1. PUBLIC HEALTH STATEMENT

This public health statement tells you about tin and tin compounds and the effects of exposure to them.

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. Tin and organotin compounds have been found in at least 214 and 8, respectively, of the 1,662 current or former NPL sites. Although the total number of NPL sites evaluated for these substances is not known, the possibility exists that the number of sites at which tin and organotin compounds are found may increase in the future as more sites are evaluated. This information is important because these sites may be sources of exposure and exposure to these substances may 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 tin and tin compounds, 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 them. You must also consider any other chemicals you are exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 WHAT ARE TIN AND TIN COMPOUNDS?

Tin is a soft, white, silvery metal that is insoluble in water. Tin metal is used to line cans for food, beverages, and aerosols. It is present in brass, bronze, pewter, and some soldering materials.

Tin is a metal that can combine with other chemicals to form various compounds. When tin is combined with chlorine, sulfur, or oxygen, it is called an inorganic tin compound. Inorganic tin compounds are found in small amounts in the earth's crust. They are also present in toothpaste, perfumes, soaps, coloring agents, food additives, and dyes.

Tin also can combine with carbon to form organotin compounds. These compounds are used in making plastics, food packages, plastic pipes, pesticides, paints, wood preservatives, and rodent (rats and mice) repellants.

There can be tin metal as well as inorganic and organic tin compounds in the air, water, and soil near places where they are naturally present in the rocks, mined, manufactured, or used. In general, organic tin compounds are from human-made sources and do not occur naturally in the environment. The time each tin compound stays in air, water, or soil differs from compound to compound.

Further information on the properties and uses of tin and its compounds and how they behave in the environment is found in Chapters 4, 5, and 6.

1.2 WHAT HAPPENS TO TIN AND TIN COMPOUNDS WHEN THEY ENTER THE ENVIRONMENT?

Tin is a component of many soils. Tin may be released in dusts from wind storms, roads, and farming activities. Gases, dusts, and fumes containing tin may be released from smelting and refining processes, burning of waste, and burning of fossil fuels (coal or oil). Particles in the air containing tin may be transported by wind or washed out of the air by rain or snow. Tin binds to soils and to sediments in water and is generally regarded as being relatively immobile in the environment. Tin cannot be destroyed in the environment. It can only change its form or become attached or separated from particles in soil, sediment, and water.

Organic tin compounds stick to soil, sediment, and particles in water. Organic tin compounds can be degraded (by exposure to sunlight and by bacteria) into inorganic tin compounds. In

water, organic tin compounds are mostly attached to particles in water. Organic tin compounds may also settle out of the water into sediments and may remain unchanged for years. Organic tin compounds may be taken up into the tissues of animals that live in water containing these compounds.

1.3 HOW MIGHT I BE EXPOSED TO TIN AND TIN COMPOUNDS?

Tin is present in the air, water, soil, and landfills and is a normal part of many plants and animals that live on land and in water. Tin is also present in the tissues of your body. There is no evidence that tin is an essential element for humans.

Since tin is naturally found in soils, it will be found in small amounts in foods. Tin concentrations of vegetables, fruits and fruit juices, nuts, dairy products, meat, fish, poultry, eggs, beverages, and other foods not packaged in metal cans are generally less than 2 parts per million (ppm) (1 ppm = 1 part of tin in a million parts of food by weight). Tin concentrations in pastas and breads have been reported to range from less than 0.003 to 0.03 ppm. You can be exposed to tin when you eat food or drink juice or other liquids from tin-lined cans. Canned food from lacquered tin-lined cans contains less than 25 ppm of tin since the lacquer prevents the food from reacting with the tin. Food from unlacquered tin-lined cans contains up to 100 ppm of tin since the reaction of the food with the can causes some of the tin to dissolve in the contents of the can. Greater than 90% of tin-lined cans used for food today are lacquered. Only light colored fruit and fruit juices are packed in unlacquered tin-lined cans, since tin helps maintain the color of the fruit. Tin concentrations in food also increase if food is stored in opened cans. Stannous fluoride, a tin-containing compound, is added to toothpaste.

You can also be exposed to higher-than-normal levels of tin if you work in a factory that makes or uses tin. Because tin compounds have many uses, you can be exposed by breathing in tin dusts or fumes or getting tin compounds on your skin. Tin compounds can also be spilled accidentally. If you live near a hazardous waste site, you could be exposed by breathing dusts, touching materials, or drinking water contaminated with tin.

