be anticipated to be carcinogens based on studies in animals. There is inadequate evidence to clearly determine lead's carcinogenicity in people.

How can lead affect children?

Small children can be exposed by eating lead-based paint chips, chewing on objects painted with lead-based paint, or swallowing house dust or soil that contains lead.

Children are more vulnerable to lead poisoning than adults. A child who swallows large amounts of lead may develop blood anemia, severe stomachache, muscle weakness, and brain damage. A large amount of lead might get into a child's body if the child ate small pieces of old paint that contained large amounts of lead. If a child swallows smaller amounts of lead, much less severe effects on blood and brain function may occur. Even at much lower levels of exposure, lead can affect a child's mental and physical growth.

Exposure to lead is more dangerous for young and unborn children. Unborn children can be exposed to lead through their mothers. Harmful effects include premature births, smaller babies, decreased mental ability in the infant, learning difficulties, and reduced growth in young children. These effects are more common if the mother or baby was exposed to high levels of lead.

How can families reduce the risk of exposure to lead?

Avoid exposure to sources of lead. Do not allow children to chew or mouth painted surfaces that may have been painted with lead-based paint (homes built before 1978). Run your water for 15 to 30 seconds before drinking or cooking with it. This will get rid of lead that may have leached out of pipes. Some types of paints and pigments that are used as make-up or hair coloring contain lead. Keep these kinds of products away from children. Wash children's hands and faces often to remove lead dusts and soil, and regularly clean the house of dust and tracked in soil.

Is there a medical test to show whether I've been exposed to lead?

A blood test is available to measure the amount of lead in your blood and to estimate the amount of your exposure to lead. Blood tests are commonly used to screen children for lead poisoning. Lead in teeth and bones can be measured with X-rays, but this test is not as readily available. Medical treatment may be necessary in children if the lead concentration in blood is higher than 45 micrograms per deciliter (45 µg/dL).

Has the federal government made recommendations to protect human health?

The Centers for Disease Control and Prevention (CDC) recommends that children ages 1 and 2 be screened for lead poisoning. Children who are 3 to 6 years old should be tested for lead if they have never been tested for lead before and if they receive services from public assistance programs; if they live in or regularly visit a building built before 1950; if they live in or visit a home built before 1978 that is being remodeled; or if they have a brother, sister, or playmate who has had lead poisoning. CDC considers children to have an elevated level of lead if the amount in the blood is 10 µg/dL.

The EPA requires lead in air not to exceed 1.5 micrograms per cubic meter (1.5 $\mu g/m^3$) averaged over 3 months. EPA limits lead in drinking water to 15 µg per liter.

The Occupational Health and Safety Administration (OSHA) develops regulations for workers exposed to lead. The Clean Air Act Amendments of 1990 banned the sale of leaded gasoline. The Federal Hazardous Substance Act bans children's products that contain hazardous amounts of lead.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. Toxicological profile for lead. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-888-422-8737, FAX: 770-488-4178. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

ATSDR

AGENCY FOR TOXIC SUBSTANCES
AND DISEASE REGISTRY

Site: United Zinc #1
ID # KSN000705026
Break: 5.0
Other: 6-1-1999

LEAD

CAS # 7439-92-1

Agency for Toxic Substances and Disease Registry ToxFAQs **June 1999**

This fact sheet answers the most frequently asked health questions (FAQs) about lead. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It's important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to lead can happen from breathing workplace air or dust, eating contaminated foods, or drinking contaminated water. Children can be exposed from eating lead-based paint chips or playing in contaminated soil. Lead can damage the nervous system, kidneys, and reproductive system. Lead has been found in at least 1,026 of 1,467 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What is lead?

(Pronounced lĕd)

Lead is a naturally occurring bluish-gray metal found in small amounts in the earth's crust. Lead can be found in all parts of our environment. Much of it comes from human activities including burning fossil fuels, mining, and manufacturing.

Lead has many different uses. It is used in the production of batteries, ammunition, metal products (solder and pipes), and devices to shield X-rays.

Because of health concerns, lead from gasoline, paints and ceramic products, caulking, and pipe solder has been dramatically reduced in recent years.

What happens to lead when it enters the environment?

- ☐ Lead itself does not break down, but lead compounds are changed by sunlight, air, and water.
- ☐ When lead is released to the air, it may travel long distances before settling to the ground.
- ☐ Once lead falls onto soil, it usually sticks to soil particles.
- ☐ Movement of lead from soil into groundwater will depend on the type of lead compound and the characteristics of the soil.
- ☐ Much of the lead in inner-city soils comes from old houses painted with lead-based paint.

