

1. PUBLIC HEALTH STATEMENT

This public health statement tells you about sulfur trioxide and sulfuric acid 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. Sulfur trioxide and sulfuric acid have been found in at least 47 of the 1,467 current or former NPL sites. As more sites are evaluated, the sites with sulfur trioxide or sulfuric acid may increase. This is important because exposure to these substances 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 trioxide or sulfuric acid, 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 ARE SULFUR TRIOXIDE AND SULFURIC ACID?

Sulfur trioxide is generally a colorless liquid but can also exist as ice- or fiber-like crystals or as a gas. When sulfur trioxide is exposed to air, it rapidly takes up water and gives off white fumes. It combines with water, releasing considerable heat while forming sulfuric acid. It also reacts violently with some metal oxides. Sulfur trioxide is also called sulfuric oxide and sulfuric anhydride. It is used as an intermediate in the production of sulfuric acid, other chemicals, and

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explosives. Sulfur trioxide is unlikely to exist in the environment except for very short periods when it may be present in the air as a gas. In the air, sulfur trioxide can be formed slowly from sulfur dioxide. Once formed, sulfur trioxide will react with water in the air to form sulfuric acid. Both sulfur dioxide and sulfuric acid are more likely to be found in air than sulfur trioxide. If you are interested in learning more about sulfur dioxide, the Agency for Toxic Substances and Disease Registry has developed a separate profile about it

Sulfuric acid is a clear, colorless, oily liquid that is very corrosive. An odor threshold of sulfuric acid in air has been reported to be 1 milligram per cubic meter of air (mg/m^3). If you are exposed to concentrated sulfuric acid in air, your nose will be irritated and it may seem like sulfuric acid has a pungent odor. When concentrated sulfuric acid is mixed with water, the solution gets very hot. Concentrated sulfuric acid can catch fire or explode when it comes into contact with many chemicals including acetone, alcohols, and some finely divided metals. When heated it emits highly toxic fumes, which include sulfur trioxide. It is also called sulphuric acid, battery acid, and hydrogen sulfate. More sulfuric acid is produced in the United States than any other chemical. It is used in the manufacture of fertilizers, explosives, other acids, and glue; in the purification of petroleum; in the pickling of metal; and in lead-acid batteries (the type commonly used in motor vehicles). Sulfuric acid can be found in the air as small droplets or it can be attached to other small particles in the air.

Fuming sulfuric acid, also called oleum, is a solution of 10-70% sulfur trioxide in sulfuric acid. Oleum is the form of sulfuric acid that is often shipped in railroad cars. For more information, see Chapters 3 and 4.

1.2 WHAT HAPPENS TO SULFUR TRIOXIDE AND SULFURIC ACID WHEN THEY ENTER THE ENVIRONMENT?

Much of the sulfuric acid in the air is formed from sulfur dioxide released when coal, oil, and gas are burned. The released sulfur dioxide slowly forms sulfur trioxide, which reacts with water in the air to form sulfuric acid. Sulfuric acid dissolves in the water in air and can remain suspended for varying periods of time; it is removed from the air as rain. Sulfuric acid in rain contributes to

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the formation of acid rain. Sulfuric acid in water separates to form hydrogen ions and sulfate. The ability of sulfuric acid to change the acidity (pH) of water is dependent on the amount of sulfuric acid and the ability of other substances in the water to neutralize the hydrogen ions (buffering capacity). For more information about sulfur trioxide and sulfuric acid in the environment, see Chapters 4 and 5.

