Comments of the American Lung Association on EPA's Risk and Exposure Assessment to Support the Review of the SO_2 Primary National Ambient Air Quality Standards: Second Draft EPA-452/P-09-003 March 2009

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The current National Ambient Air Quality Standards (NAAQS) for sulfur dioxide (SO_2) were set in 1971. These standards are an annual average standard of 30 ppb and a 24-hour average standard of 140 ppb, not to be exceeded more than once per year. The American Lung Association concurs with EPA's assessment in the second draft Risk and Exposure Assessment (REA) that the current standards are inadequate to protect public health.

Heath Studies Provide Clear Evidence of Effects Below the Current Standards

- Clinical studies provide clear evidence for harm to people with asthma who breathed high levels of SO_2 while they were exercising. These studies generally found that these individuals suffered a decline in lung function and an increase in respiratory symptoms, even after only a 15-minute exposure of 200 ppb and greater.[1] People with asthma suffered increased airway resistance after several minutes of breathing SO_2 at concentrations of 100 ppb under conditions of exercise, when exposed to SO_2 via a facemask.[2]

- Animal toxicology studies have demonstrated lung inflammation, airway hyperreactivity, and exaggerated allergic responses after repeated exposures of 100 ppb and greater.[3]

[1] U.S. EPA. Integrated Science Assessment for Sulfur Oxides - Health Criteria. ISA: EPA/600/R-08/047F, September 2008, p. 3-4.
[2] Sheppard D, Saisho A, Nadel JA, Boushey HA.. Exercise increases sulfur dioxide-induced bronchoconstriction in asthmatic subjects. *Am Rev Respir Dis* 1981; 123: 486-491.
[3] U.S. EPA. Integrated Science Assessment for Sulfur Oxides - Health Criteria. ISA: EPA/600/R-08/047F, September 2008, pp. 3-19 - 3-20, 3-31.

- Epidemiological studies find effects at far lower concentrations than the clinical chamber studies. The community health studies provide convincing evidence of increased respiratory symptoms in children at current ambient concentrations, well below the level of the current 24-hour current NAAQS of 140 ppb. A large multi-city study linked previous day SO_2 concentrations with morning respiratory symptoms in 8 urban areas where median 3-hour average SO_2 levels ranged from 17 ppb to 37 ppb.[4] Inner city children with asthma suffer from declines in lung function following exposure to higher daily concentrations of sulfur dioxide.[5] Present day concentrations of SO_2 are also implicated in increased emergency department visits and hospitalizations for respiratory causes among children and older adults.[6]

- A study in Bronx, New York found that asthma hospitalizations in children climbed as hourly sulfur dioxide concentrations increased. Hospitalizations began to rise at hourly concentrations greater than 9 ppb, with a sharp increase an concentrations greater than 40 ppb.[7]

- Reducing SO_2 levels results in an immediate gain in life expectancy, according to evidence from intervention studies that examine health effects after reduction in sulfur dioxide exposures.[8]

- According to the EPA Integrated Science Assessment: "The evidence is suggestive of a causal relationship between short-term exposure to SO_2 and mortality."[9]

Court Remands Standards to EPA

EPA last considered revisions to the SO_2 standards in 1996. At that time, there was considerable new evidence that short exposures to peak levels of SO_2 in the air can make it difficult for people with asthma to breathe when they are active outdoors.

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[4] Mortimer KM, Neas LM, Dockery DW, Redline S, Tager IB. The effect of air pollution on inner-city children with asthma. *Eur Respir J* 2002; 19: 699-705; Schwartz J, Dockery DW, Neas LM, Wypij D, Ware JH, Spengler JD, Koutrakis P, Speizer FE, Ferris BG Jr. Acute effects of summer air pollution on respiratory symptom reporting in children. *Am J Respir Crit Care Med* 1994; 150: 1234-1242.

[5] O'Connor GT, Neas L, Vaughn B, Katttan M, Mitchell H, Crain EF, Evans III R, Gruchalla R, Morgan W, Stout J, Adams GK, Lippmann M. Acute respiratory health effects of air pollution on children with asthma in US inner cities. *J Allergy Clin Immunol* 2008; Article in press doi: 10.1016/j.jaci.2008.02.020.

