1. PUBLIC HEALTH STATEMENT

1.1 PUBLIC HEALTH STATEMENT FOR HYDROGEN SULFIDE

This Public Health Statement summarizes what is known about hydrogen sulfide such as possible health effects from exposure and what you can do to limit exposure.

The U.S. 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 sites targeted for long-term federal clean-up activities. U.S. EPA has found hydrogen sulfide in at least 34 of the 1,832 current or former NPL sites. The total number of NPL sites evaluated for hydrogen sulfide is not known. But the possibility remains that as more sites are evaluated, the sites at which hydrogen sulfide is found may increase. This information is important because these future sites may be sources of exposure, and exposure to hydrogen sulfide may be harmful.

If you are exposed to hydrogen sulfide, many factors determine whether you'll be harmed. These include how much you are exposed to (dose), how long you are exposed (duration), and how you are exposed (route of exposure). You must also consider the other chemicals you are exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

WHAT IS HYDROGEN SULFIDE?

Hydrogen sulfide (H_2S) is a flammable, colorless gas that smells like rotten eggs. People usually can smell hydrogen sulfide at low concentrations in air, ranging from 0.0005 to 0.3 parts hydrogen sulfide per million parts of air (ppm). At high concentrations, a person might lose their ability to smell it. This is important because a person might falsely think that hydrogen sulfide is no longer present; this may increase their exposure risk to air levels that may cause serious health effects.

Hydrogen sulfide occurs both naturally and from human-made processes. It is in the gases from volcanoes, sulfur springs, undersea vents, swamps, stagnant bodies of water, and in crude petroleum and natural gas. Hydrogen sulfide is also associated with municipal sewers and sewage treatment plants, swine containment and manure-handling operations, and pulp and paper operations. Other industrial sources of hydrogen sulfide include petroleum refineries, natural gas plants, petrochemical plants, coke

oven plants, food processing plants, and tanneries. Bacteria found in your mouth and gastrointestinal tract produce hydrogen sulfide during the digestion of food containing vegetable or animal proteins.

Hydrogen sulfide is used primarily in the production of sulfur and sulfuric acid. It can also be used to make other chemicals such as sodium sulfide and sodium hydrosulfide, which are used to make a variety of products.

WHAT HAPPENS TO HYDROGEN SULFIDE WHEN IT ENTERS THE ENVIRONMENT?

Most of the hydrogen sulfide released to air comes from natural sources such as swamps, bogs, and volcanoes. Hydrogen sulfide can also be released from industrial sources such as petroleum refineries, natural gas plants, kraft paper mills, manure treatment facilities, waste water treatment facilities, and tanneries. Hydrogen sulfide air concentrations from natural sources range between 0.00011 and 0.00033 ppm. In urban areas, the air concentrations are generally less than 0.001 ppm. Hydrogen sulfide remains in the atmosphere for approximately 1–42 days, depending on the season. It can change into sulfur dioxide and sulfates in the air.

Hydrogen sulfide might be released to water in liquid waste of an industrial facility or as the result of a natural event. It can be naturally present in well water. Hydrogen sulfide concentrations in surface water are usually very low because it readily evaporates from water. It can also be present in groundwater. Groundwater concentrations of hydrogen sulfide are generally less than 1 ppm; however, measured sulfur concentrations in surface and waste waters have ranged from slightly less than 1 to 5 ppm.

Hydrogen sulfide can enter soil through atmospheric deposition or from spills. In soil, hydrogen sulfide is consumed by bacteria, which change it to sulfur.

HOW MIGHT I BE EXPOSED TO HYDROGEN SULFIDE?

Your body makes small amounts of hydrogen sulfide. Hydrogen sulfide is produced by the natural bacteria in your mouth. It is also produced when some types of proteins are broken down by bacteria in the intestines.

The levels of hydrogen sulfide in air and water are typically low. Household exposures to hydrogen sulfide can occur through misuse of drain cleaning materials. Hydrogen sulfide can be found in well

water and can be formed in hot water heaters, giving tap water a rotten egg odor. Cigarette smoke and emissions from gasoline vehicles contain hydrogen sulfide. The general population can be exposed to lower levels from accidental or deliberate release of emissions from pulp and paper mills; from natural gas drilling and refining operations; and from areas of high geothermal activity, such as hot springs.

