

1. PUBLIC HEALTH STATEMENT

This public health statement tells you about vinyl chloride and the effects of exposure to it.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites are then placed on the National Priorities List (NPL) and are targeted for long-term federal clean-up activities. Vinyl chloride has been found in at least 616 of the 1,662 current or former NPL sites. Although the total number of NPL sites evaluated for this substance is not known, the possibility exists that the number of sites at which vinyl chloride is found could increase in the future as more sites are evaluated. This information is important because these sites may be sources of exposure, and exposure to this substance can harm you.

When a substance is released either from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. Such a release does not always lead to exposure. You can be 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 vinyl chloride, many factors will determine whether you will 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 any other chemicals you are exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

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1.1 WHAT IS VINYL CHLORIDE?

Vinyl chloride is known also as chloroethene, chloroethylene, ethylene monochloride, or monochloroethylene. At room temperature, it is a colorless gas, it burns easily, and it is not stable at high temperatures. Vinyl chloride exists in liquid form if kept under high pressure or at low temperatures. Vinyl chloride has a mild, sweet odor, which may become noticeable at 3,000 parts vinyl chloride per million parts (ppm) of air. However, the odor is of little value in preventing excess exposure. Most people begin to taste vinyl chloride in water at 3.4 ppm.

Vinyl chloride is a manufactured substance that does not occur naturally; however, it can be formed in the environment when other manufactured substances, such as trichloroethylene, trichloroethane, and tetrachloroethylene, are broken down by certain microorganisms. Production of vinyl chloride in the United States grew at an average rate of about 7% from the early 1980s to the early 1990s, with current growth at about 3% annually. Most of the vinyl chloride produced in the United States is used to make a polymer called polyvinyl chloride (PVC), which consists of long repeating units of vinyl chloride. PVC is used to make a variety of plastic products including pipes, wire and cable coatings, and packaging materials. Other uses include furniture and automobile upholstery, wall coverings, housewares, and automotive parts. At one time, vinyl chloride was used as a coolant, as a propellant in spray cans, and in some cosmetics. However, since the mid-1970s, vinyl chloride mostly has been used in the manufacture of PVC. Refer to Chapter 4 for more information about the chemical and physical properties of vinyl chloride. For more information about the production and use of vinyl chloride, see Chapter 5.

1.2 WHAT HAPPENS TO VINYL CHLORIDE WHEN IT ENTERS THE ENVIRONMENT?

Most of the vinyl chloride that enters the environment comes from vinyl chloride manufacturing or processing plants, which release it into the air or into waste water. EPA limits the amount that industries can release. Vinyl chloride also is a breakdown product of other synthetic chemicals. Vinyl chloride has entered the environment at hazardous waste sites as a result of improper

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disposal or leakage from storage containers or spills, but some may result from the breakdown of other chemicals. In addition, vinyl chloride has been found in tobacco smoke at very low levels.

Liquid vinyl chloride evaporates easily. Vinyl chloride in water or soil evaporates rapidly if it is near the surface. Vinyl chloride in the air breaks down in a few days, resulting in the formation of several other chemicals including hydrochloric acid, formaldehyde, and carbon dioxide.

Some vinyl chloride can dissolve in water. Vinyl chloride can migrate to groundwater and can be in groundwater due to the breakdown of other chemicals. Vinyl chloride is unlikely to build up in plants or animals that you might eat. For more information about what happens to vinyl chloride in the environment, see Chapter 6.

1.3 HOW MIGHT I BE EXPOSED TO VINYL CHLORIDE?

Because vinyl chloride usually exists in a gaseous state, you are most likely to be exposed to it by breathing it. Vinyl chloride is not normally found in urban, suburban, or rural air in amounts that are detectable by the usual methods of analysis. However, vinyl chloride has been found in the air near vinyl chloride manufacturing and processing plants, hazardous waste sites, and landfills. The amount of vinyl chloride in the air near these places ranges from trace amounts to over 1 ppm. Levels as high as 44 ppm were found in the air at some landfills. You can also be exposed to vinyl chloride in the air through tobacco smoke from cigarettes or cigars (both active smoking and second-hand smoke). Levels of vinyl chloride in tobacco smoke are very low, usually around 5–30 nanograms per cigarette (a nanogram is 0.000000001 gram).

