VOLUME III: CHAPTER 18

STRUCTURE FIRES

Revised Final
January 2001

Prepared by:
Eastern Research Group, Inc.

Prepared for:
Area Sources Committee
Emission Inventory Improvement Program

DISCLAIMER

As the Environmental Protection Agency has indicated in Emission Inventory Improvement Program (EIIP) documents, the choice of methods to be used to estimate emissions depends on how the estimates will be used and the degree of accuracy required. Methods using site-specific data are preferred over other methods. These documents are non-binding guidance and not rules. EPA, the States, and others retain the discretion to employ or to require other approaches that meet the requirements of the applicable statutory or regulatory requirements in individual circumstances.

ACKNOWLEDGEMENT

This document was prepared by Eastern Research Group, Inc. for the Area Sources Committee of the Emission Inventory Improvement Program and for Charles Mann of the Air Pollution Prevention and Control Division, U.S. Environmental Protection Agency. Members of the Area Sources Committee contributing to the preparation of this document are:

Kristin Abraham, West Virginia Department of Environmental Protection
Kwame Agyei, Puget Sound Air Pollution Control Agency
Ray Bishop, Oklahoma Department of Environmental Quality
Dan Brisko, New York State Department of Environmental Conservation
Orlando Cabrera-Rivera, Wisconsin Department of Natural Resources
Andy Delao, California Air Resources Board
Laurel Driver, Emission Factor and Inventory Group, U.S. Environmental Protection Agency
Mark Eastburn, Delaware Department of Natural Resources
Charles Mann, Air Pollution Prevention and Control Division, U.S. Environmental Protection Agency
Sally Otterson, Washington Department of Ecology
Kenneth Santlal, Massachusetts Department of Environmental Protection
Walter Simms, Maryland Department of the Environment
Jack Sipple, Delaware Department of Natural Resources and Environmental Control
Karla Smith-Hardison, Texas Natural Resources Conservation Commission
Angel Thompson, South Carolina Department of Health and Environmental Control
Lee Tooly, Emission Factor and Inventory Group, U.S. Environmental Protection Agency

Also contributing to this document was Joy Bell of Maricopa County, AZ, Environmental Services Department.

This page is intentionally left blank

CONTENTS

Section **Page**

CONTENTS (CONTINUED)

Section **Page**

TABLES

This page is intentionally left blank.

1

INTRODUCTION

This chapter is one of a series of documents developed to provide cost-effective, reliable and consistent approaches to estimating emissions for area source inventories. Multiple methods are provided in the chapters to accommodate needs of state agencies with different levels of available resources and skills; and different levels of needs for accuracy and reliability of their estimates. More information about the EIIP program can be found in Volume 1 of the EIIP series, Introduction and Use of EIIP Guidance for Emissions Inventory Development.

Throughout this chapter and other EIIP area source methods chapters, we stress that area source categories should be prioritized by the inventory planners so that resources can be spent on the source categories that are the largest emitters, most likely to be subject to regulations or are already subject to regulations, or require special effort because of some policy reason. Prioritization is particularly important for area source inventories, because in some cases, a difficult to characterize source category may contribute very little to overall emissions and attempting a high quality estimate for that source category may not be cost effective.

EIIP chapters are written for the state and local air pollution agencies, with their input and review. EIIP is a response to EPA's understanding that state and local agency personnel have more knowledge about their inventory area's activities, processes, emissions, and availability of information; and require flexible inventory methods to best use their sometimes limited resources. These EIIP area source chapters are written as a set of options presented to inventory professionals capable of using their own experience and judgement to apply the method that best fits their overall needs and constraints.

This chapter describes the procedures and recommended approaches for estimating emissions from structure fires. Section 2 of this chapter contains a description of this category. Section 3 of this chapter provides an overview of available emission estimation methods. Section 4 presents the preferred emission estimation methods for structure fires, and Section 5 presents alternative emission estimation techniques. Quality assurance and quality control procedures are described in Section 6. Data coding procedures are discussed in Section 7, and Section 8 lists all references cited in this chapter.

This page is intentionally left blank.

2

SOURCE CATEGORY DESCRIPTION

Accidental structure fires result from unintentional actions, arson, or natural events. Structure fires covered in this chapter are accidental fires that occur in residential and commercial structures. Accidental industrial fires are not included in this chapter because detailed emission estimates are required that depend on the materials burned in each fire. Discussions about this source can be found in two EPA documents (EPA, 1991 and EPA, 1993). A method for estimating emissions from firefighters' practice fires is not defined in this chapter, but if it is necessary to estimate fires from this source, the emission factors and the approach used in this chapter to determining fuel loading may be useful.