Humans are usually exposed to tin at far less than 1 ppm from air and water. The amounts in air and water near hazardous waste sites could be higher.

Young children sometimes eat soil during play. While most soil contains about 1 ppm tin, some soils may contain as much as 200 ppm tin. Assuming that children eat 200 mg of soil per day, exposure to tin from eating soil would be low.

You may be exposed to organic tin compounds (mainly butyltin compounds) by eating seafood from coastal waters or from contact with household products that contain organotin compounds, (polyurethane, plastic polymers, and silicon-coated baking parchment paper). Organic tin compounds have been detected in drinking water in Canada where pipes made of polyvinyl chloride (PVC), which contain organic tin compounds, are used in the distribution of drinking water.

Additional information on how you can be exposed to tin compounds is given in Chapter 6.

1.4 HOW CAN TIN AND TIN COMPOUNDS ENTER AND LEAVE MY BODY?

Tin can enter your body when you eat contaminated food or drink contaminated water, when you touch or eat soil that has tin in it, or when you breathe tin-containing fumes or dusts. Tin compounds can enter your body from nearby hazardous waste sites by exposure to contaminated air, water, and soil. When you eat tin in your food, very little leaves the gastrointestinal tract and gets into your bloodstream. Most tin travels through the intestines and leaves your body in the feces. Some leaves your body in the urine. If you breathe air containing tin dust or fumes, some of the tin could be trapped in your lungs, but this does not affect your breathing if it is a small amount. If you swallow some metallic tin particles, they will leave your body in the feces. Very little tin can enter the body through unbroken skin. Your body can rid itself of most inorganic tin in weeks, but some can stay in your body for 2–3 months. Inorganic tin compounds leave your body very quickly; most are gone within a day. Very small amounts of tin stay in some tissues of your body, like the bones, for longer periods of time.

Further information on how tin enters and leaves your body is given in Chapter 3.

1.5 HOW CAN TIN AND TIN COMPOUNDS AFFECT MY HEALTH?

Scientists use many tests to protect the public from harmful effects of toxic chemicals and to find ways for treating persons 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.

Because inorganic tin compounds usually enter and leave your body rapidly after you breathe or eat them, they do not usually cause harmful effects. However, humans who swallowed large amounts of inorganic tin in research studies suffered stomachaches, anemia, and liver and kidney problems. Studies with inorganic tin in animals have shown similar effects to those observed in humans. There is no evidence that inorganic tin compounds affect reproductive functions, produce birth defects, or cause genetic changes. Inorganic tin compounds are not known to cause cancer.

Inhalation (breathing in), oral (eating or drinking), or dermal exposure (skin contact) to some organotin compounds has been shown to cause harmful effects in humans, but the main effect will depend on the particular organotin compound. There have been reports of skin and eye irritation, respiratory irritation, gastrointestinal effects, and neurological problems in humans exposed for a short period of time to high amounts of certain organotin compounds. Some neurological problems have persisted for years after the poisoning occurred. Lethal cases have been reported following ingestion of very high amounts. Studies in animals have shown that certain organotins mainly affect the immune system, but a different type primarily affects the

nervous system. Yet, there are some organotins that exhibit very low toxicity. Exposure of pregnant rats and mice to some organotin compounds has reduced fertility and caused stillbirth, but scientists still are not sure whether this occurs only with doses that are also toxic to the mother. Some animal studies also suggested that reproductive organs of males may be affected. There are no studies of cancer in humans exposed to organotin compounds. Studies of a few organotins in animals suggest that some organotin compounds can produce cancer. On the basis of no data in humans and questionable data from a study in rats, EPA has determined that one specific organotin, tributyltin oxide, is not classifiable as to human carcinogenicity; that is, it is not known whether or not it causes cancer in humans.

More information on the health effects of tin in humans and animals is found in Chapter 3.

1.6 HOW CAN TIN AND TIN COMPOUNDS AFFECT CHILDREN?

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

Children can be exposed to tin compounds (inorganic or organic) in the same manner as adults: through the diet or by contact with contaminated soil at or near hazardous waste sites where these compounds are found. Some children eat significant amounts of dirt (a behavior called pica), which may lead to increased exposure if the soil is contaminated. In addition, children can be exposed if family members work with tin compounds and bring home tin residues in their clothing or tools.