How might I be exposed to lead?

- ☐ Eating food or drinking water that contains lead.
- ☐ Spending time in areas where lead-based paints have been used and are deteriorating.
- ☐ Working in a job where lead is used.
- ☐ Using health-care products or folk remedies that contain lead.
- ☐ Engaging in certain hobbies in which lead is used (for example, stained glass).

How can lead affect my health?

Lead can affect almost every organ and system in your body. The most sensitive is the central nervous system, particularly in children. Lead also damages kidneys and the reproductive system. The effects are the same whether it is breathed or swallowed.

At high levels, lead may decrease reaction time, cause weakness in fingers, wrists, or ankles, and possibly affect the memory. Lead may cause anemia, a disorder of the blood. It can also damage the male reproductive system. The connection between these effects and exposure to low levels of lead is uncertain.

How likely is lead to cause cancer?

The Department of Health and Human Services has determined that lead acetate and lead phosphate may reasonably

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TOXICOLOGICAL PROFILE FOR ARSENIC

Prepared by:

Life Systems, Inc.
Under Subcontract to:

Clement International Corporation
Under Contract No. 205-88-0608

Prepared for:

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry

April 1993

CONTENTS

1. PUBLIC HEALTH STATEMENT

This Statement was prepared to give you information about arsenic and to emphasize the human health effects that may result from exposure to it. The Environmental Protection Agency (EPA) has identified 1,300 sites on its National Priorities List (NPL). Arsenic has been found in at least 781 of these sites. However, we do not know how many of the 1,300 NPL sites have been evaluated for arsenic. As EPA evaluates more sites, the number of sites at which arsenic is found may change. This information is important for you to know because arsenic may cause harmful health effects and because these sites are potential or actual sources of human exposure to arsenic.

When a chemical 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 as a chemical emission. This emission, which is also called a release, does not always lead to exposure. You can be exposed to a chemical only when you come into contact with the chemical. You may be exposed to it in the environment by breathing, eating, or drinking substances containing the chemical or from skin contact with it.

If you are exposed to a hazardous chemical such as arsenic, several factors will determine whether harmful health effects will occur and what the type and severity of those health effects will be. These factors include the dose (how much), the duration (how long), the route or pathway by which you are exposed (breathing, eating, drinking, or skin contact), the other chemicals to which you are exposed, and your individual characteristics such as age, sex, nutritional status, family traits, life style, and state of health.

1.1 WHAT IS ARSENIC?

Arsenic is a naturally-occurring element. Pure arsenic is a gray metal-like material which is usually found in the environment combined with other elements such as oxygen, chlorine, and sulfur. Arsenic combined with these elements is called inorganic arsenic. Arsenic combined with carbon and hydrogen is called organic arsenic. You should know the difference between inorganic and organic arsenic because the organic forms are usually less harmful than the inorganic forms.

Most inorganic and organic arsenic compounds are white or colorless powders that do not evaporate. They have no smell, and most have no special taste. Thus, you usually cannot tell if arsenic is present in your food, water, or air.

Inorganic arsenic occurs naturally in many kinds of rock, especially in ores that contain copper or lead. When these ores are heated at smelters to get the copper or lead, most of the arsenic enters the air as a fine dust. Smelters collect this dust and purify the arsenic for several uses. The main use is as a preservative for wood to make it resistant to rotting and decay. Arsenic is also used to make several types of insect killers and weed killers, such as Ansar®, Scorch®, Phytar®, Bueno®, Crab-E-Rad®, Premix®, and others.

You can find more information on the sources, properties, and uses of arsenic in Chapters 3 and 4.

1.2 WHAT HAPPENS TO ARSENIC WHEN IT ENTERS THE ENVIRONMENT?

Arsenic can enter the environment in several ways. Even though it does not evaporate, arsenic can get into air as dust. This can happen when smelters heat ores containing arsenic, when people burn any material containing arsenic, or when wind blows soil that contains arsenic into the air. Once in the air, the arsenic particles will travel with the wind for a while, but will then settle back to the ground. Most arsenic compounds can also dissolve in water. Thus, arsenic can get into lakes, rivers, or underground water by dissolving in rain or snow, or through the discharge of industrial wastes. Some of the arsenic will stick to the sediment on the bottom of the lake or river, and some will be carried along by the water.