You can be exposed to vinyl chloride by drinking water from contaminated wells. Most drinking water supplies do not contain vinyl chloride. In a 1982 survey, vinyl chloride was found in fewer than 1% of the 945 groundwater supplies tested in the United States. The concentrations in groundwater were up to 0.008 ppm. Other studies have reported vinyl chloride in groundwater at concentrations at or below 0.38 ppm. At one time, the flow of water through PVC pipes added very low amounts of vinyl chloride to water. For example, in one study of newly installed pipes, the drinking water had 0.001 ppm of vinyl chloride. No current

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information is available about the amount of vinyl chloride released from PVC pipes into water. In the past, vinyl chloride could get into food stored in materials containing PVC, but the U.S. government now regulates the amount of vinyl chloride in food packaging materials. When less than about 1 ppm of vinyl chloride is trapped in PVC packaging, vinyl chloride in detectable amounts does not enter food by contact with these products.

People who work at facilities that make vinyl chloride or PVC usually are exposed to higher levels than the general population. Work exposure occurs primarily from breathing air that contains vinyl chloride, but workers also are exposed when vinyl chloride contacts the skin or eyes. Based on studies using animals, it is possible that if vinyl chloride comes into contact with your skin or eyes, extremely small amounts could enter your body.

Please refer to Chapter 6 for more information on ways that people are exposed to vinyl chloride.

1.4 HOW CAN VINYL CHLORIDE ENTER AND LEAVE MY BODY?

If vinyl chloride gas contacts your skin, tiny amounts may pass through the skin and enter your body. Vinyl chloride is more likely to enter your body when you breathe air or drink water containing it. This could occur near certain factories or hazardous waste sites or in the workplace. At low levels (<20 ppm), most of the vinyl chloride that you breathe or swallow enters your blood rapidly, then travels throughout your body. When some portion of it reaches your liver, your liver changes it into several substances. Most of these new substances also travel in your blood; once they reach your kidneys, they leave your body in your urine. Most of the vinyl chloride is gone from your body a day after you breathe or swallow it. The liver, however, makes some new substances that do not leave your body as rapidly. A few of these new substances are more harmful than vinyl chloride because they react with chemicals inside your body and interfere with the way your body normally uses or responds to these chemicals. Some of these substances react in the liver and, depending on how much vinyl chloride you breathe in, may produce damage there. Your body needs more time to get rid of these changed chemicals, but eventually removes them as well. If you breathe or swallow more vinyl chloride

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than your liver can chemically change, you will breathe out excess vinyl chloride. Chapter 3 contains more information about how vinyl chloride enters and leaves your body.

1.5 HOW CAN VINYL CHLORIDE AFFECT MY HEALTH?

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

One way to learn whether a chemical will harm people is to determine how the body absorbs, uses, and releases the chemical. For some chemicals, animal testing may be necessary. Animal testing may also help identify health effects, such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method for getting information needed to make wise decisions that protect public health. Scientists have the responsibility to treat research animals with care and compassion. Scientists must comply with strict animal-care guidelines because laws today protect the welfare of research animals.

If you breathe high levels of vinyl chloride, you will feel dizzy or sleepy. These effects occur within 5 minutes if you are exposed to about 10,000 ppm of vinyl chloride. You can easily smell vinyl chloride at this concentration. It has a mild, sweet odor. If you breathe still higher levels (25,000 ppm), you may pass out. You can rapidly recover from these effects if you breathe fresh air. Some people get a headache when they breathe fresh air immediately after breathing very high levels of vinyl chloride. People who breathe extremely high levels of vinyl chloride can die. Studies in animals show that extremely high levels of vinyl chloride can damage the liver, lungs, and kidneys. These levels also can damage the heart and prevent blood clotting. The effects of ingesting vinyl chloride are unknown. If you spill liquid vinyl chloride on your skin, it will numb the skin and produce redness and blisters.