There are no studies on health effects in children exposed to tin compounds. However, it is reasonable to assume that children would exhibit the same type of health effects observed in exposed adults. We do not know whether children are more susceptible to the effects of exposure to tin and tin compounds than adults. There are no reports of adverse developmental effects in humans exposed to tin or its compounds, or of inorganic tin in animals. Studies in animals have shown that organotin compounds can cross the placenta and reach the fetus. Exposure of rodents to some organotins during pregnancy has produced birth defects in the

newborn animals. The results of several studies suggest that this may occur only at high exposure levels that cause maternal toxicity, but further research is needed to clarify this issue. One study found that rats whose mothers were exposed to tributyltin during pregnancy showed altered performance in some neurological tests conducted when they were young adults. Another study, also with tributyltin, found that exposure during gestation, lactation, and post-lactation affected some developmental landmarks in female rats. There are no reports of tin or tin compounds in human breast milk, and there is no direct evidence in animals of transfer of these compounds to the young through nursing.

More information regarding children's health and tin and related compounds can be found in Section 3.7.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO TIN AND TIN COMPOUNDS?

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

Children living near waste sites containing tin and tin compounds are likely to be exposed to higher than normal environmental levels of tin through breathing, touching soil, and eating contaminated soil. You should discourage your children from eating dirt. Make sure they wash their hands frequently and before eating. Discourage your children from putting their hands in their mouths. Some toothpastes and other dental products contain stannous fluoride, a tin containing compound. Children should be watched carefully when using these products and should not swallow these products.

Because tin is naturally found in the environment at low levels, we cannot avoid being exposed to it. The major route of exposure to tin is from eating or drinking canned products. Reducing the amount of canned products you eat or drink may reduce your exposure to tin. Since tin concentrations in food increase if food is stored in opened cans, you can reduce your exposure by

storing unused portions of canned foods in a separate container. You may be exposed to organic tin compounds by eating seafood from areas that may be contaminated with organic tin compounds or from contact with household products that contain organotin compounds (polyurethane, plastic polymers, and silicon-coated baking parchment paper). Reducing the amount of seafood that you eat from areas that may be contaminated with organic tin compounds and reducing contact with household products that contain organic tin compounds may reduce your exposure to organic tin compounds. If you are accidentally exposed to large amounts of tin or tin compounds, consult a physician immediately.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO TIN AND TIN COMPOUNDS?

There are tests to measure tin and organotin compounds in your blood, urine, feces, and body tissues. Normally, small amounts of tin are found in the body because of the daily exposure to small amounts in the food. Therefore, the available tests cannot tell you when you were exposed or the exact amount of tin to which you were exposed, but can help determine if you were exposed to an amount of tin or tin compounds unusually high in the near past. This information can be used to locate the source of exposure.

Tests for tin and related compounds are not routinely performed at a doctor's office because they require special equipment, but the doctor can take samples and send them to a testing laboratory.

Further information on how tin can be measured in exposed humans is presented in Chapter 7.

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 tin and tin compounds include the following:

Several government agencies and the Congress have acted to protect human health by regulating tin compounds. The EPA has limited the use of certain organotin compounds in paints. OSHA has established workplace exposure limits of 0.1 milligrams per cubic meter of air (mg/m^3) for organotin compounds and 2 mg/m^3 for inorganic tin compounds, except oxides. NIOSH recommends workplace exposure limits of 2 mg/m^3 for inorganic tin compounds, except for tin oxides, and 0.1 mg/m^3 for organotins, except tricyclohexyltin hydroxide. NIOSH states that a concentration of tricyclohexyltin hydroxide of 25 mg/m^3 should be considered as immediately dangerous to life or health. The FDA regulates the use of some organic tin compounds in coatings and plastic food packaging. The FDA also has set limits for the use of tin, as stannous chloride, as an additive for food.

Additional information on governmental regulations and guidelines regarding tin and compounds is found in Chapter 8 and Table 8-1.

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 are also available on-line at www.atsdr.cdc.gov and on CD-ROM. You may request a copy of the ATSDR ToxProfilesTM CD-ROM by calling the toll-free information and technical assistance number at 1-888-42ATSDR (1-888-422-8737), by e-mail at atsdric@cdc.gov, or by writing to:

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

Organizations for-profit may request copies of final Toxicological Profiles from the following:

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/