

## Chapter 2: SO<sub>2</sub> Emissions and Monitoring Data

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### Synopsis

This chapter describes the available SO<sub>2</sub> emissions and air quality data used to inform and develop the control strategies outlined in this RIA. We first describe data on SO<sub>2</sub> emission sources contained in available EPA emission inventories. We then provide an overview of data sources for air quality measurement. For a more in-depth discussion of SO<sub>2</sub> emissions and air quality data, see the Integrated Science Assessment for the SO<sub>2</sub> NAAQS.<sup>1</sup>

### 2.1 Sources of SO<sub>2</sub>

In order to estimate risks associated with SO<sub>2</sub> exposure, principal sources of the pollutant must first be characterized because the majority of human exposures are likely to result from the release of emissions from these sources. Anthropogenic SO<sub>2</sub> emissions originate chiefly from point sources, with fossil fuel combustion at electric utilities (~66%) and other industrial facilities (~29%) accounting for the majority of total emissions (ISA, section 2.1). Other anthropogenic sources of SO<sub>2</sub> include both the extraction of metal from ore as well as the burning of high sulfur containing fuels by locomotives, large ships, and non-road diesel equipment. Notably, almost the entire sulfur content of fuel is released as SO<sub>2</sub> or SO<sub>3</sub> during combustion. Thus, based on the sulfur content in fuel stocks, oxides of sulfur emissions can be calculated to a higher degree of accuracy than can emissions for other pollutants such as PM and NO<sub>2</sub> (ISA, section 2.1).

The largest natural sources of SO<sub>2</sub> are volcanoes and wildfires. Although SO<sub>2</sub> constitutes a relatively minor fraction (0.005% by volume) of total volcanic emissions, concentrations in volcanic plumes can be in the range of several to tens of ppm (thousands of ppb). Volcanic sources of SO<sub>2</sub> in the U.S. are limited to the Pacific Northwest, Alaska, and Hawaii. Emissions of SO<sub>2</sub> can also result from burning vegetation. The amount of SO<sub>2</sub> released from burning vegetation is generally in the range of 1 to 2% of the biomass burned and is the result of sulfur from amino acids being released as SO<sub>2</sub> during combustion.

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<sup>1</sup> U.S. Environmental Protection Agency (2007c), Review of the National Ambient Air Quality Standards for SO<sub>2</sub>: Policy Assessment of Scientific and Technical Information, Integrated Science Assessment, Chapter 2, EPA-452/R-08-xxx, Office of Air Quality Planning and Standards, RTP, NC.

Emissions inventory inputs representing the year 2005 for the sources above were developed to provide a base year for the air quality analysis presented in Chapter 3. The 2005 National Emissions Inventory (NEI), version 2 from October 6, 2008 was the starting point for the U.S. inventories used for the air quality analysis. This inventory includes 2005-specific data for most point and mobile sources, while most nonpoint and other data were carried forward from version of the 2002 NEI. For more information on the 2005 NEI, upon which significant portions of the 2005 modeling platform are based, see <http://www.epa.gov/ttn/chief/net/2005inventory.html>.

## **2.2 Air Quality Monitoring Data**

### *2.2.1 Background on SO<sub>2</sub> monitoring network*

The following section provides general background on the SO<sub>2</sub> monitoring network. A more detailed description of this network can be found in Watkins (2009). The SO<sub>2</sub> monitoring network was originally deployed to support implementation of the SO<sub>2</sub> NAAQS established in 1971. Despite the establishment of an SO<sub>2</sub> standard, uniform minimum monitoring requirements for SO<sub>2</sub> monitoring did not appear until May 1979. From the time of the implementation of the 1979 monitoring rule through 2008, the SO<sub>2</sub> network has steadily decreased in size from approximately 1496 sites in 1980 to the approximately 488 sites operating in 2008.

The 1979 monitoring rule established two categories of SO<sub>2</sub> monitoring sites: State and Local Ambient Monitoring Stations (SLAMS) and the smaller set of National Ambient Monitoring Stations (NAMS). No minimum requirements were established for SLAMS. Minimum requirements (described below) were established for NAMS. The 1979 rule also required that SO<sub>2</sub> only be monitored using Federal Reference Methods (FRMs) or Federal Equivalent Methods (FEMs). The 1979 monitoring rule called for a range of number of sites in a metropolitan statistical area (MSA) based both on population size and known concentrations relative to the NAAQS (at that point in time; see Watkins, 2009).

In October 2006, EPA revised the monitoring requirements for SO<sub>2</sub> in light of the fact that there was not an SO<sub>2</sub> non-attainment problem (Watkins, 2009). The 2006 rule eliminated the minimum requirements for the number of SO<sub>2</sub> monitoring sites. The current SO<sub>2</sub> monitoring rule, 40 CFR Part 58, Appendix D, section 4.4 states:

**Sulfur Dioxide (SO<sub>2</sub>) Design Criteria:**

(a) There are no minimum requirements for the number of SO<sub>2</sub> monitoring sites. Continued operation of existing SLAMS SO<sub>2</sub> sites using FRM or FEM is required until discontinuation is approved by the EPA Regional Administrator. Where SLAMS SO<sub>2</sub> monitoring is ongoing, at least one of the SLAMS SO<sub>2</sub> sites must be a maximum concentration site for that specific area.

