1. PUBLIC HEALTH STATEMENT

This public health statement tells you about sulfur dioxide and the effects of exposure.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation These sites make up the National Priorities List (NPL) and are the sites targeted for long-term federal cleanup activities. Sulfur dioxide has been found in at least 16 of the 1,467 current or former NPL sites. However, the total number of NPL sites evaluated for this substance is not known. As more sites are evaluated, the sites at which sulfur dioxide is found may increase. This information is important because exposure to this substance may harm you and because these sites may be sources of exposure.

When a substance is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. This release does not always lead to exposure. You are exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance or by skin contact.

If you are exposed to sulfur dioxide, many factors determine whether you'll be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with it. You must also consider the other chemicals you're exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

1 .1 WHAT IS SULFUR DIOXIDE?

Sulfur dioxide is a colorless gas with a pungent odor. It is a liquid when under pressure. Sulfur dioxide dissolves in water very easily. It cannot catch fire.

Sulfur dioxide in the air results primarily from activities associated with the burning of fossil fuels (coal, oil) such as at power plants or from copper smelting. In nature, sulfur dioxide can be

released to the air, for example, from volcanic eruptions. Chapters 3 and 4 contain further information.

1.2 WHAT HAPPENS TO SULFUR DIOXIDE WHEN IT ENTERS THE ENVIRONMENT?

Once released into the environment, sulfur dioxide moves to the air. In the air, sulfur dioxide can be converted to sulfuric acid, sulfur trioxide, and sulfates. Sulfur dioxide dissolves in water. Once dissolved in water, sulfur dioxide can form sulfurous acid. Soil can absorb sulfur dioxide, but we do not know if or how it moves in soil. Chapters 4 and 5 contain further information.

1.3 HOW MIGHT I BE EXPOSED TO SULFUR DIOXIDE?

You may be exposed to sulfur dioxide mainly by breathing air that contains it. You may also be exposed to sulfur dioxide by skin contact with it.

The people most often exposed to sulfur dioxide are workers in plants where sulfur dioxide occurs as a by-product, such as in the copper smelting industry and in the processing or burning of coal or oil. Other exposures occur in the manufacture of sulfuric acid, paper, food preservatives, and fertilizers. The primary way that workers are exposed to sulfur dioxide is through the air. Workers may be exposed to concentrations of sulfur dioxide that are higher than typical outdoor air levels. People living near heavily industrial activities that involve smelting copper or the processing or burning of coal or oil are also likely to be exposed to sulfur dioxide by breathing it. Chapter 5 contains further information.

1.4 HOW CAN SULFUR DIOXIDE ENTER AND LEAVE MY BODY?

If you breathe air containing sulfur dioxide, you may absorb it into your body through your nose and lungs. Sulfur dioxide can easily and rapidly enter your bloodstream through your lungs. Once in the body, it breaks down to sulfate and leaves through the urine. Chapter 2 contains further information.

1.5 HOW CAN SULFUR DIOXIDE AFFECT MY HEALTH?

To protect the public from the harmful effects of toxic chemicals and to find ways to treat people who have been harmed, scientists use many tests.

One way to see if a chemical will hurt people is to learn how the chemical is absorbed, used, and released by the body; for some chemicals, animal testing may be necessary. Animal testing may also be used to identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method to get information needed to make wise decisions to protect public health. Scientists have the responsibility to treat research animals with care and compassion. Laws today protect the welfare of research animals, and scientists must comply with strict animal care guidelines.

Short-term exposures to high levels of sulfur dioxide can be life-threatening. Exposure to 100 parts of sulfur dioxide per million parts of air (ppm) is considered immediately dangerous to life and health. Previously healthy nonsmoking miners who breathed sulfur dioxide released as a result of an explosion in an underground copper mine developed burning of the nose and throat, breathing difficulties, and severe airway obstructions. Long-term exposure to persistent levels of sulfur dioxide can also affect your health. Lung function changes have been observed in some workers exposed to 0.4-3.0 ppm sulfur dioxide for 20 years or more. However, these workers were also exposed to other chemicals, making it difficult to attribute their health effects to sulfur dioxide exposure alone. Additionally, exercising asthmatics are sensitive to the respiratory effects of low concentrations (0.25 ppm) of sulfur dioxide.

For comparative purposes, typical outdoor concentrations of sulfur dioxide may range from 0 to 1 ppm. Occupational exposures to sulfur dioxide may lawfully range from 0 to 5 ppm as enforced by your state OSHA (Occupational Safety and Health Administration). During any 8-hour workshift of a 40-hour workweek, the average concentration of sulfur dioxide in the workplace

may not exceed 5 ppm. However, during system malfunctions or unforseen events, levels approaching 50 ppm or more have been reported.