People who work in certain industries can be exposed to higher levels of hydrogen sulfide than the general population. These industries include rayon textiles manufacturing, pulp and paper mills, petroleum and natural gas drilling operations, and waste water treatment plants. Workers on farms with manure storage pits or landfills can also be exposed to higher levels of hydrogen sulfide than the general population. As a member of the general public, you might be exposed to higher-than-normal levels of hydrogen sulfide if you live near a waste water treatment plant, a gas and oil drilling operation, a farm with manure storage or livestock confinement facilities, or a landfill. Exposure from these sources is mainly from breathing air that contains hydrogen sulfide. You can find more information about hydrogen sulfide exposure in Chapter 6.

HOW CAN HYDROGEN SULFIDE ENTER AND LEAVE MY BODY?

Hydrogen sulfide enters your body primarily through the air you breathe. Much smaller amounts can enter your body through the skin. Hydrogen sulfide is a gas, so you would not likely be exposed to it by ingestion. When you breathe air containing hydrogen sulfide or when hydrogen sulfide comes into contact with skin, it is absorbed into the blood stream and distributed throughout the body. In the body, hydrogen sulfide is primarily converted to sulfate and is excreted in the urine. Hydrogen sulfide is rapidly removed from the body.

HOW CAN HYDROGEN SULFIDE AFFECT MY HEALTH?

You are not likely to have health effects if you are exposed to typical environmental concentrations of hydrogen sulfide. You can have respiratory and neurological effects if you are exposed to higher concentrations of hydrogen sulfide, at least 100 times higher than typical environmental levels. The effects can include:

- Eye irritation
- Nose irritation
- Throat irritation
- Difficulty breathing in people with asthma
- Headaches

- Poor memory
- Tiredness
- Balance problems

If you are exposed to very high concentrations of hydrogen sulfide, you may have severe problems breathing even if you do not have a pre-existing respiratory condition. You could lose consciousness if you are briefly exposed to very high concentrations (more than 1 million times higher than the amount typically found in the environment). If this happens, you may regain consciousness without any other effects. However, some people may have longer lasting effects such as headaches, poor attention span, poor memory, and poor motor function.

Hydrogen sulfide has not been shown to cause cancer in humans, and its possible ability to cause cancer in animals has not been studied thoroughly. The Department of Health and Human Services (HHS) and the International Agency for Research on Cancer (IARC) have not classified hydrogen sulfide as to its carcinogenicity. EPA has determined that data for hydrogen sulfide are inadequate for carcinogenic assessment.

See Chapters 2 and 3 for more information on the health effects from exposure to hydrogen sulfide.

HOW CAN HYDROGEN SULFIDE AFFECT CHILDREN?

This section discusses potential health effects of hydrogen sulfide exposure in humans from when they're first conceived to 18 years of age.

There is very little information on possible health problems in children who have been exposed to hydrogen sulfide. Children exposed to hydrogen sulfide may have effects similar to adults. However, we do not know whether children are more sensitive to hydrogen sulfide than adults.

We do not know whether hydrogen sulfide causes birth defects in humans. Studies in laboratory animals suggest that exposure to low concentrations of hydrogen sulfide during pregnancy does not cause birth defects.

HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO HYDROGEN SULFIDE?

If your doctor finds that you have been exposed to significant amounts of hydrogen sulfide, ask whether your children might also be exposed. Your doctor might need to ask your state health department to investigate.

Hydrogen sulfide is part of the natural environment; the general population will have some exposure to hydrogen sulfide. How much hydrogen sulfide you are exposed and for how long are two factors that could determine whether you get sick. Families can be exposed to more hydrogen sulfide than the general population if they live near natural or industrial sources of hydrogen sulfide, such as hot springs, manure holding tanks, or pulp and paper mills. However, these exposure levels are generally not high enough to make you sick.

Families can reduce their exposure to hydrogen sulfide by avoiding areas that are sources of hydrogen sulfide. For example, individuals of families that live on farms can avoid manure storage areas where high concentrations of hydrogen sulfide may be found.