Prescribed fires, agricultural fires, and other forms of open burning are discussed in Chapters 16, 19, and 20 of this volume. Fires covered in these chapters are those that occur because of intentional actions (excluding arson) and are used to reduce or remove waste materials.

2.1 PROCESS DESCRIPTION

Structure fires covered in this chapter are only those affecting residential or commercial structures. Accidental fires in yards, of vehicles and telephone poles are not included in this chapter. Emissions from these types of fires are assumed to be very small.

Structural materials such as insulation and wood, and the contents of structures such as furniture, carpets, clothing, paper and plastics, can burn in a structure fire. Not all of the contents and structural materials burn in a fire, rather, the fire burns a portion of the contents and structural material in the rooms where the fire originates and spreads. The average total material burned (fuel loading) in a residential fire is estimated to be 1.15 tons (CARB, 1994). The emission estimation methods discussed here are not valid for industrial fires where chemicals or industrial materials are burned. Emission estimates for industrial fires should be based on the type of industrial chemicals burned in each fire.

2.2 FACTORS INFLUENCING EMISSIONS

Emissions from structure fires depend on the structure type, physical properties of combustible materials, and amount of material combusted. Residential and commercial structures will tend to have differences in mixtures and quantities of combustible materials that will cause

differences in structural fire emissions. The portion of the structure and contents that are burned is a function of the extent of the fire as well as the available fuel loading.

Process control mechanisms do not exist for accidental structure fires. Programs that improve public awareness may reduce the number of accidental structure fires. However, the correlation between such programs and reductions in structure fires is difficult to determine. Fire codes also serve to reduce emissions from structure fires by requiring reductions in available fuel, installation of sprinkler systems, and warning systems that improve emergency response time.

3

OVERVIEW OF AVAILABLE METHODS

Calculations for estimating emissions for structure fires use an equation based on emission factors, fuel loading, and activity data. Area source methods can not address all of the complexity involved in this source category. This section provides an overview of inventory planning issues for the structure fire source category, outlines the preferred and alternative methods, and discusses temporal adjustments and emission projection issues.

One of the particular difficulties in estimating emissions from the structure fire source category is the lack of activity data, in terms of the number of incidents and the quantity of material burned. When parameters have poorly defined or unavailable information, inventory preparers will need to make well-educated assumptions.

Preferred and alternative methods in this chapter differ mainly in the level of detail and area-specificity of the collected fuel loading and activity data. Each method has advantages and disadvantages in terms of the expense and labor required for the method and the resulting quality of the emission estimate. The inventory preparer must select a method based on the desired accuracy of the emissions inventory, the resources available to develop the inventory, and the potential for the source to contribute to the emissions inventory.

3.1 PLANNING

The first step in planning for structure fire estimation is to determine if enough fires took place in the inventory area during the inventory time period to warrant including this source category in the inventory. Refer to the second alternative method for ways to estimate the scale of potential emissions from this source.

If it is determined that this source category should be included in the inventory, then the next step is to choose an emission estimation method. This choice is based on the inventory data quality objectives (DQOs), the estimated scale of the emissions relative to other area sources, and availability of the information needed to make the calculations. The available information and the amount of time and resources needed to collect it should be balanced with the priorities and DQOs of the inventory to select the appropriate method for the inventory. Refer to EIIP Volume VI, Quality Assurance Procedures, Sections 2.1 and 2.4 for discussions of inventory categories and DQOs. Detailed information about this source category should be available from local fire marshals and public safety departments, or state agencies that oversee public safety.

National summary statistics on structure fires are available from the United States Fire Administration and the National Fire Protection Agency (NFPA).[1,2]

3.2 AVAILABLE METHODS AND DATA REQUIREMENTS

The preferred and alternative methods for estimating emissions from structure fires are summarized in Table 8.3-1. Emission factors are available to estimate particulate matter (PM), total organics (TOG), methane (CH_4), sulfur oxides (SO_x), carbon monoxide (CO), hydrogen cyanide, formaldehyde, acrolein, and nitrogen oxides (NO_x) (Butler, 1972; EPA, 1995). To use these emission factors, the total tons of material burned must be obtained from the activity and the fuel loading. Calculation parameters to determine the quantity of material burned are provided with the description of each estimation method.