Some people who have breathed vinyl chloride for several years have changes in the structure of their livers. People are more likely to develop these changes if they breathe high levels of vinyl chloride. Some people who have worked with vinyl chloride have nerve damage, and others develop an immune reaction. The lowest levels that produce liver changes, nerve damage, and

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immune reaction in people are not known. Certain jobs related to PVC production expose workers to very high levels of vinyl chloride (i.e., pools of liquid vinyl chloride in vats or autoclaves). Some of these workers have problems with the blood flow in their hands. Their fingers turn white and hurt when they go into the cold and may take a long time to recover when they go into a warm place. In some of these people, changes have appeared on the skin of their hands and forearms. Also, bones at the tips of their fingers have broken down. Studies suggest that some people may be more sensitive to these effects than others.

Some men who work with vinyl chloride have complained of a lack of sex drive. Studies in animals showed that long-term exposure can damage the sperm and testes. Some women who work with vinyl chloride have reported irregular menstrual periods. Some have developed high blood pressure during pregnancy.

Results from several studies have suggested that breathing air or drinking water containing moderate levels (100 ppm) of vinyl chloride might increase their risk for cancer. However, the levels used in these studies were much higher than levels found in the ambient air and/or most drinking water supplies. Studies of workers who have breathed vinyl chloride over many years showed an increased risk for cancer of the liver. Brain cancer, lung cancer, and some cancers of the blood also may be connected with breathing vinyl chloride over long periods. Studies of long-term exposure in animals showed that cancer of the liver and mammary gland may increase at very low levels of vinyl chloride in the air (50 ppm). Lab animals fed low levels of vinyl chloride each day (2 mg/kg/day) during their lifetime had an increased risk of getting liver cancer.

The U.S. Department of Health and Human Services has determined that vinyl chloride is a known carcinogen. The International Agency for Research on Cancer has determined that vinyl chloride is carcinogenic to people, and EPA has determined that vinyl chloride is a human carcinogen.

More information about the adverse health effects of vinyl chloride in humans and animals can be found in Chapters 2 and 3.

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1.6 HOW CAN VINYL CHLORIDE AFFECT CHILDREN?

This section discusses potential health effects in humans from exposures during the period from conception to maturity at 18 years of age.

No studies are available that specifically address the effects of vinyl chloride in children. Studies of women who live near vinyl chloride manufacturing plants did not show that vinyl chloride produces birth defects. Studies using pregnant animals showed that breathing high levels of vinyl chloride (5,000 ppm) can harm unborn baby animals. Animal studies also show that vinyl chloride can produce more miscarriages early in pregnancy and decrease weight and delay skeletal development in fetuses. These same very high levels of vinyl chloride also caused harmful effects in the pregnant animals. Inhalation studies with animals have suggested that vinyl chloride might affect growth and development. Animal studies also suggest that infants and young children might be more susceptible than adults to vinyl chloride-induced cancer.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO VINYL CHLORIDE?

If your doctor finds that you have been exposed to substantial amounts of vinyl chloride, ask whether your children might also have been exposed. Your doctor might need to ask your state health department to investigate.

You can take some steps to limit your exposure to vinyl chloride. Very low levels of vinyl chloride exist in the ambient air, but these levels are usually not high enough to be a cause of concern. If you live near a hazardous waste site, municipal landfill, or a chemical plant that produces vinyl chloride or PVC, you might be exposed to higher levels of this compound than the general public. Vinyl chloride can leach from plastic PVC bottles or containers used to contain foods or beverages, but government agencies such as the Food and Drug Administration (FDA) have restricted the amount of vinyl chloride that can be present in these packages.

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Tobacco smoke contains low levels of vinyl chloride, so limiting your family's exposure to cigarette or cigar smoke may help reduce their exposure to vinyl chloride.

