^{-3}	8.5430×10^{1}	0.001	....

[illegible]

CONVERSION FACTORS FOR VARIOUS SUBSTANCES[a]

Type Of Substance	Conversion Factors
Fuel	
Oil	1 bbl = 159 liters (42 gal)
Natural gas	1 therm = 100,000 Btu (approx.25000 kcal)
Gaseous Pollutants	
O_3	1 ppm, volume = 1960μg/m^3
NO_2	1 ppm, volume = 1880μg/m^3
SO_2	1 ppm, volume = 2610μg/m^3
H_2S	1 ppm, volume = 1390 μg/m^3
CO	1 ppm, volume = 1.14 mg/m^3
HC (as methane)	1 ppm, volume = 0.654 mg/m^3
Agricultural products	
Corn	1 bu = 25.4 kg = 56 lb
Milo	1 bu = 25.4 kg = 56 lb
Oats	1 bu = 14.5 kg = 32 lb
Barley	1 bu = 21.8 kg = 48 lb
Wheat	1 bu = 27.2 kg = 60 lb
Cotton	1 bale = 226 kg = 500 lb
Mineral products	
Brick	1 brick = 2.95 kg = 6.5 lb
Cement	1 bbl = 170 kg = 375 lb
Cement	1 yd^3 = 1130 kg = 2500 lb
Concrete	1 yd^3 = 1820 kg = 4000 lb
Mobile sources, fuel efficiency	
Motor vehicles	1.0 mi/gal = 0.426 km/liter
Waterborne vessels	1.0 gal/naut mi = 2.05 liters/km
Miscellaneous liquids	
Beer	1 bbl = 31.5 gal
Paint	1 gal = 4.5 to 6.82 kg = 10 to 15 lb
Varnish	1 gal = 3.18 kg = 7 lb
Whiskey	1 bbl = 190 liters = 50.2 gal
Water	1 gal = 3.81 kg = 8.3 lb

[a] Many of the conversion factors in this table represent average values and approximations and some of the values vary with temperature and pressure. These conversion factors should, however, be sufficiently accurate for general field use.

APPENDIX IV-C

EXCERPT FROM THE *1995 PROTOCOL FOR EQUIPMENT LEAK EMISSION ESTIMATES*

APPENDIX IV-D

EXAMPLE QUALITY CONTROL CHECKLIST

APPENDIX IV-E

SOURCE CLASSIFICATION CODES LIST

APPENDIX IV-F

THE NATIONAL INSTITUTE OF ECOLOGY POINT SOURCE QUESTIONNAIRES

APPENDIX IV-G

DEVICE LEVEL DATA COLLECTION FORMS

Example QC Checklist

Completeness Checks - Point Sources	**Yes**	**No**	**Comments**
Have all applicable VOC point sources been included in the inventory?			
Have process, point, and segment level data been provided for all VOC point sources?			
Have all process, point, and segment level documentation data been provided for NO_X and CO sources been provided?			
Is the Annual Emission Inventory signed by the proper authority who will take legal responsibility for the accuracy of the information verified in the report to the state?			
Is the following information provided in the report (to the regulatory agency) and is it accurate: source addresses, contact information, and industrial process classification code(s)?			
Procedures Checks			
Have you made a copy of the inventory and report you are mailing to the regulatory agency?			
Does the inventory documentation describe the methodology used (i.e., survey, plant inspections, continuous emissions monitoring data, fuel analysis data, air quality modeling data, material balance, and permit files) to develop the point source inventory listing?			
Does the point source inventory documentation include the contact person(s) for referring questions?			
Select a subset that represents at least 10 percent of the listed point sources and determine if the following data are compiled and presented for each source. *Note: Identify in the comment column the record number of those plants that were checked.*			

Example QC Checklist (Continued)