TABLE 18.3-1

SUMMARY OF AVAILABLE METHODS FOR STRUCTURAL FIRES

Method Description	Activity Data
PREFERRED Collect data for the number of residential and non-residential structural fires. Use the fuel loading and emission factors provided. Calculation: Number of fires * Fuel Loading Factor * Emission Factor	- Number of fires occurring within inventory area
ALTERNATIVE 1 Collect data on the number of fires for a representative portion of the inventory area and scale to the entire inventory area based on population. Use the fuel loading and emission factors provided.	- Number of fires for superset or subset area - Inventory area and subset area population
ALTERNATIVE 2 Use the fires per capita factor provided with the method, fuel loading and emission factors provided.	- Inventory area population

[1] The United States Fire Administration can be contacted at: 16825 South Seton Ave., Emmitsburg, MD 21727, phone: (301) 447-1000, or on the Internet: http://www.usfa.fema.gov/

[2] The National Fire Protection Agency can be contacted at: 1 Batterymarch Park, Quincy, MA, 02269, phone: (617) 770-3000, or on the Internet: http://www.nfpa.org/

The preferred method uses activity data collected for the entire inventory area. The first alternative method uses activity data for either a subarea or a similar area that is scaled or apportioned to the entire inventory area. A similar area is one that has the same population density and housing characteristics. The second alternative is based on default per capita activity.

3.3 ADJUSTMENTS

3.3.1 APPLICATION OF CONTROLS

No controls are available for this sources. The number of structure fires may be reduced as a result of public awareness programs. The activity may reflect the impact of such programs.

3.3.2 SPATIAL ALLOCATION

Spatial allocation of the activity data is necessary for the alternative estimation methods. In those cases, the data must be extrapolated or scaled to the inventory area using a spatial surrogate. In addition to scaling or extrapolating emissions or activity from one area to another, emissions or activity may need to be allocated within the inventory area. The recommended spatial allocation surrogate for structure fires is population.

3.3.3 TEMPORAL RESOLUTION

Seasonal Resolution

Structure fires vary seasonally. Structural fires may increase during cold weather for some inventory areas due to careless open burning, Christmas lights, or space heater or fireplace use. For this reason, it is emphasized that the inventory preparer should investigate the time of occurrence for these fires relative to the time period of the inventory during the inventory planning stage.

The preferred method for apportioning structural emissions by season is to use local season-specific activity data. The preferred emission estimation method is detailed enough to collect season-specific data. In this case, information is collected on an incident-by-incident basis, and emissions are either calculated for each incident or can be apportioned according to locally specific activity levels.

Alternative apportioning methods for structure fires are, in order of preference:

- Collect data from another area, either a subset, superset, a similar area, or from a year other than that of the inventory for the inventory area. Using this approach should include an effort to match the surrogate area or year to the inventory area and year in terms of the factors that influence the frequency and severity of accidental fires;

- Use estimates of activity from a local expert, such as the fire marshal or public safety office; or

- Use the seasonal distribution reported in the National Fire Data Center's report, *Fire in the United States*.[3] An example for 1994 of the monthly distribution of residential and nonresidential structure fires is provided in Table 18.3-2. Please note that this distribution represents national averages, and the distribution of occurrences within a particular inventory area may differ. Non-residential fires for this report are classified as industrial and commercial properties, institutions, educational establishments, mobile properties, and properties that are vacant or under construction.

Daily Resolution

Structure fires can be expected to take place seven days a week. Structure fire occurrences are consistent through the week.[3] The preferred and alternate methods discussed above for attaining seasonal resolution apply for daily resolution as well.

3.3.4 OTHER FACTORS INFLUENCING EMISSION ESTIMATES

Natural disasters may affect structure fire activity and the resulting emissions. Natural disasters such as hurricanes, tornadoes, ice storms or floods may cause electricity outages which increases the use of fire in residences and increase the risk of structure fires. If the per capita activity factor is used to develop the inventory, expert opinion may be required to estimate the impact of natural disasters on structural fire activity.