People who work in facilities that manufacture or use vinyl chloride could be exposed to high levels of this chemical. The Occupational Safety and Health Administration (OSHA) regulates these levels and employers must comply with these rules. If you work in an industry that manufactures or uses vinyl chloride, strictly adhere to the rules provided by the safety officer and always use respirators when advised.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO VINYL CHLORIDE?

The results of several tests can sometimes show if you have been exposed to vinyl chloride, depending on the amount of your exposure and how recently it happened. However, scientists do not know whether these measurements can tell how much vinyl chloride you have been exposed to. These tests are not normally available at your doctor's office. Vinyl chloride can be measured in your breath, but the test must be done shortly after exposure. This test is not very helpful for measuring very low levels of the chemical. The amount of the major breakdown product of vinyl chloride, thiodiglycolic acid, in the urine may give some information about exposure. However, this test must be done shortly after exposure and does not reliably indicate the level of exposure. Also, exposure to other chemicals can produce the same breakdown products in your urine. Vinyl chloride can bind to genetic material in your body. The amount of this binding can be measured by sampling your blood and other tissues. This measurement will give information about whether you have been exposed to vinyl chloride, but it is not sensitive enough to determine the effects on the genetic material resulting from exposure. For more information, see Chapters 3 and 7.

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

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 that is usually based on levels that affect animals; they are then adjusted to levels that will help protect humans. Sometimes these not-to-exceed levels differ among federal organizations because they used different exposure times (an 8-hour workday or a 24-hour day), different animal studies, or other factors.

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 provides it. Some regulations and recommendations for vinyl chloride include the following:

Vinyl chloride is regulated in drinking water, food, and air. Because it is a hazardous substance, regulations on its disposal, packaging, and other forms of handling also exist. EPA requires that the amount of vinyl chloride in drinking water not exceed 0.002 milligrams per liter (mg/L) of water (0.002 ppm). Under the EPA's Ambient Water Quality Criteria for the protection of human health, a concentration of 0.025 micrograms per L ($\mu\text{g/L}$) of water (0.025 ppb) was established for protecting human health from water and organism ingestion and 2.4 micrograms per L ($\mu\text{g/L}$) of water (2.4 ppb) was determined for consumption of organisms only.

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To limit intake of vinyl chloride through foods to levels considered safe, FDA regulates the vinyl chloride content of various plastics. These include plastics that carry liquids and plastics that contact food. The limits for vinyl chloride content vary depending on the nature of the plastic and its use.

EPA has established a reportable quantity for vinyl chloride. If quantities of more than 1 pound (0.454 kilograms) are released to the environment, the National Response Center of the federal government must be told immediately.

OSHA regulates levels of vinyl chloride in the workplace. No employee may be exposed to vinyl chloride at levels greater than 1 ppm averaged over any 8-hour period or levels greater than 5 ppm averaged over any period exceeding 15 minutes. NIOSH recommends that the exposure limit (for a time-weighted average [TWA]) for vinyl chloride in air be the lowest reliably detectable concentration. Workers exposed to any measurable amount of it must wear special breathing equipment. EPA sets emission standards for vinyl chloride and PVC plants. The amount of vinyl chloride allowed to be emitted varies depending on the type of production and the discharge system used.

Further regulations and guidelines that apply to vinyl chloride are presented in Chapter 8.

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 contact ATSDR at the address and phone number below.

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

Toxicological profiles also are available on-line at www.atsdr.cdc.gov and on CD-ROM. You can request a copy of the ATSDR ToxProfiles™ CD-ROM by calling the toll-free information

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and technical assistance number at 1-888-42ATSDR (1-888-422-8737), by e-mailing atsdric@cdc.gov, or by writing to:

Agency for Toxic Substances and Disease Registry
Division of Toxicology and Environmental Medicine
1600 Clifton Road NE
Mailstop F-32
Atlanta, GA 30333
Fax: 1-770-488-4178

For-profit organizations may request copies of final Toxicological Profiles from

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161
Phone: 1-800-553-6847 or 1-703-605-6000
Web site: <http://www.ntis.gov/>