[6] U.S. EPA Draft ISA. Table 5-5. Effects of short-term SO_2 exposure on emergency department visits and hospital admissions for respiratory outcomes. May 2008.

[7] Lin S, Hwang SA, Pantea C, Kielb C, Fitzgerald E. Childhood asthma hospitalizations and ambient air sulfur dioxide concentrations in Bronx County, New York. *Arch Environ Health* 2004; 59: 266-275.

[8] Hedley AJ, Wong CM, Thach TQ, Ma S, Lam TH, Anderson HR. Cardiorespiratory and all-cause mortality after restrictions on sulphur content of fuel in Hong Kong: an intervention study. *Lancet* 2002; 360: 1646-1652.

[9] U.S. EPA. Integrated Science Assessment for Sulfur Oxides - Health Criteria. ISA: EPA/600/R-08/047F, September 2008, p. 5-10.

However, in 1996, EPA declined to set a short-term standard for SO_2, reasoning that too few people were likely to be exposed to high concentrations. The American Lung Association challenged the final decision not to set a 5-minute standard in court. On January 30, 1998, the Court of Appeals for the District of Columbia found that EPA had failed to adequately explain its decision not to set a 5-minute standard and remanded the matter back to EPA.

In response to the remand, EPA embarked on a voluntary program with the states to collect and analyze additional air quality data focused on 5-minute concentrations of SO_2.

However, the results of the data collection effort focusing on short-term concentrations are quite limited and disappointing. Not a lot of additional data was generated, and where five-minute data was provided, monitors may not have been optimized for short-term data collection.

Now, over a decade later, we are pleased that EPA is considering revisions to the NAAQS for SO_2. Unfortunately, the limitations on the data leave us urging that EPA be more conservative in the ranges under review. For many reasons listed below, the need to protect public health calls for recognition that the risks are to more widespread populations and that the effects are larger than previously assumed.

Evidence Does Not Support Relying on a 1-hour Standard to Control 5-minute Exposures

Simply put, there is too little data to assume that 1-hour standard will be protective of 5-minute peak exposures. Given the very limited data on 5-minute exposures, we do not have confidence in the peak-to-mean ratios generated to scale up to a 1-hour average standard.

The peak-to-mean ratios based on the limited data are highly variable and uncertain. Table 10-1 indicates that the 5-minute max: 1 hour daily max ratio ranges from 1.2 to 4.6, difference of nearly a factor of four.

It is inaccurate and an oversimplification to assume a 2:1 peak to mean ratio. There are a range of emissions scenarios and atmospheric conditions that drive peak concentrations, including start up, shutdown, upsets, malfunctions, downwash, and inversions. Further, the peak to mean ratio may not relevant for non-utility sources such as ports.

In fact, an independent analysis of short-term monitoring data performed by A.S. L. & Associates concluded that "No relationship could be found between the hourly maximum 5-minute and hourly maximum SO_2 values."[10]

[10] LeFohn, Allen S. A.S.L. & Associates. Assessing the Potential for the Occurrence of Hourly Maximum 5-Minute Concentrations $\geq$ 0.5 ppm at SO_2 Emission Sources in the United States. Prepared for Clean Air Task Force. March 22, 1999.

Even for a One-hour Standard, the Upper End of the Range Must Be Lower

If EPA pursues a 1-hour standard, several factors suggest that 150 ppb is too high an upper end of the range for a maximum daily one-hour concentration form. EPA should limit the upper end of range to no higher than 100 ppb.

First of all, the benchmark concentrations for assessing the impacts of the 5-minute exposures in the chamber studies range from 100 to 400 ppm. This range needs to be adjusted when considering a 1-hour average standard.

Evidence exists of changes in airway resistance at 5-minute concentrations as low as 100 ppb when combined with exercise for a period of several minutes. The REA fails to mention a controlled human exposure study that examined changes in specific airway resistance in seven exercising subjects with mild asthma. Investigators reported that 2 of the 7 subjects experienced increased airway resistance after inhalation of 100 ppb.[11] SO_2 in this study was administered by mouthpiece. A subsequent study reported that both oral and oronasal breathing of low concentrations of SO_2 during exercise can cause significant bronchoconstriction in people with asthma.[12] The mouthpiece studies are relevant because a substantial percent of the population are mouth breathers whether by preference, habit, or obligation. Mouth breathing may also occur when people are breathing hard due to exercise, or when their nasal passages are blocked by a respiratory infection. These conditions are known risk factors for asthma exacerbations. Regardless of the cause, inhaling air contaminated with sulfur dioxide that bypasses the nasal defense mechanisms initiates reactions at lower concentrations.