---

[3] Fire in the United States 1985 - 1994, Ninth Edition, FA - 173/July 1997, or a similar and more recent publication can be ordered from: United States Fire Administration, Federal Emergency Management Agency, Publications Center, Room N310, 16825 South Seton Avenue, Emmitsburg, MD 21727, or ordered through the Web site: http://www.usfa.fema.gov/

TABLE 18.3-2

OCCURRENCE OF RESIDENTIAL AND NON-RESIDENTIAL STRUCTURE FIRES IN 1994, BY MONTH[a]

Month	Residential Structure Fires %	Non-Residential Structure Fires %
January	12.6	9.0
February	9.8	7.8
March	9.1	9.0
April	8.2	9.3
May	7.4	8.6
June	7.5	8.9
July	7.4	8.5
August	6.9	7.8
September	6.6	7.4
October	7.5	8.1
November	8.0	7.8
December	9.0	7.7
Total	100	99.9

[a] Source: FEMA, 1997.

3.3.5 PROJECTING EMISSIONS

A discussion about developing growth factors and projecting emission estimates can be found in Section 4 of Chapter 1 of this volume, *Introduction to Area Source Emission Inventory Development*.

Projecting emissions for structure fires usually will take into account only changes in activity levels. Sources of variation in structural fires include:

- Changes in population, either in total population or population shift in residential housing types; and

- Changes in fire codes, building codes, or inspection policies that reduce the risk of fires.

4

PREFERRED METHOD FOR ESTIMATING EMISSIONS

Emissions from structure fires are determined by the incidence of fires and the amount and the type of material burned. The preferred method presented here is a set of guidelines for identifying the parameters that need to be collected, where the information can be located, and the assumptions that can be used in order to develop reasonable estimates. There is no universal data source that can be used for every inventory to estimate emissions for this source category. When lists of potential data sources are given as part of a method, one or more of these data sources may need to be contacted.

As with all area source inventory categories, documentation should be maintained for data collected, assumptions, information contacts, and calculations. Because preparation of an inventory for this source category requires making assumptions in order to develop activity levels, the basis for all assumptions must be well documented.

For structure fires, costs and labor efforts are highest the first time that the preferred method is used. Subsequent updates to the inventory can be done using a local activity adjustment factor, if a suitable scaling surrogate can be identified. Subsequent inventories should take advantage of the data handling and quality assurance/quality control (QA/QC) routines put into place the first time the method was used. See discussions of surveys for area sources in Volume 1 of the EIIP series and in Chapter 1 of this volume for more information.

4.1 STRUCTURE FIRES

The preferred method for estimating emissions from structure fires should be used if more detailed emission estimates are needed for planning, or the source category is a high priority. If the information needed for this method can be easily compiled, then it may be worthwhile to develop locality-specific activity surrogate factors and fuel loadings.

4.1.1 ACTIVITY LEVEL DATA COLLECTION

The preferred method for structural fires uses the statistics for the total number of fires in an inventory area. Structure fire statistics by month are preferred for seasonal inventories such as

ozone or CO inventories. If the default fuel loading factor is being used, then data on the structure types that are involved in the fires need not be collected.

Potential information sources for locality-specific structure fires activity data are local or state fire marshals or local or state fire and public safety departments. Reporting and availability of information about structure fires will vary by locality. These contacts may also be able to provide estimates of material loss for the inventory area, either as a portion of the structure or as tons burned per fire.

When collecting information about occurrences of structure fires, be certain that the definition of a structure fire counted by the fire marshal is actual fires and not the number of emergency calls. Also, clarify the size of the fires if possible. Structure fires can be very small, such as electrical wiring or cooking fires, or they can be large, consuming the entire structure. Most reported fires will be small. Additionally, if fires that take place on residential property, such as garage fires, are classified separately from other residential fires, then statistics for garage fires should be obtained and included in the activity used to estimate emissions. Descriptions of the statistics will also assist in determining if the majority of fires within the inventory area are accounted for by the fire marshal.

4.1.2 FUEL LOADING

Fuel loading estimates are necessary to convert the activity (number of fires) to units compatible with the emission factors, which are based on the weight of material burned. The material burned will be a function of the total material available and the duration of the fire. The total combustible material depends on the intended use of the structure. Structures can be broadly classified as residential and non-residential, which includes commercial and institutional structures. Residential structures can be further classified as single family and multi-family dwellings. The state or local fire marshal may be able to provide estimates of material loss for the inventory area, either as a portion of the structure or tons burned per fire. However, losses are usually reported in terms of the dollar value lost.