Arsenic is not broken down or destroyed in the environment. However, it can change from one form to another by natural chemical reactions, and also by the action of bacteria that live in soil or water. Although some fish and shellfish build up arsenic in their tissues, most of this is in a form (often called "fish arsenic") that is not toxic.

You can find more information on how arsenic gets into the environment and how it behaves in air, soil, and water in Chapters 4 and 5.

1.3 HOW MIGHT I BE EXPOSED TO ARSENIC?

Because arsenic is a natural part of the environment, low levels of arsenic are present in soil, water, food, and air. Soil usually contains the most, with average levels of about 5,000 parts of arsenic per billion parts of soil (ppb). Levels in food are usually about 20-140 ppb and levels in water are about 2 ppb. Levels in air are usually about 0.02-0.10 micrograms per cubic meter. Thus, you normally take in small amounts of arsenic in the air you breathe, the water you drink, and the food you eat. Of these, food is usually the largest source. You are also likely to swallow small amounts of dust or dirt each day, so this is another way you can be exposed to arsenic. The total amount you take in from these sources is probably about 50 micrograms each day.

In addition to the normal levels of arsenic in air, water, soil, and food, you could be exposed to higher levels in several ways, such as the following:

- Some areas of the country contain unusually high natural levels of arsenic in rock, and this can lead to unusually high levels of arsenic in soil or water. If you live in an area like this, you could take in above-average amounts of arsenic from the soil or from the water.
- Some hazardous waste sites contain large quantities of arsenic. If the material is not properly disposed of, it can get into surrounding water, air, or soil. If you live near such a site, you could be exposed to above-average levels of arsenic from these media.
- If you work in an occupation that involves arsenic production or use (for example, copper or lead smelting, wood treating, pesticide application), you could be exposed to above-average levels of arsenic during your work. The government estimates that about 55,000 people may be exposed in this way.
- If you saw or sand arsenic-treated wood, you could inhale some of the sawdust into your nose or throat. Similarly, if you burn arsenic-treated wood, you could inhale arsenic in the smoke.
- In the past, several kinds of products used in the home (rat poison, ant poison, weed killer, some types of medicines) had arsenic in them. However, most of these uses of arsenic have ended, so you are not likely to be exposed from home products any longer.

You can find more information on how you may be exposed to arsenic in Chapter 5.

1.4 HOW CAN ARSENIC ENTER AND LEAVE MY BODY?

If you swallow arsenic in water, soil, or food, most of the arsenic quickly enters into your body. This is the most likely way for you to be exposed near a waste site. If you breathe air that contains arsenic dusts, many of the dust particles settle onto the lining of the lungs. Most of the arsenic in these particles is then taken up from the lungs into the body. You might be exposed in this way near waste sites where arsenic-contaminated soils are allowed to blow into the air. If you get arsenic-contaminated soil or water on your skin, only a small amount will go through your skin into your body, so this is usually not of concern.

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HANDBOOK OF TOXIC AND HAZARDOUS CHEMICALS AND CARCINOGENS

Second Edition

by

Marshall Sittig
Princeton University

np NOYES PUBLICATIONS
Park Ridge, New Jersey, U.S.A.

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Preface

This handbook presents concise chemical, health and safety information on nearly 800 toxic and hazardous chemicals (up from nearly 600 in the first edition so that responsible decisions can be made by chemical manufacturers, safety equipment producers, toxicologists, industrial safety engineers, waste disposal operators, health care professionals, and the many others who may have contact with or interest in these chemicals due to their own or third party exposure.

Included in the book are:

- all of the EPA Priority Toxic Pollutants,
- all of the substances whose allowable concentrations in workplace air are adopted or proposed by ACGIH (1983/1984),
- all of the substances considered to date in the Standards Completion Program of NIOSH, and
- most of the chemicals classified as EPA "hazardous wastes,"
- most of the chemicals classified as EPA "hazardous substances,"
- most of the chemicals reviewed in EPA "CHIPS" documents, and
- most of the chemicals reviewed in NIOSH Information Profiles.