Procedures Checks (Continued)	**Yes**	**No**	**Comments**
• Plant name and location (including latitude, longitude, and zip code)			
• Operating schedule			
• Applicable regulations			
• UTM zone			
• Pollutant code or CAS number			
• Stack ID (for point pollutant data)			
• Emission limitations (only if subject to INE regulation)			
• Compliance year (only if subject to INE Regulation)			
• Daily process rate and units			
• Control equipment type			
• Control efficiency			
• Emissions estimation method			
• Emission factors			
Reasonableness Checks			
If point source VOC emissions are attributed to the synthetic organic chemical manufacturing industry (SOCMI), are fugitive leaks also quantified? *Note: Fugitive equipment leak emissions should be 1 to 10 times larger than emissions from vents, reactors, etc.*			
Are the following data elements within the ranges listed below for general point sources data?			

Example QC Checklist (Continued)

Reasonableness Checks (Continued)	**Yes**	**No**	**Comments**
• Hours per day ≤24			
• Days per week ≤7			
• Hours per year = hours x days			
• Seasonal throughputs 0 - 100			
• Boiler capacity 80 - 120 percent of hourly maximum rate x fuel heat content			
• Is percent space heat for winter greater than summer			
• Are the following data elements within the ranges listed below for point pollutant data?			
• Stack height >50 Feet			
• Stack diameter .5 >30 Feet			
• Plume height >200 Feet			
• Temperature of exit gases 60 >2,000°F			
• Temperature of exit gases with wet scrubber >250°F			
• Temperature of exit gases without wet scrubber >250°F			
• Exhaust gas flow rate equal to capacity x temperature			
• Exhaust gas velocity			
Are the following data elements within the ranges listed below for general segment data?			
• Process hourly rate units < 10 percent of >125 percent x maximum design capacity.			
• For control devices, is the control efficiency between 0 - 100 percent?			

Example Data Collection Form Instructions-
Surface Coating Operations

1. This form may be used as a work sheet to aid the plant engineer in collecting the information necessary to calculate emissions from each surface coating operation. The information requested on the form relates to the different methods for quantifying emissions. This form may also be used by the regulatory agency to assist in area wide inventory preparation.

2. The completed forms should be maintained in a reference file by the plant engineer with other supporting documentation.

3. If the information requested is unknown, write "unknown" in the blank. If the information requested does not apply to a particular unit or process, write "NA" in the blank.

4. If hourly or monthly material use information is not available, enter the information in another unit (quarterly or yearly). Be sure to indicate the unit of measure on the form.

5. Use the comments field on the form to record all useful information that will allow your work to be reviewed and reconstructed.

6. Collect all Material Safety Data Sheets (MSDSs) for all materials containing potential air contaminants that are used at the facility.

7. For each material used, determine maximum hourly usage rates and annual usage rates.

8. The plant engineer should maintain all material usage information and MSDSs in a reference file.

Example Data Collection Form - Surface Coating Operations

GENERAL INFORMATION

Facility/Plant Name:

Facility Description:

Location:

County:

City:

State:

Plant Geographical coordinates:

Latitude:______________________________
Longitude:_____________________________
UTM Zone:_____________________________
UTM Easting: ______________________
UTM Northing:_________________________

Contact Name:

Title:

Telephone Number:

Unit ID Number:

Permit Number:

Example Data Collection Form - Surface Coating Operations

EQUIPMENT AND PROCESS INFORMATION **COMMENTS**

Name or description of equipment:

Make:

Model:

Rated capacity of equipment:

Type of Operation:

- surface coater:
- dryer:
- printing press:
- other:

Type of equipment for this operation:

- dip coater:
- letter press:
- other:

Application/Dryer evaporation split (%):

Typical use:

- hours/days:
- days/week:
- weeks/year:

Seasonal Variations (%):

January:	February:	March:
April:	May:	June:
July:	August:	September:
October:	November:	December:

Example Data Collection Form - Surface Coating Operations

W4444444444444444444444444444444444444444444U

MATERIAL INFORMATION

W44444444444444444444444444444444444444444444

MATERIAL COMPOSITION

S))