The most conservative fuel loading estimate will assume that all the combustible material is burned. However, this is not likely for most structural fires. Locality-specific fuel loading factors for different structure types would improve the emission estimate, but a fuel loading factor of 1.15 tons per fire using a method developed by California Air Resources Board

(CARB) is an acceptable default value for all types of structures.[4] The CARB approach to developing a local fuel loading factor could be used for other inventory areas.

The fuel loading factor is based on an estimate of combustible structural content for a typical residence, and an estimate of the average loss per fire. Combustible structural content is the sum of the combustible structural materials and the building contents. Fuel loading is a percentage of the total combustible structural content. Fuel loading is calculated:

$$\text{Combustible Structural Materials} = (\text{Structural Mass} + \text{Contents}) * \text{Loss Percentage} \quad (18.4\text{-}1)$$

Combustible structural mass is calculated by multiplying an estimate of combustible material per square foot in the building structure by the average residence's square footage:

$$\text{Combustible Structural Materials (tons)} = \left(\begin{array}{c} \text{Combustible} \\ \text{Structural Mass} \\ \text{lb/sq ft} \end{array} * \begin{array}{c} \text{Square Footage} \\ \text{per Residence} \\ \text{sq ft} \end{array} \right) \div 2000 \text{ lb/ton} \quad (18.4\text{-}2)$$

CARB's estimate for combustible structural mass is 16.3 pounds per square foot. Assuming an average residence size is 1350 square feet, combustible structural materials would be:

$$\begin{aligned} \text{Combustible Structural Materials} &= (16.3 \text{ lb/sq ft} * 1350 \text{ sq ft}) \div 2000 \text{ lb/ton} \\ &= 11 \text{ tons} \end{aligned} \quad (18.4\text{-}3)$$

Average residence size can vary from region to region. Inventory preparers are encouraged to identify a local average residence size. The U.S. Census Bureau[5] reports that the national median residence size in 1995 was 1732 square feet.

Combustible building contents are calculated by multiplying an estimate of contents per square foot in the building structure by the average residence's interior floor space:

---

[4] This method is derived from the CARB *Emission Inventory Procedural Manual, Vol. III: Methods for Assessing Area Source Emissions,* developed by the California Environmental Protection Agency: Air Resources Board. The latest version of the manual is available on the internet at: http://www.arb.ca.gov/emisinv/areasrc/areameth.htm

[5] The U.S. Census Bureau maintains an Internet Web site at: http://www.census.gov/

$$\text{Combustible Building Contents (tons)} = \left(\begin{array}{c} \text{Combustible} \\ \text{Building Contents} \\ \text{lb/sq ft} \end{array} * \begin{array}{c} \text{Floor Space} \\ \text{per Residence} \\ \text{sq ft} \end{array} \right) \div 2000 \text{ lb/ton} \qquad (18.4\text{-}4)$$

CARB's estimate for combustible building contents is 7.91 pounds per square foot. Assuming an average floor space per residence is 1200 square feet, combustible building contents would be:

$$\begin{aligned} \text{Combustible Building Contents} &= (7.91 \text{ lb/sq ft} * 1200 \text{ sq ft}) \div 2000 \text{ lb/ton} \\ &= 4.7 \text{ tons} \end{aligned} \qquad (18.4\text{-}5)$$

CARB estimates that the average loss per fire is 7.3 percent of the combustible structural content. The average loss is based on monetary losses reported by FEMA and the average value of residences reported by the California Association of Realtors. The loss rate is applied to the estimated total combustible structural content to obtain a fuel loading per fire:

$$\begin{aligned} \begin{array}{c} \text{Fuel} \\ \text{Loading} \\ \text{tons/fire} \end{array} &= \left(\begin{array}{c} \text{Combustible} \\ \text{Structural Materials} \\ \text{tons} \end{array} + \begin{array}{c} \text{Combustible} \\ \text{Building Contents} \\ \text{tons} \end{array} \right) * \begin{array}{c} \text{Loss} \\ \text{Rate} \\ \% \end{array} \\ &= (11 \text{ tons} + 4.7 \text{ tons}) * 0.073 \\ &= 1.15 \text{ tons/fire} \end{aligned} \qquad (18.4\text{-}6)$$

The percent loss was estimated based on monetary losses. Fire marshalls typically report losses as dollar loss statistics. There are, however, several weaknesses in using the dollar loss to estimate the percentage of material combusted. First, material may be damaged by smoke or sprinkler systems and counted as loss even though it is not combusted. Second, the value of contents or structures is not directly proportional to the mass. Finally, the percent monetary loss is the average loss divided by the average dollar value of structures. Since these two values do not come from the same data source, there can be discrepancies in how they are determined. Despite these weaknesses in representing material combusted, percent dollar losses may be the most practical way to represent the percentage of material burned in a fire.