(b) The appropriate spatial scales for SO<sub>2</sub> SLAMS monitoring are the microscale, middle, and possibly neighborhood scales. The multi-pollutant NCore sites can provide for metropolitan area trends analyses and general control strategy progress tracking. Other SLAMS sites are expected to provide data that are useful in specific compliance actions, for maintenance plan agreements, or for measuring near specific stationary sources of SO<sub>2</sub>.

(1) Micro and middle scale – Some data uses associated with microscale and middle scale measurements for SO<sub>2</sub> include assessing the effects of control strategies to reduce concentrations (especially for the 3-hour and 24-hour averaging times) and monitoring air pollution episodes.

(2) Neighborhood scale – This scale applies where there is a need to collect air quality data as part of an ongoing SO<sub>2</sub> stationary source impact investigation. Typical locations might include suburban areas adjacent to SO<sub>2</sub> stationary sources for example, or for determining background concentrations as part of these studies of population responses to exposure to SO<sub>2</sub>.

(c) Technical guidance in reference 1 of this appendix should be used to evaluate the adequacy of each existing SO<sub>2</sub> site, to relocate an existing site, or to locate new sites.

To ascertain what the current SO<sub>2</sub> network is addressing or characterizing, and in light of the relatively recent removal of a specific SO<sub>2</sub> monitoring requirement, EPA reviewed some of the SO<sub>2</sub> network meta-data (Watkins, 2009). The data reviewed are those available from AQS for calendar year 2008, for any monitors reporting data at any point during the year. In 2008, there were 488 SO<sub>2</sub> monitors reporting data to AQS at some point during the year.

### *2.2.2 Ambient concentrations of SO<sub>2</sub>*

Since the integrated exposure to a pollutant is the sum of the exposures over all time intervals for all environments in which the individual spends time, understanding the temporal and spatial patterns of SO<sub>2</sub> levels across the U.S is an important component of conducting air quality, exposure, and risk analyses. SO<sub>2</sub> emissions and

ambient concentrations follow a strong east to west gradient due to the large numbers of coal-fired electric generating units in the Ohio River Valley and upper Southeast regions. In the 12 CMSAs that had at least 4 SO<sub>2</sub> regulatory monitors from 2003-2005, 24-hour average concentrations in the continental U.S. ranged from a reported low of ~1 ppb in Riverside, CA and San Francisco, CA to a high of ~12 ppb in Pittsburgh, PA and Steubenville, OH (ISA, section 2.4.4). In addition, inside CMSAs from 2003-2005, the annual average SO<sub>2</sub> concentration was 4 ppb (ISA, Table 2-8). However, spikes in hourly concentrations occurred; the mean 1-hour maximum concentration was 130 ppb, with a maximum value of greater than 700 ppb (ISA, Table 2-8).

In addition to considering 1-hour, 24-hour, and annual SO<sub>2</sub> levels, examining the temporal and spatial patterns of 5-minute peaks of SO<sub>2</sub> is also important given that human clinical studies have demonstrated exposure to these peaks can result in adverse respiratory effects in exercising asthmatics (see REA, Chapter 4). Although the total number of SO<sub>2</sub> monitors across the continuous U.S. can vary from year to year, in 2006 there were approximately 500 SO<sub>2</sub> monitors in the NAAQS monitoring network (ISA, section 2.5.2). State and local agencies responsible for these monitors are required to report 1-hour average SO<sub>2</sub> concentrations to the EPA Air Quality System (AQS). However, a small number of sites, only 98 total from 1997 to 2007, and not the same sites in all years, voluntarily reported 5-minute block average data to AQS (ISA, section 2.5.2). Of these, 16 reported all twelve 5-minute averages in each hour for at least part of the time between 1997 and 2007. The remainder reported only the maximum 5-minute average in each hour. When maximum 5-minute concentrations were reported, the absolute highest concentration over the ten-year period exceeded 4000 ppb, but for all individual monitors, the 99<sup>th</sup> percentile was below 200 ppb (ISA, section 2.5.2). Medians from these monitors reporting data ranged from 1 ppb to 8 ppb, and the average for each maximum 5-minute level ranged from 3 ppb to 17 ppb. Delaware, Pennsylvania, Louisiana, and West Virginia had mean values for maximum 5-minute data exceeding 10 ppb (ISA, section 2.5.2). Among aggregated within-state data for the 16 monitors from which all 5-minute average intervals were reported, the median values ranged from 1 ppb to 5 ppb, and the means ranged from 3 ppb to 11 ppb (ISA, section 2.5.2). The highest reported concentration was 921 ppb, but the 99th percentile values for aggregated within-state data were all below 90 ppb (ISA, section 2.5.2).