Name of Material:

S))

VOC Content (lb/gal or wt.%):

S))

Solids Content (wt.%):

S))

Density of Material:

S))

Composition (lb_x/lb material) * 100%:

- name of component ____________

- wt.% of component ____________

W44444444444444444444444444444444444444444444

MATERIAL USAGE

S))

Hourly throughput:

S))

Monthly throughput:

S))

Annual throughput:

S))

Maximum throughput:

W44444444444444444444444444444444444444444444

SURFACE COATING OPERATIONS

S))

Type of Coating (ink, primer, paint, etc.):

S))

Substrate Coated (wood, metal, etc.):

S))

Mixture Name (for multi-part coatings):

S))

Brand/Product Name (for each part of coating mixture):

S))

Mix Ratio for Coating Mixtures:

S))

% VOC Evaporated as Fugitive:

S))

Particulate Emission Factor:

S))

- Reference:

W44444444444444444444444444444444444444444444

Worksheet A
Solvent Description

Solvent Composition	**Annual Usage (gal/yr)**	**Percent of Total Solvents Listed**	**Molecular Weight (lb/lb_{mole})**	**Liquid Density (lb/gal)**
Total				
Solvent Molecular Weight (weighted average), (M_i)			lb/lb_{mole}	
Solvent Liquid Density (weighted average), (d_i)			lb/lb_{mole}	

$$Y = \sum_{i=1}^{n} (x_i \quad y_i)$$

where:

Y = Weighted average molecular weight (M_i) or liquid density (d_i)
y_i = Molecular weight (M_i) or liquid density (d_i) for VOC_i
x_i = Fraction of total solvent for VOC_i
n = Number of VOC species in the solvent(s)

Worksheet B
Spray Booths

Annual Hours of Operation of this Booth:

EXHAUST GAS STREAM CHARACTERISTICS

Flow Rate (acfm)		Exhaust Stack			Building Height (ft)	Abatement Device Particulate Loading (lb/hr)	
Design Maximum	Average Expected	Temperature °F	Height (ft)	Diameter (ft)		Inlet	Outlet

TYPE OF COATING AND MAXIMUM RATE OF USE

Type	Max. Rate of Use (lb/hr)	Max. Rate of Use (ton/yr)	Volatile Portion (%weight)
Lacquer			
Varnish			
Enamel			
Metal Primer			
Metal Spray			
Resin			
Sealer			
Shellac			
Stain			
Zinc Chromate			
Epoxy			
Polyurethane			
Other			

SOLVENT COMPOSITION AND RATE OF USE (INCLUDE THAT SUPPLIED WITH COATING)

Chemical Composition of Volatiles & wt. (%)	Max. Rate of Use (lb/hr)	Max. Rate of Use (ton/yr)

TYPE OF PM ABATEMENT DEVICE

G Spray Chamber (water use gal/hr) ________________
G Dry Filter Pads (total number in all layers) __________
(size) ____
G Water Curtain (water use gal/hr) ________________
G Other (explain) ____________________________
G Manufacturer's Rating for PM Control Efficiency __________

TYPE OF VOC ABATEMENT DEVICE

Type ____
Rated Control Efficiency ______________________________

Worksheet B

(Continued)

METHOD OF SPRAYING	DESCRIPTION OF ITEMS TO BE COATED (SHAPE AND SIZE)
☐ Air Atomization ☐ Airless Electrostatic ☐ Disc ☐ Airless ☐ Air-Atomized ☐ Other ________________________	

Example Data Collection Form Instructions - Boilers

1. This form may be used as a work sheet to aid the plant engineer in collecting the information necessary to calculate emissions from boilers. The information requested on the form relates to the different methods for quantifying emissions. This form may also be used by the regulatory agency to assist in area wide inventory preparation.

2. The completed forms should be maintained in a reference file by the plant engineer with other supporting documentation.