In addition, this Second Edition includes:

- all of the carcinogens identified by the U.S. National Toxicology Program,
- many of the chemicals profiled by the Dutch Association of Safety Experts, the Dutch Chemical Industry Association, and the Dutch Safety Institute,
- most of the chemicals described in the ILO *Encyclopedia of Occupational Health and Safety* (1983),
- most of the chemicals in the United Nations' *IRPTC Legal File* (1984), and
- most of the chemicals described in the journal publication: *Dangerous Properties of Industrial Materials Report.*

The necessity for informed handling and controlled disposal of hazardous and toxic materials has been spotlighted over and over in recent days as news of fires and explosions at factories and waste sites and groundwater contamination near dump sites has been widely publicized. In late 1980 the EPA imposed long-delayed regulations governing the handling of hazardous wastes–from creation to disposal. Prerequisite to control of hazardous substances, however, is knowledge of the extent of possible danger and toxic effects posed by any particular chemical. This book provides the prerequisites.

The 1984 tragedy at Bhopal, India involving methyl isocyanate (see entry on page 609) may will stimulate the enactment of "right-to-know" legislation requiring that workers be furnished data akin to the entries in this volume on chemicals they encounter in the workplace.

The chemicals are presented alphabetically and each is classified as a "carcinogen," "hazardous substance," "hazardous waste," and/or a "priority toxic pollutant"—as defined by the various federal agencies, and explained in the comprehensive Introduction to the book.

Particular attention is given in the second edition to delineation of the identity and properties of those chemicals now known to be carcinogens.

Data is furnished, to the extent currently available, on any or all of these important categories:

Chemical Description
Code Numbers
DOT Designation
Synonyms
Potential Exposure
Incompatibilities
Permissible Exposure Limits in Air
Determination in Air
Permissible Concentration in Water
Determination in Water
Routes of Entry
Harmful Effects and Symptoms
Points of Attack
Medical Surveillance
First Aid
Personal Protective Methods
Respirator Selection
Disposal Method Suggested
References

Essentially the book attempts to answer seven questions about each compound (to the extent information is available):

(1) What is it?
(2) Where do you encounter it?
(3) How much can one tolerate?
(4) How does one measure it?
(5) What are its harmful effects?
(6) How does one protect against it?
(7) Where can I learn more?

Under category (7), "where can I learn more?" this second edition provides hundreds of new citations to secondary reference sources which in turn provide access to thousands of references on properties and toxicology and safe handling of all the compounds listed.

An outstanding and noteworthy feature of this book is the Index of Carcinogens. There were 92 listed in the first edition, 178 in the second edition.

This book will thus be a valuable addition to industrial and medical libraries.

Advanced composition and production methods developed by Noyes Publications are employed to bring these durably bound books to you in a minimum of time. Special techniques are used to close the gap between "manuscript" and "completed book." Industrial technology is progressing so rapidly that time-honored, conventional typesetting, binding and shipping methods are no longer suitable. We have bypassed the delays in the conventional book publishing cycle and provide the user with an effective and convenient means of reviewing up-to-date information in depth.

The alphabetical table of contents serves as a subject index and provides easy access to the information contained in the book.

Introduction

The toxic chemicals problem in the United States and indeed in all the world is a frightening problem with news stories about Love Canal, the Valley of the Drums, the Valley of Death in Brazil and the like. All these generate emotional responses, often from people uninformed about science or technology. On the other hand, one encounters some industrialists who tell us that toxic chemicals are present in nature and that industrial contributions are just the price we have to pay for progress. Somewhere in between lies the truth—or at least an area in which we can function. It is the aim of this book to present data on specific industrial chemicals from an unemotional point of view so that decisions can be made by:

Chemicals manufacturers
Protective safety equipment producers
Toxicologists
Industrial hygienists
Lawyers
Doctors
Industrial safety engineers
Analytical chemists
Industrial waste disposal operators
Legislators
Enforcement officials
First aid squad members
Fire department personnel
Schoolteachers
The informed public

This book gives the highlights of available data on nearly 800 important toxic and hazardous chemicals. Importance is defined by inclusion in official and semiofficial listings as follows:

- All the substances whose allowable concentrations in workplace air are adopted or proposed by the American Conference of Government Industrial Hygienists as of 1983/84 (over 500 substances). In the interests of conserving space, however, detailed entries are not given for most "nuisance particulates" nor for most "simple asphyxiants." The following are the categories as defined by ACGIH (A-6).