Emission Factors

Emission factors for structural fires are presented in Table 18.4-1. The emission factors given are assumed to apply to all structure types.

TABLE 18.4-1

EMISSION FACTORS FOR STRUCTURE FIRES

Pollutant	Factor (lb/ton burned)	Reference
PM	10.8	CARB, 1994[a]
TOG	13.9	CARB, 1994[a]
Hydrogen cyanide	35.49	EPA, 2000
Formaldehyde	1.02	EPA, 2000
Acrolein	4.41	EPA, 2000
Hydrochloric acid	15.11	EPA, 2000
VOC	11	EPA, 1991
NO_X	1.4	EPA, 1991
CO	60	EPA, 1991

[a] See footnote 4 in the text for more information about this document.

Emission Calculations

Emissions from structure fires are determined by multiplying the number of reported structure fires by the fuel loading per fire and the emission factors from Table 18.4-1:

$$\text{Emissions} = \text{Emission factor} * \text{Activity} * \text{Fuel loading} \qquad (18.4\text{-}7)$$

where:

Emissions	=	Emissions for a given pollutant (lb emitted)
Emission factor	=	Emission factor for a certain pollutant (lb emitted/ton burned)
Activity	=	Number of fires within the inventory area (fires)
Fuel loading	=	Fuel loading per fire (ton burned/fire)

If emissions are being calculated for an inventory season, and local season-specific activity is not available, emissions can be apportioned using any of the three alternative apportioning approaches from Section 3.3.3 of this chapter. Example 18.4-1 shows a typical calculation for one county in an inventory area.

Example 18.4-1:

County A has had 115 structure fires reported for the inventory year. Information about the structure types and the extent of the material burned in each fire was not collected, so the default fuel loading of 1.15 tons per fire was used. The PM emissions for structure fires in County A are:

Emissions = 10.8 lb/ton * 115 fires/year * 1.15 tons/fire
= 1,428 lbs/year
= 0.71 tons/year

5

ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

Alternative methods require less effort and less cost, but may result in estimates that are less detailed and/or less locality-specific. The choice of a preferred over an alternative method will be determined by the DQOs and budget for the inventory. For this source category in particular, the significance of sources to the total area emissions should be considered when choosing methods.

During the planning stage of the inventory, research should be done to identify data sources and other factors that might influence emissions from the source category. See Section 3.1 of this chapter for specific issues.

5.1 FIRST ALTERNATIVE METHOD

The first alternative method for estimating emissions from structural fires uses the same emission factors and same default fuel loading described in the preferred method for this category. The first alternative method relies on activity data from a larger inventory area that is apportioned to the inventory area, or on activity data from a subarea that is scaled to the inventory area. Activity information may be available from state or local fire marshals and public safety departments, neighboring inventory areas, or from a subset of the inventory area.

When activity data is available for the whole state, or an area larger than the inventory area, then the number of fires for the state will need to be apportioned to the county level. Population can be used to apportion the number of fires. The equation to apportion the number of fires is:

$$\text{Fires in county} = \text{Fires in state} * \text{county population/state population} \qquad (18.5\text{-}1)$$

If activity data is scaled from a subarea or similar area, population is also used for scaling. When information is collected for a small area and scaled to the inventory area, the number of fires that occurred in that subarea can be collected from the few fire departments that serve that subarea. The area that is used as a source of activity data should be similar to the entire inventory area. According to statistics in the report, *Fire in the United States: 1985 - 1994* (FEMA, 1997), cooking and heating are the leading causes of residential structure fires. As a

result, heating types may have some influence on fire incidences, and structure fire activity from an area that has distinctly different residential heating types than the inventory area may not be a good match. The U.S. Bureau of Census can provide data on population and heating types.[6] The scaling equation for structure fire activity from a subarea to a county in the inventory area is:

$$\text{Fires in county} = \text{Fires in subarea} * \text{county population/subarea population} \quad (18.5\text{-}2)$$

After activity data is scaled or apportioned to the inventory area, the default fuel loading factor, emission factors, and emission calculations are the same as those described for the preferred method.

Use any of the three alternative seasonal apportioning methods listed in Section 3.3.3 of this chapter.