Studies in animals support the human data regarding respiratory effects of sulfur dioxide. At low levels (less than 1 ppm) of sulfur dioxide exposure, guinea pigs displayed changes in their ability to breathe as deeply or as much air per breath. More severe symptoms seen in animals exposed to high concentrations of sulfur dioxide include decreased respiration, inflammation or infection of the airways, and destruction of areas of the lung.

For more information refer to Chapter 2.

1.6 HOW CAN SULFUR DIOXIDE AFFECT CHILDREN?

This section discusses potential health effects from exposures during the period from conception to maturity at 18 years of age in humans. Potential effects on children resulting from exposures of the parents are also considered.

Since sulfur dioxide is primarily present as a gas, the general public is exposed to it mostly by breathing contaminated air. Levels of sulfur dioxide in the atmosphere vary from region to region and are mainly influenced by the intensity of industry and development usually associated with cities. Therefore, children with the highest exposure to sulfur dioxide are those living near industrial sources (i.e., industries that process or burn coal or oil, copper smelting plants, sulfuric acid manufacturers, fertilizer factories, or paper pulp factories).

Members of the general public may also have additional risk for exposure if they live near a hazardous waste site contaminated with sulfur dioxide. At 16 of the 1,467 NPL hazardous waste sites, sulfur dioxide has been identified in air, surface water, groundwater, soil, or sediment. Children, as well as adults, living near these sites are most likely to be exposed by breathing contaminated air.

Most of the effects of sulfur dioxide exposure that occur in adults (i.e., difficulty breathing, changes in the ability to breathe as deeply or take in as much air per breath, and burning of the nose and throat) are also of potential concern in children, but it is unknown whether children are more vulnerable to exposure. Children may be exposed to more sulfur dioxide than adults because they breathe more air for their body weight than adults do. Children also exercise more frequently than adults. Exercise increases breathing rate. This increase results in both a greater amount of sulfur dioxide in the lungs and enhanced effects on the lungs. One study suggested that a person's respiratory health, and not his or her age, determines vulnerability to the effects of breathing sulfur dioxide. This study implies that healthy adolescents (ages 12-17) are no more vulnerable to the effects of breathing sulfur dioxide than healthy senior citizens.

Long-term studies surveying large numbers of children have indicated possible associations between sulfur dioxide pollution and respiratory symptoms or reduced breathing ability. Children who have breathed sulfur dioxide pollution may develop more breathing problems as they get older, may make more emergency room visits for treatment of wheezing fits, and may get more respiratory illnesses than is typical for children. However, studies like these are unable to provide conclusive evidence about sulfur dioxide's effects on children's health because many other pollutants are also present in the air.

It is known that exercising asthmatics are sensitive to low concentrations of sulfur dioxide. Therefore, increased susceptibility is expected in children with asthma, but it is not known whether asthmatic children are more sensitive than asthmatic adults. Additionally, asthma occurs most often in African Americans, children between the ages of 8 and 11, and people living in cities. For unknown reasons, the death rates associated with asthma are also higher in non-Caucasian people. Therefore, it is expected that asthmatic, African American children living in urban areas have increased sensitivity to sulfur dioxide.

There are few studies which provide evidence of reproductive or developmental effects of sulfur dioxide exposure in humans. One study found no relationship between spontaneous abortion and exposure to sulfur dioxide among women living in an industrial community in Finland. However,

another study in China showed a relationship between decreased infant birth weight and exposure to sulfur dioxide pollution during pregnancy. Another study, in the Czech Republic, showed that 18- year-old males who were exposed to high levels of sulfur dioxide had sperm with more abnormalities and reduced abilities to move. Studies like these, though, are often hard to interpret. It can be difficult to distinguish among the effects of individual pollutants within air pollution mixtures. Tests on laboratory mice have shown that sulfur dioxide exposure did not affect reproductive function

Only a small number of developmental studies have been done in animals, and of these, in only one study were serious effects on development observed. Developmental studies are designed to determine how a pregnant female's exposure to a chemical might affect the normal processes that take place in her child as it grows (i.e., adverse effects might include a child with learning deficits or problems in social behavior). In one study the offspring of mice who breathed sulfur dioxide during their pregnancy were born small and had some abnormal reflexes. Three other studies in mice and one in rabbits showed no serious effects. Minor variations in the skeleton did occur in the offspring of the rabbits exposed to sulfur dioxide during pregnancy, and delayed bone hardening occurred in the offspring of treated mice. Due in large part to these conflicting results, conclusions about the effects of sulfur dioxide on unborn children cannot be drawn from the available studies.