1.3 HOW MIGHT I BE EXPOSED TO SULFUR TRIOXIDE OR SULFURIC ACID?

You may be exposed to sulfur trioxide or sulfuric acid at your job if you work in the chemical or metal plating industry; if you produce detergents, soaps, fertilizers, or lead-acid batteries; or if you work in printing and publishing, or photography shops. Because sulfur trioxide forms sulfuric acid when it contacts the moist surfaces of your respiratory tract or your skin, the effects caused by sulfur trioxide and sulfuric acid are similar. In occupational settings, breathing small droplets of sulfur trioxide or sulfuric acid or touching it with your skin are the most likely ways you would be exposed to sulfuric acid. According to estimates from a survey conducted by the National Institute for Occupational Safety and Health (NIOSH) more than 56,103 U.S. workers may be exposed to sulfur trioxide, and more than 775,348 U.S. workers may be exposed to sulfuric acid. However, this survey used estimates from small samples, so the number of workers exposed to sulfur trioxide and sulfuric acid may be overestimated.

You may also be exposed to sulfuric acid by breathing outdoor air containing this compound. As mentioned before, sulfuric acid droplets can form in the air when sulfur dioxide is released from the burning of coal, oil, and gas. This released sulfur dioxide slowly forms sulfur trioxide and then reacts with water in the air to form sulfuric acid. While sulfuric acid could be present in the air during episodes of high pollution, all air pollution is not due to sulfuric acid contamination. The effects of other pollutants in air may be of greater concern to the general population. Likewise, there are relatively few sulfuric acid air pollution episodes today.

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People living near hazardous waste sites that contain sulfuric acid are at greater risk of exposure by breathing contaminated air than is the general public. For these people, spending time outdoors, especially exercising, could increase their risks of being exposed.

You can also be exposed to sulfuric acid when you touch the material that forms on the outside of your car battery. Sulfuric acid is formed when some toilet bowl cleaners mix with water. Therefore, if these products touch skin or are accidentally swallowed, you could be exposed to sulfuric acid. When you cut onions a chemical called propanethiol *S*-oxide is released into the air. When this chemical reaches your eyes, it reacts with the water in your eyes to form sulfuric acid, which causes your eyes to water. People have also been exposed following accidental spills of sulfuric acid or oleum. These accidents occurred more frequently at a site than while the substances were being transported. For more information on the ways people might be exposed to sulfuric acid, see Chapter 5.

1.4 HOW CAN SULFUR TRIOXIDE AND SULFURIC ACID ENTER AND LEAVE MY BODY?

If you breathe in sulfur trioxide, small droplets of sulfuric acid will form when the sulfur trioxide contacts water. Small droplets of sulfuric acid may also enter the respiratory tract when you breathe. Where the droplets will deposit in the respiratory tract depends on their size and how deeply you are breathing. Smaller droplets will deposit deeper into the lung. If you breathe through your mouth, more droplets will deposit in your lungs than if you breathe only through your nose. Extra sulfur dioxide breakdown products are excreted in the urine.

Sulfuric acid causes its effects by direct action on tissues that it touches. With the exception of how sulfuric acid droplets deposit in the lungs, how sulfur trioxide and sulfuric acid enter and leave your body does not alter the effects of sulfuric acid. For more information, see Chapter 2.

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1.5 HOW CAN SULFUR TRIOXIDE AND SULFURIC ACID 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.

Sulfuric acid and other acids are very corrosive and irritating and cause direct local effects on the skin, eyes, and respiratory and gastrointestinal tracts when there is direct exposure to sufficient concentrations. Breathing sulfuric acid mists can result in tooth erosion and respiratory tract irritation. Drinking concentrated sulfuric acid can burn your mouth and throat, and it can erode a hole in your stomach; it has also resulted in death. If you touch sulfuric acid, it will burn your skin. If you get sulfuric acid in your eyes, it will burn your eyes and cause them to water. The term "burn" used in these sections refers to a chemical burn, not a physical burn resulting from contacting a hot object. People have been blinded by sulfuric acid when it was thrown in their faces.

Breathing small droplets of sulfuric acid at levels that might be in the air on a day with high air pollution may make it more difficult to breathe. This effect is more likely to occur if you have been exercising or if you have asthma. This effect may also be more likely to occur in children than adults. Breathing sulfuric acid droplets may affect the ability of your respiratory tract to remove other small particles that you have inhaled. If you breathe sulfur trioxide, it turns into sulfuric acid in your upper respiratory tract, and the effects you may experience will be similar to those of sulfuric acid inhalation.