Several additional aspects of the chamber studies underline the need for conservative ranges and standards:

- As noted by the REA, severe asthmatics and children were not studied.
- In evaluating the controlled human exposure studies, it is important to consider the responses by individual subjects as well as the group mean responses.
- Due to the small number of subjects included in any one study, the most sensitive people may not have been included.
- In the real world, people breathe sulfur dioxide under different atmospheric conditions than in the laboratory. For instance, chamber studies are usually

[11] Sheppard D, Saisho A, Nadel JA, Boushey HA.. Exercise increases sulfur dioxide-induced bronchoconstriction in asthmatic subjects. *Am Rev Respir Dis* 1981; 123: 486-491.
[12] Kirkpatrick MB, Sheppard D, Nadel JA, Boushey HA. Effect of the oronasal breathing route on sulfur dioxide-induced bronchoconstriction in exercising asthmatic subjects. *Am Rev Respir Dis* 1982; 125: 627-631.

conduced at room temperature; some asthmatics experience increased response when sulfur dioxide is administered in cold dry air.[13]

- Exposures in the laboratory are to sulfur dioxide alone, not in combination with sulfates and other fine particles as people breathe in real world atmospheres.

The Lower End of the Proposed Range for the One-Hour Standard is Too High

Just as the upper end of the proposed range is too high, the lower end is not low enough. As discussed above, there is a range of conversion factors for the 5-minute to one-hour extrapolation, and ratios larger than 2 applied to the chamber study results would lead to a lower bottom end of the range.

In addition, epidemiology studies find effects at concentrations below 50 ppb, the lower end of the proposed range.

For instance, as mentioned earlier, multi-city studies have linked previous day SO_2 concentrations with morning respiratory symptoms in 8 urban areas where median 3-hour average SO_2 levels ranged from 17 ppb to 37 ppb.[14]

The previously referenced study in Bronx, New York found that asthma hospitalizations in children climbed as hourly sulfur dioxide concentrations increased. Hospitalizations began to rise at hourly concentrations greater than 9 ppb, with a sharp increase an concentrations greater than 40 ppb.[15]

A Short-Term Standard, Preferably a 5-minute Standard, is Needed for Practical Reasons

We need a 5-minute SO_2 standard to protect against peak exposures that can result from start-up, shutdown, upset, malfunction, downwash, complex terrain, and atmospheric inversion conditions.

SO_2 control programs such as the acid rain program is a trading programs that allow some utility sources to forgo controls by buying credits from other, so-called "over controlled" sources. Such trading programs fail to protect the local population nearest to the source, who face the greatest, continuing exposure. Thus, in the absence of a short-term standard for SO_2, there is no way to ensure that people are protected from breathing

[13] Sheppard D et al. Magnitude of the interaction between the bronchomotor effects of sulfur dioxide and those of dry (cold) air. *Am Rev Resp Dis* 1984; 130: 52-55.
[14] Mortimer KM, Neas LM, Dockery DW, Redline S, Tager IB. The effect of air pollution on inner-city children with asthma. *Eur Respir J* 2002; 19: 699-705; Schwartz J, Dockery DW, Neas LM, Wypij D, Ware JH, Spengler JD, Koutrakis P, Speizer FE, Ferris BG Jr. Acute effects of summer air pollution on respiratory symptom reporting in children. *Am J Respir Crit Care Med* 1994; 150: 1234-1242.
[15] Lin S, Hwang SA, Pantea C, Kielb C, Fitzgerald E. Childhood asthma hospitalizations and ambient air sulfur dioxide concentrations in Bronx County, New York. *Arch Environ Health* 2004; 59: 266-275.

short term spikes that can be harmful. We need the backstop measure of a short-term standard to accompany further trading programs.