A study in rats indicated that poor maternal nutrition might cause offspring to be more susceptible later in life to the damage that can occur from breathing sulfur dioxide. In rats, offspring whose mothers were fed a low protein diet while they were pregnant showed greater lung damage from breathing sulfur dioxide when they were older. It is unknown if similar conclusions about human maternal nutrition can be drawn.

It is not likely that parental exposure to sulfur dioxide will cause any changes in a mother's eggs or father's sperm that could affect their unborn children. It is not known if sulfur dioxide or the products to which it is broken down within the body can cross the placenta or accumulate in breast milk; further, it is also unknown whether these resulting breakdown products would be

harmful Accumulation of sulfur dioxide in maternal tissues and then, movement during pregnancy, is unlikely because this compound is water soluble.

Sections 2.6 and 5.6 contain more information about the effects of sulfur dioxide on children.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO SULFUR DIOXIDE?

If your doctor finds that you have been exposed to significant amounts of sulfur dioxide, ask if children may also be exposed. When necessary your doctor may need to ask your State Department of Public Health to investigate.

Because exposure to sulfur dioxide is most likely to occur by breathing contaminated air, families should try to limit their outdoor activities during times of high air pollution. While levels of sulfur dioxide in the air are typically highest during the winter months, human exposure to sulfur dioxide has been shown to be greatest during the summer months. This result is most likely seen because people enjoy being outdoors in warm weather and often leave their household windows open for ventilation.

By paying attention to news bulletins and air pollution advisories, families can control their amount of exposure. The EPA (Environmental Protection Agency) issues the vast majority of air quality alerts. Such warnings might reach the public when ATSDR (Agency for Toxic Substances and Disease Registry) issues a Public Health Advisory and notifies the EPA of a public health threat caused by high levels of atmospheric sulfur dioxide. State and local health and environmental agencies will also be notified and will, in turn, notify their communities. People with respiratory difficulties should pay special attention to these warnings. Additionally, asthmatic children’s outdoor exercise should be limited when high levels of sulfur dioxide are present in the air.

Since exposure to sulfur dioxide occurs primarily through direct breathing of contaminated air, workers in plants where sulfur dioxide occurs as a by-product will not expose their family members at home through residues on their skin or clothes.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO SULFUR DIOXIDE?

Sulfur dioxide in the body is changed into other sulfur-containing chemicals in the body. These breakdown products can be found and measured in the blood and urine. However, their measurement requires special equipment which is not routinely available in a doctor's office. Furthermore, exposure to chemicals other than sulfur dioxide can also produce sulfate, so, the presence of sulfate breakdown in your body does not necessarily mean you have been exposed to sulfur dioxide. Lung function tests can be used to examine potential respiratory effects of sulfur dioxide. However, tests of lung function changes cannot determine whether or not you have been specifically exposed to sulfur dioxide because other chemicals can produce similar lung function changes. Chapters 2 and 6 contain further information.

1.9 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The federal government develops regulations and recommendations to protect public health. Regulations can be enforced by law. Federal agencies that develop regulations for toxic substances include the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA). Recommendations provide valuable guidelines to protect public health but cannot be enforced by law. Federal organizations that develop recommendations for toxic substances include the Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH).

Regulations and recommendations can be expressed in not-to-exceed levels in air, water, soil, or food that are usually based on levels that affect animals, then they are adjusted to help protect

people. Sometimes these not-to-exceed levels differ among federal organizations because of different exposure times (an 8-hour workday or a 24-hour day), the use of different animal studies, or other factors.

Recommendations and regulations are also periodically updated as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for sulfur dioxide include the following:

The federal government has set regulations to protect individuals from the possible health effects of breathing sulfur dioxide. EPA recommends that the long-term, 1-year average concentrations of sulfur dioxide should not exceed 0.03 ppm. The short-term, 24-hour average concentration should not exceed 0.14 ppm more than once a year. OSHA regulates levels of sulfur dioxide in the workplace. This regulation states that workroom air should contain no more than an average of 2 ppm sulfur dioxide over an 8-hour working shift for 5 consecutive days in a workweek. NIOSH recommends that the average workroom air levels of sulfur dioxide not exceed 2 ppm over a 10-hour period. The 15-minute average exposure in air that should not be exceeded at any time during a workday is 5 ppm. For more information on rules and standards for sulfur dioxide, see Chapter 7.

1.1 0 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department or:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop E-29
Atlanta, GA 30333

* Information line and technical assistance

Phone: l-800-447- 1544
Fax: (404) 639-6359

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses resulting from exposure to hazardous substances.

* To order toxicological profiles. contact:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Phone: (800) 553-6847 or (703) 4874650