3. The information identified on these forms is needed to generate a complete emissions inventory. If the information requested does not apply to a particular boiler, write "NA" in the blank.

4. If rated capacity is not documented in MMBtu/hr, please enter the capacity in lb/hr steam produced, or other appropriate units of measure.

5. If hourly or monthly fuel use information is not available, enter the information in another unit (quarterly or yearly). Be sure to indicate on the form, what the unit of measure is.

6. Use the comments field on the form to record all useful information that will allow your work to be reviewed and reconstructed.

Example Data Collection Form - Boilers

GENERAL INFORMATION

Facility/Plant Name:

Facility Description:
Utility ___________________
Commercial ___________________
Industrial ___________________

Location:

County:

City:

State:

Plant Geographical coordinates:
Latitude:______________________________
Longitude:_____________________________
UTM Zone:____________________________
UTM Easting: ______________________
UTM Northing:_________________________

Contact Name:

Title:

Telephone Number:

Unit ID Number:

Permit Number:

Example Data Collection Form - Boilers

SOURCE INFORMATION	**COMMENTS**

Unit ID:

Manufacturer:

Date Installed:

Rated Capacity (units):

Maximum Heat Input (units):

Fuel Type:

Operating Schedule:

Hours/Day:

Days/Week:

Weeks/Year:

FUEL USE[a]:

Year:

Maximum Hourly Fuel Use (units):

Monthly Fuel Use (units):

January:	July:
February:	August:
March:	September:
April:	October:
May:	November:
June:	December:

Total Annual Fuel Use (units):

[a] This form should be completed for each fuel type used.

Example Data Collection Form - Boilers

FIRING CONFIGURATION (Check the appropriate type)

Tangential Fired ☐ Horizontally Fired ☐ Vertically Fired ☐ Pulverized Coal Fired ☐

Dry Bottom ☐ Wet Bottom ☐

Cylone Furnace ☐

Spreader Stoker ☐ Uncontrolled ☐ Controlled ☐

Overfeed Stoker ☐ Uncontrolled ☐ Controlled ☐

Underfired Stoker ☐ Uncontrolled ☐ Controlled ☐

Handfired Units ☐

POLLUTION CONTROL EQUIPMENT (Enter control efficiency and source of information):

ESP:

Baghouse:

Wet Scrubber:

Dry Scrubber:

Spray Dryer:

Cyclone:

Other:

Example Data Collection Form - Boilers

FUEL ANALYSIS:	**COMMENTS**
Sulfur Content (S):	
Ash Content:	
Nitrogen Content (N):	
Lead Content (Pb):	
Mercury (Hg):	
Others:	
Higher Heating Value (HHV in Btu/lb):	
Reference (Attach Analysis if Available):	
STACK INFORMATION:	
Stack ID:	
Unit ID:	
Stack (Release) Height (feet):	
Stack Diameter (inch):	
Stack Gas Temperature (^{o}F):	
Stack Gas Velocity (ft/sec):	
Stack Gas Flow Rate (ascf/min):	
Do Other Sources Share This Stack (Y/N)?: (If yes, include Unit IDs for each).	
Site-specific Stack Sampling Report Available (Y/N)?:	
Reference (Include Full Citation of Test Reports Used):	

Example Data Collection Form
Instructions-Equipment Leak Fugitives

1. This form may be used as a worksheet to aid in collecting the information/data necessary to estimate HAP and VOC emissions from equipment leaks.

2. The form is divided into five sections: General Information; Stream Composition Data; Equipment Counts; Screening Data; and Equipment Leaks Controls.

3. Some of the sections require entry on a stream basis; for these, a separate copy of the section will need to be made for each stream in the process unit.

4. For the stream composition data section, weight percents may not need to be provided for constituents present in concentrations less than 1.0 weight percent.

5. For the stream composition data section, in the row labelled "OTHER", identify total weight percent of all constituents not previously listed. The total weight percent of constituents labelled as "OTHER" must not exceed 10 percent. Total weight percent of all constituents in the stream must equal 100 percent.