5.2 SECOND ALTERNATIVE METHOD

The second alternative method for estimating emissions from structural fires uses the same emission factors and the same fuel loading that is described in the preferred method. However, for this method, the activity is obtained by multiplying a national average factor of fires per capita by the inventory area population. The number of fires per capita is based on an estimated 602,500 total fires reported for 1994 (FEMA, 1997) and a U.S. population of 260.4 million (1994 U.S. population)[7], averaging 2.3 fires per 1,000 people. If more recent data on total fires becomes available, then those data can be used to calculate a more recent per capita activity factor. Inventory area population is multiplied by the per capita factor to get the estimated number of structure fires in the area.

After the inventory area activity level is determined, emission calculations are the same as those described for the prescribed method, using the default fuel loading of 1.15 tons per fire and the emission factors in Table 18.4-1. Example 18.5-1 shows typical calculations.

---

[6] Census data is available through the U.S. Bureau of Census, Commerce Department, Washington, DC, or through the Web site: http://www.census.gov.

[7] U.S. Bureau of Census Web site: http://www.census.gov.

Example 18.5-1:

County B's population is 0.5 million people. The structure fire activity is determined to be:

Activity = population * fires/population
= 0.5 million people * 2.3 fires/ 1,000 persons
= 1,150 fires

PM emissions can then be calculated as:

Emissions = emission factor * activity * fuel loading
= 10.8 lb/ton * 1,150 fires/year * 1.15 tons/fire
= 14,283 lbs/year

Use any of the three alternative seasonal apportioning methods listed in Section 3.3.3 of this chapter.

This page is intentionally left blank.

6

QUALITY ASSURANCE/QUALITY CONTROL

Data collection and handling for the structure fire source category should be planned and documented in the Quality Assurance Plan. Assumptions used and decisions made concerning data sources should be documented. Refer to the Quality Assurance Quality Control (QA/QC) section of Chapter 1, *Introduction to Area Source Emission Inventory Development,* of this volume, and the QA volume (VI) of the Emission Inventory Improvement Program (EIIP) series. Potential pitfalls when developing emissions estimates:

- Incomplete or inaccurate reports of the number of fires;
- Reporting that covers a geographic area that is either larger or smaller than that for the inventory; and
- Inaccurate estimates of the material burned for each fire.

Potential errors common to many area source methods are calculation errors, including unit conversion errors and data transfer errors.

6.1 EMISSION ESTIMATE QUALITY INDICATORS

In this chapter, three estimation methods are presented. The preferred method uses local data on fire incidences collected for the entire inventory area, fuel loading factors developed from local data or default factors from CARB, and a set of emission factors compiled from multiple sources (see Table 18.4-1). The first alternative method uses local data on fire incidences collected for a subset of the inventory area, the CARB default fuel loading factors, and the same set of emission factors as the preferred method. The second alternative method uses the national average factor of fires per capita to develop the activity, the CARB default fuel loading factor, and the emission factors used for the preferred and first alternative methods. Using the most accurate activity data, in the form of fire incidences and fuel loading, is the way to develop the best emission estimates. However, inventory planners should consider the costs of data collection versus the benefit of a more accurate estimate for a very small emissions source.

6.1.1 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

The Data Attribute Rating System (DARS) has been developed as a tool to rate emission inventories. A description of the system and the EIIP recommendations for its use can be found in Appendix F of EIIP Volume VI, Quality Assurance Procedures. The following discussion uses the DARS rating system as a way to compare the estimation approaches presented in this chapter and analyze their strengths and weaknesses.

The DARS scores for the three estimation methods are summarized in Tables 18.6-1 through 18.6-3. Variation between scores depends on the activity data used. All scores assume that good QA/QC measures were performed and that no significant deviations from the prescribed methods were made.

TABLE 18.6-1

STRUCTURE FIRES
PREFERRED METHOD: LOCAL DATA

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.5	0.6	0.3
Source specificity	0.7	0.4	0.28
Spatial congruity	0.7	0.7	0.49
Temporal congruity	0.7	0.9	0.63
Composite	0.65	0.65	0.43

TABLE 18.6-2

STRUCTURE FIRES
ALTERNATIVE METHOD 1: SCALED LOCAL ACTIVITY

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.5	0.5	0.25
Source specificity	0.7	0.4	0.28
Spatial congruity	0.7	0.6	0.42
Temporal congruity	0.7	0.9	0.63
Composite	0.65	0.6	0.4