ARE THERE MEDICAL TESTS TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO HYDROGEN SULFIDE?

Hydrogen sulfide and its breakdown products such as thiosulfate can be measured in blood and urine. However, the detection of hydrogen sulfide or its metabolites cannot predict the kind of health effects that might develop from that exposure. Because hydrogen sulfide and its metabolites leave the body fairly rapidly, the tests need to be conducted soon after exposure.

For more information on the different substances formed by hydrogen sulfide breakdown and on tests to detect these substances in the body, see Chapters 3 and 7.

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 are not enforceable 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 as “not-to-exceed” levels; that is, levels of a toxic substance in air, water, soil, or food that do not exceed a critical value usually based on levels that affect animals; levels are then adjusted to help protect humans. Sometimes these not-to-exceed levels differ among federal organizations. Different organizations use different exposure times (an 8-hour workday or a 24-hour day), different animal studies, or emphasize some factors over others, depending on their mission.

Recommendations and regulations are also updated periodically as more information becomes available. For the most current information, check with the federal agency or organization that issued the regulation or recommendation.

OSHA set an acceptable ceiling limit of 20 ppm for hydrogen sulfide in workplace air; the ceiling limit is a 15-minute time-weighted average that cannot be exceeded at any time during the working day. This is a regulation enforceable by law.

NIOSH recommends a 10-minute ceiling level of 10 ppm for workers. This is not enforceable by law. NIOSH also determined that 100 ppm is immediately dangerous to life or health to workers.

1.2 PUBLIC HEALTH STATEMENT FOR CARBONYL SULFIDE

This Public Health Statement summarizes what is known about carbonyl sulfide such as possible health effects from exposure and what you can do to limit exposure.

The U.S. 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 sites targeted for long-term federal clean-up activities. U.S. EPA has found carbonyl sulfide in at least 4 of the 1,832 current or former NPL sites. The total number of NPL sites evaluated for carbonyl sulfide is not known. But the possibility remains that as more sites are evaluated, the sites at which carbonyl sulfide is found may increase. This information is important because these future sites may be sources of exposure, and exposure to carbonyl sulfide may be harmful.

If you are exposed to carbonyl sulfide, many factors determine whether you'll be harmed. These include how much you are exposed to (dose), how long you are exposed (duration), and how you are exposed (route of exposure). You must also consider the other chemicals you are exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

WHAT IS CARBONYL SULFIDE?

Carbonyl sulfide (COS) is a colorless gas that smells like rotten eggs; it does not have an odor when it is free from impurities. Carbonyl sulfide can also be called carbon oxide sulfide and carbon oxysulfide.

At concentrations of 135 micrograms per cubic meter ($\mu g/m^3$) (0.055 ppm), people may be able to smell carbonyl sulfide in air.

Carbonyl sulfide is present in both natural and human-made sources. It can be found in volcanic gases, crude petroleum oil, sulfurous waters, marshes, and soils. It is in the emissions from diesel engines, natural gas and refinery emissions, and tobacco smoke.

Carbonyl sulfide does not have many commercial uses, as it is primarily used in small-scale chemical syntheses. It is an intermediate in the manufacture of certain herbicides. It may also be used in the agricultural industry as a grain fumigant.

WHAT HAPPENS TO CARBONYL SULFIDE WHEN IT ENTERS THE ENVIRONMENT?

Carbonyl sulfide can be released into the air, water, and soil at places where it is produced or used. Carbonyl sulfide is released to air from natural sources such as soils, wetlands, volcanoes, and oceans. It is also released during chemical processing, natural gas and oil recovery, combustion of coal, biomass burning, and others. The average carbonyl sulfide level in outdoor air is 0.0018 ppm. Carbonyl sulfide can remain in the atmosphere for 2–10 years.

Carbonyl sulfide in the atmosphere may settle to surface water or soil. Carbonyl sulfide reacts with water to form carbon dioxide and hydrogen sulfide. It is expected to rapidly volatilize to air. It does not bind to soil. It may move through the soil and enter groundwater.