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Studies in people who breathed high concentrations of sulfuric acid at work have shown an increase in cancers of the larynx. However, most of the cancers were in smokers who were also exposed to other acids and other chemicals. There is no information that exposure to sulfuric acid by itself is carcinogenic. The carcinogenicity of sulfuric acid has not been studied in animals. The EPA and the U.S. Department of Health and Human Services (DHHS) have not classified sulfur trioxide or sulfuric acid for carcinogenic effects. Based on very limited human data, the International Agency for Research on Cancer (IARC) believes that evidence is sufficient to state that occupational exposure to strong inorganic acid mists containing sulfuric acid is carcinogenic to humans. IARC has not classified pure sulfuric acid for its carcinogenic effects.

For more information on the health effects of sulfuric acid, see Chapter 2.

1.6 HOW CAN SULFUR TRIOXIDE OR SULFURIC ACID 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.

Children may be exposed to sulfur trioxide and sulfuric acid in the same manner as adults, with the exception of chemical encounters in the workplace. Sulfur trioxide is only used in industry as an intermediate in the production of chemicals such as sulfuric acid and quickly converts to sulfuric acid when it contacts water in air. Therefore, children will most likely only be at risk of exposure from sulfuric acid, not sulfur trioxide. Exposure to sulfuric acid may occur through skin contact, eye contact, ingestion, and breathing contaminated air. Sulfuric acid can cause severe skin burns, it can burn the eyes, burn holes in the stomach if swallowed, irritate the nose and throat, and cause difficulties breathing if inhaled.

Exposure to sulfuric acid from accidental contact with or misuse of sulfuric acid-containing consumer products is the most likely way your child could be exposed. Household products that contain sulfuric acid include drain and toilet bowl cleaners, and some acid car batteries. The

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national estimate (derived by United States Consumer Product Safety Commission, USCPSC) for injuries related to drain cleaners over a 5-year period ending January 1996 is between 2,800 and 3,150 injuries per year. Inquisitive toddlers may get into unsealed or improperly stored containers of sulfuric acid-containing products. Transfer of cleaning agents containing sulfuric acid into containers not designed for their storage can allow leakage from the container. Improper flushing of areas recently cleaned with a sulfuric acid-containing product can lead to inadvertent skin exposure to both children and adults.

While younger children are most at risk from accidental swallowing, skin contact, or eye contact with sulfuric acid in household products, teenagers might have jobs in which they may contact sulfuric acid. If teenagers must use acid cleaners in their jobs or work in car repair where they may contact car batteries, they might be exposed. Furthermore, there have been reports of older children using sulfuric acid-containing solutions as weapons, thereby causing severe skin damage when intentionally splashed on others.

Small droplets of sulfuric acid may exist in the outdoor air. You and your children have the greatest chances of inhaling the compound during times of high air pollution with sulfuric acid. This may lead to difficulty breathing. If you live near electrical, metal processing, or paper processing industries, you may also have a greater chance of exposure to sulfuric acid. When sulfuric acid is inhaled into the lungs in the form of small droplets that exist in air, these droplets are deposited within the lung and the ability of your respiratory tract to remove other small, unwanted particles may be decreased. A study has shown that children can have greater deposition of sulfuric acid in their lungs than adults due to children's smaller airway diameters. Also, because children breathe more air per kilogram of body weight than adults, children may take in more sulfuric acid when they breathe the same contaminated air. Increased sensitivity has been witnessed in both animal studies with young guinea pigs and in human studies of asthmatic adolescents. This evidence suggests that children may be more vulnerable than adults to the health effects associated with breathing sulfuric acid.