TABLE 18.6-3

STRUCTURE FIRES
ALTERNATIVE METHOD 2: PER CAPITA ACTIVITY

Attribute	Scores		
	Factor	Activity	Emissions
Measurement	0.5	0.4	0.2
Source specificity	0.7	0.3	0.21
Spatial congruity	0.7	0.5	0.35
Temporal congruity	0.7	0.8	0.56
Composite	0.65	0.5	0.33

6.1.2 SOURCES OF UNCERTAINTY

Another way to assess the emission methods is to examine the associated uncertainty. For the preferred and first alternative methods, activity data is derived from local data, and can be treated as survey data. Uncertainty for survey data can be quantified (see Chapter 4 of Volume VI of the EIIP series). The uncertainty for the second alternative method, using fires per 1,000 people, can be calculated by referring to the supporting documentation for the national fire estimates (FEMA, 1997). This uncertainty will only pertain to the national estimate.

Additional uncertainty will be introduced by scaling the activity estimate to an inventory area, where average conditions of fire incidence may not exist.

A source of uncertainty for all of the methods is the fuel loading factor. No two fires will burn the same amount of material, and material types and structure sizes vary from region to region in the United States, as well as within a single county. The default fuel loading factor provided here is an average of a highly variable factor, and should be understood to represent a practical way to estimate area-wide emissions.

Emission factors also contribute to overall uncertainty. Emission rates of any pollutant for this source category will be highly variable, given that the process is uncontrolled combustion of mixed materials, and is not well constrained. This uncertainty cannot be quantified.

7

DATA CODING PROCEDURES

The inventory preparer should check the EPA website (http://www.epa.gov/ttn/chief/) for the latest information (codes) available to characterize emission estimates from structure fires. A complete list of Source Classification Codes (SCC) can be retrieved at http://www.epa.gov/ttn/chief/codes/. Table 18.7-1 lists the applicable SCCs for structure fires.

Available codes and process definitions influence and help guide the preparation of emission estimates for this category. Data transfer formats should be taken into account when an inventory preparer plans for data collection, calculation, and inventory presentation. Consistent categorization and coding will result in greater continuity between emission inventories for use in regional and national scale analyses.

7.1 NECESSARY DATA ELEMENTS

If the category emissions data will be transferred to EPA for incorporation into the national criteria and toxics air pollutant inventory, specific data transfer formats are acceptable. The acceptable data transfer format(s) are described and available for download at http://www.epa.gov/ttn/chief/net/. The acceptable data transfer formats contain the data elements necessary to complete the data set for use in regional or national air quality and human exposure modeling. The inventory preparer should review the area source portion of the acceptable file format(s) to understand the necessary data elements. The EPA describes its use and processing of the data for purposes of completing the national inventory, in its Data Incorporation Plan, also located at http://www.epa.gov/ttn/chief/net/.

TABLE 18.7-1

AREA AND MOBILE SOURCE CATEGORY CODES FOR STRUCTURE FIRES

Process Description	Source Category Code
Structure Fires - total	28-10-030-000

This page is intentionally left blank.

8

REFERENCES

CARB. 1994. *Emission Inventory Procedural Manual, Vol. III: Methods for Assessing Area Source Emissions*. California Environmental Protection Agency: Air Resources Board.

EPA. 2000. *National Toxics Inventory.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, N.C.

EPA. 1998. *National Air Pollutant Emission Trends, Procedures Document, 1900 - 1996.* EPA-454/R-98-008. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, N.C.

EPA, 1995. *Development of Area Source Hazardous Air Pollutant Inventories, Volume 1: Air Toxic Emission Inventories for the Chicago Area.* U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina.

EPA. 1994. *AIRS Database.* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, NC.

EPA, 1993. *Identification and Characterization of Five Non-Traditional Source Categories: Catastrophic/Accidental Releases, Vehicle Repair Facilities, Recycling, Pesticide Application and Agricultural Operations.* EPA-600/R-93-045. U.S. Environmental Protection Agency, Air and Energy Engineering Research Laboratory. Research Triangle Park, North Carolina.

EPA. 1991. *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Vol. I.* EPA-450/4-91-016. U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina.

FEMA. 1997. *Fire in the United States: 1985-1994*, Ninth Edition (FA-173/July 1997). Federal Emergency Management Agency, United States Fire Administration, National Fire Data Center. Emmitsburg, MD.

This page is intentionally left blank.