HOW MIGHT I BE EXPOSED TO CARBONYL SULFIDE?

Everybody is exposed to very low levels of carbonyl sulfide in the air. You may also be exposed if you consume products such as wheat, oats, barley, and canola shortly after they have been fumigated with carbonyl sulfide to increase plant resistance to insects.

If you are involved in the production or use of carbonyl sulfide, you may be exposed to higher levels in the air. You may also be exposed to higher levels if you work in a petroleum refinery or coal distillation plant.

HOW CAN CARBONYL SULFIDE ENTER AND LEAVE MY BODY?

We know that carbonyl sulfide can enter your body from the air because health effects have been observed in studies with animals. We do not know how much or how fast it can enter your body. We do not know how carbonyl sulfide is broken down in the body or how it leaves the body.

HOW CAN CARBONYL SULFIDE AFFECT MY HEALTH?

We have very little information on the health effects of carbonyl sulfide. The health effects of carbonyl sulfide appear to depend on several factors such as how much you are exposed to and the length of that exposure. Studies in animals show that nervous system effects can occur after short- or long-term exposure. Animal studies show that exposure to high levels of carbonyl sulfide in the air can damage the areas of the brain that control movement and process sound information.

No human or animal studies have examined whether carbonyl sulfide exposure can cause cancer. HHS, IARC, and EPA have not classified carbonyl sulfide as to its carcinogenicity.

HOW CAN CARBONYL SULFIDE AFFECT CHILDREN?

This section discusses potential health effects of carbonyl sulfide exposure in humans from when they're first conceived to 18 years of age.

There is no information on possible health problems in children who have been exposed to carbonyl sulfide. Children exposed to high levels of carbonyl sulfide may have similar health effects as adults. However, we do not know whether children are more sensitive to carbonyl sulfide than adults. We do not know if exposure to carbonyl sulfide will cause birth defects in humans. No studies looked for birth defects in animals.

HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO CARBONYL SULFIDE?

If your doctor finds that you have been exposed to significant amounts of carbonyl sulfide, ask whether your children might also be exposed. Your doctor might need to ask your state health department to investigate.

Carbonyl sulfide is part of the natural environment; the general population will have some exposure to carbonyl sulfide. Families can be exposed to higher levels of carbonyl sulfide if they live near natural or industrial sources of carbonyl sulfide, such as wetlands, volcanos, or coal combustion. However, their exposure levels are generally unlikely to approach those that sicken people exposed at work. Families can reduce their exposure to carbonyl sulfide by avoiding areas that are sources of carbonyl sulfide.

ARE THERE MEDICAL TESTS TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO CARBONYL SULFIDE?

How carbonyl sulfide is broken down in the body and how it is removed from the body is not known. Thus, no medical tests have been identified that can determine carbonyl sulfide exposure.

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 as "not-to-exceed" levels; that is, levels of a toxic substance in air, water, soil, or food that do not exceed a critical value usually based on levels that affect animals; levels are then adjusted to help protect humans. Sometimes these not-to-exceed levels differ among federal organizations. Different organizations use different exposure times (an 8-hour workday or a 24-hour day), different animal studies, or emphasize some factors over others, depending on their mission.

Recommendations and regulations are also updated periodically as more information becomes available. For the most current information, check with the federal agency or organization that issued the regulation or recommendation.

OSHA and NIOSH have not established regulations for workers exposed to carbonyl sulfide.

WHERE CAN I GET MORE INFORMATION?

If you have any questions or concerns, please contact your community or state health or environmental quality department, or contact ATSDR at the address and phone number below. ATSDR can also provide publically available information regarding medical specialists with expertise and experience recognizing, evaluating, treating, and managing patients exposed to hazardous substances.

- Call the toll-free information and technical assistance number at 1-800-CDCINFO (1-800-232-4636) or

- Write to:

  Agency for Toxic Substances and Disease Registry
  Division of Toxicology and Human Health Sciences
  1600 Clifton Road NE
  Mailstop F-57
  Atlanta, GA 30329-4027

Toxicological profiles and other information are available on ATSDR's web site: http://www.atsdr.cdc.gov.