6. For the screening data section, complete the information/data for each screened stream.

7. For the equipment count section, complete the questions and table for each stream in the facility.

8. For the equipment count section, the Leak Detection and Repair (LDAR) trigger concentration refers to the concentration level that the component is considered to be leaking.

9. For the equipment count section, enter the control parameters for each component type in the stream. Provide the percent of the total equipment type in the stream that has the controls listed in Table III-1.

10. For the equipment count section, if other controls are used, specify what they are in the space left of the slash. Specify the percent of each component type in the stream that use the other control in the space to the right of the slash.

11. For the equipment count section, indicate any secondary control devices to which the closed vent system transports the process fluid.

Example Data Collection Form -
Fugitive Emissions from Equipment Leaks

GENERAL INFORMATION						
Process Unit Capacity (lb/yr)						
Portable VOC Monitoring Instrument Used[a]						
Calibration Gas of Monitoring Instrument[a]						
STREAM COMPOSITION DATA						
CAS Number	Chemical Name	Concentration (wt%)				
		Stream 1	Stream 2	Stream 3	Stream 4	Stream 5
--	OTHER					
--	Total HAP					
--	Total VOC					
--	Source[b]					
Amount of Time Fluid in Stream (hr/yr)						

[a] Collect information if screening data has been gathered at the process unit.

[b] EJ = Engineering judgement; TD = Test data; LV = Literature values.

Example Data Collection Form -
Fugitive Emissions from Equipment Leaks

EQUIPMENT COUNTS					
Component	Service	Count Source[b]	Stream 1	Stream 2	Stream 3
Valves	gas/vapor				
	light liquid				
	heavy liquid				
Connectors	all				
Pumps	light liquid				
	heavy liquid				
Compressor	gas/vapor				
Open Lines	all				
Sample Connections	all				
Pressure Relief Valve	gas/vapor				

[a] Do not include equipment in vacuum service.

[b] D = Design specifications; I = Inspection and maintenance tags; C = Actual count; and R = Ratio, if ratio specify (i.e., 25 valves per pump).

Example Data Collection Form -
Fugitive Emissions from Equipment Leaks

SCREENING DATA	
Stream ID:	Component Type:
Date Components Screened:	Total Number of Components Screened
Component ID	Screening Value (ppmv)

Example Data Collection Form -
Fugitive Emissions from Equipment Leaks

EQUIPMENT LEAKS CONTROLS

Stream ID:

Is the equipment in this stream subject to a LDAR program? (Yes/No)

Type of Monitoring System[a]:

	Leak Detection and Repair Parameters				Control Parameters				
Equipment	Quantity in Program	LDAR Trigger Conc.	Monitoring Frequency	Response Time[b]	Percent with Control A[c]	Percent with Control B[c]	Percent with Control C[c]	Other	Closed-Vent Secondary Control
Valves							NA	/	
Pumps								/	
Compressors							NA	/	
Connectors						NA	NA	/	
Open-ended lines							NA	/	
Sampling Connections	NA	NA	NA	NA				/	
Pressure Relief Valves							NA	/	

NA = Not applicable.

[a] V = Visual; P = Portable; F = Fixed point; If other, please specify.

[b] IM = Immediately; D = 1 day; D3 = 3 days; W = 1 week; W2 = 2 weeks; and M = 1 month.

[c] See Table III-1 (Controls by Equipment Type).

Table IV-1
Controls By Equipment Type

Control Option	Equipment	Controls
A	All	Closed vent system
B	Valves	Sealless
	Pumps	Dual mechanical seal with barrier fluid[a]
	Compressors	Mechanical seals with barrier fluid[a]
	Open-ended lines	Capped, plugged, blind-flagged
	Sampling Connections	*In-situ* sampling
	PRV's	Rupture disk
C	Pumps	Sealless
	Sampling connections	Closed loop sampling