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No studies examining effects on unborn children following a mother's exposure to sulfuric acid during pregnancy were identified in humans. Limited evidence in animals indicates that sulfuric acid is not a hazard to unborn children. Birth defects have not been observed in animals that breathed high levels of sulfuric acid mist. Exposing pregnant rabbits to sulfuric acid did not significantly affect the body weights or cause malformations in their offspring. Again, because sulfuric acid causes adverse effects at its point of contact with the body, the acid, as such, is not expected to be absorbed or distributed throughout the body. Sulfuric acid is not expected to be transported across a mother's placenta into her developing baby or into breast milk. Therefore, an exposed mother most likely will not threaten her unborn or nursing child. Since sulfuric acid's effects occur at the point of contact, it is not likely that it will reach a mother's egg or father's sperm. Therefore, parents exposure to sulfuric acid or sulfur trioxide should not affect their unborn children.

For more information see Sections 2.6 and 5.6.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO SULFUR TRIOXIDE OR SULFURIC ACID?

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

Sulfuric acid is a highly corrosive chemical that is potentially explosive in concentrated form. It can cause severe skin burns, can irritate the nose and throat and cause difficulties breathing if inhaled, can burn the eyes and possibly cause blindness, and can burn holes in the stomach if swallowed.

Concentrated sulfuric acid is commonly used in the United States as a drain and toilet bowl cleaner. Children and adults have suffered full thickness skin burns upon accidental contact or intentional assault with sulfuric acid in this form. Additionally, sulfuric acid is formed when some toilet bowl cleaners mix with water, so care should be taken not to breathe associated vapors or

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splash any liquid on the skin or in the eyes. All household chemicals containing sulfuric acid should be stored in their original, labeled containers, kept in locked cabinets away from children, kept away from fire, and should be used only for their intended purposes. The material that forms on the outside of a car battery is also a source of sulfuric acid and you should avoid touching it. Wear safety glasses and use chemical resistant gloves to avoid this type of exposure. Upon any exposure to sulfuric acid, the contacted body part should be immediately flushed with plentiful water and then the Poison Control Center contacted. Keep your Poison Control Center's number by the phone. If sulfuric acid is spilled in the home, the local Fire Department should be contacted for assistance in handling the spill.

When levels of air pollution are high, families are advised to stay indoors as much as possible and to avoid exercising outdoors. Families can be aware of levels of air pollution by paying attention to news bulletins and air pollution advisories, most of which are issued by the EPA (Environmental Protection Agency). This is particularly important for individuals with respiratory conditions and asthmatic children. Staying indoors during times of sulfuric acid air pollution will help you avoid breathing sulfuric acid droplets.

Adults may be occupationally exposed to sulfuric acid if they work in the chemical or metal plating industry; produce detergents, soaps, fertilizers, or lead-acid batteries; or work in printing or publishing, or photography shops. It is not anticipated that workers in such industries can expose their families at home (through their clothing, skin, or breath) to sulfuric acid contacted at work.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO SULFUR TRIOXIDE OR SULFURIC ACID?

There is no medical test to determine whether you have been exposed to sulfur trioxide or sulfuric acid. Breathing in acids, including sulfuric acid, will increase the acidity of your saliva. Measuring the acidity of saliva may determine whether you have been exposed to acid but cannot determine which acid. For more information on where and how sulfuric acid can be detected in your body after you have been exposed, see Chapters 2 and 6.

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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 24hour 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 trioxide and sulfuric acid include the following:

EPA limits the amount of sulfur dioxide that can be released into the air. This limits the amount of sulfur trioxide and sulfuric acid that form from sulfur dioxide in the air.

OSHA limits the amount of sulfuric acid that can be present in workroom air to 1 mg/ m^3 . NIOSH also recommends a time-weighted average limit of 1 mg/ m^3 . For more information on regulations and guidelines to protect human health, see Chapter 7.

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1.10 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: 1-800-447- 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 22 16 1
Phone: (800) 553-6847 or (703) 487-4650