Nuisance Particulates

α-Alumina (Al_2O_3)
Calcium carbonate
Calcium silicate
Cellulose (paper fiber)
Emery
*Glycerin mist
*Graphite (synthetic)
Gypsum
Kaolin
Limestone
Magnesite
Marble
Mineral wool fiber
*Pentaerythritol
Plaster of Paris
*Portland cement
Rouge
*Silicon
*Silicon carbide
Starch
Sucrose
*Titanium dioxide
Vegetable oil mists (except castor, cashew nut, or similar irritant oils)
Zinc stearate
Zinc oxide dust

Simple Asphyxiants

*Acetylene
*Argon
Ethane
Ethylene
Helium
Hydrogen
Methane
Neon
*Propane
*Propylene

Some of these compounds (marked by asterisks) have been included because of the availability of other information on these materials. For the general picture on "nuisance particulates," see The entry under "Particulates."

- All the substances considered to date in the Standards Completion Program by the National Institute of Occupational Safety and Health (some 380 substances). The second edition includes updated data sheets to 1981 (A-61).
- All the priority toxic water pollutants defined by the U.S. Environmental Protection Agency as a result of consent decrees in 1976 and 1979 which resulted in draft criteria in 1979 and final criteria in 1980 (for 65 pollutants and classes of pollutants which yielded 129 specific substances).
- Most of the chemicals in the following categories: (1) EPA "Hazardous wastes" as defined under the Resource Conservation and Recovery Act in April 1980 (A-52); (2) EPA "hazardous substances" as defined under the Clean Water Act; (3) chemicals which EPA has made the subject of Chemical Hazards Information Profiles or "CHIPS" review documents; and (4) chemicals which NIOSH has made the subject of "Information Profile" review documents.
- All of the carcinogens identified by the National Toxicology Program of the U.S. Department of Health and Human Services at Research Triangle Park, N.C. (A-62)(A-64).

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- Many of the chemicals profiled by the combination of the Dutch Association of Safety Experts, the Dutch Chemical Industry Association and the Dutch Safety Institute (A-60). These provide a source similar to the U.S. Coast Guard CHRIS system of material data sheets.
- Most of the chemicals described in the current and timely periodical entitled "Dangerous Properties of Industrial Materials Report" edited by N. Irving Sax.
- Most of the chemicals described in the 2-volume "Encyclopedia of Occupational Health and Safety" published by the International Labor office in 1983 (A-69).
- Most of the chemicals covered in the Legal File published by International Register of Potentially Toxic Chemicals Program (IRPTC) of the United Nations in 1984 (A-70). The reader who is particularly concerned with legal standards (allowable concentration in air, in water or in foods) is advised to check these most recent references because data may exist in this UN publication which has not been quoted in toto in this volume because of time and space limitations.

All this information from U.S. Government sources has been supplemented by a careful search of, and citations to, publications from the United Kingdom, European and Japanese sources as well as United Nations and World Health Organization publications.

The result, we believe, is a handbook that is more than a handbook. When one looks at most handbooks, one simply expects to get numerical data. Here, we have tried wherever possible to reference the source of the numerical values and to provide a literature reference to some sort of timely review document which opens the door to a much wider field of published materials.

As pointed out in May 1980 by the Toxic Substances Strategy Committee, an interagency group, in a report to President Carter (A-47):

> Exposures to toxic substances are linked to a variety of health problems. The immediate effects of high level exposures for a short time include burns, rashes, nausea, loss of eyesight, and fatal poisoning. Prolonged exposure to low doses can cause chronic lung disease (e.g., from coal or cotton dust), heart disease (from exposure to cadmium or carbon monoxide), sterility (from dibromochloropropane—DBCP), and kidney, liver, brain, nerve, and other damage. Exposure to industrial solvents can cause depression, and carbon disulfide workers are associated with a higher suicide rate than the general population. Although most chemicals do not cause cancers, exposure to some has been linked to cancer. Some workers exposed to asbestos, even for a short time, have developed a rare cancer of the chest and stomach linings 30 to 40 years after initial exposure. Vinyl chloride gas is linked to a rare liver cancer, to a brain cancer, and possibly to lung cancer. Diethylstilbestrol (DES), when taken by pregnant women to prevent miscarriages, led to increased risk of vaginal cancer in their daughters and abnormal sexual organs in their sons. Methylmercury, formed by the action of bacteria in sediments on mercury metal and on mercuric ions, can cause acute poisoning, deafness, brain damage, and a range of birth defects.

A single substance can have several kinds of adverse effects, depending on the route and level of exposure. Some effects of exposure to chemicals which are produced in substantial quantities are shown in Table 1. Chemicals listed in the National Occupational Hazard Survey were preselected for all chemicals to which more than 100,000 workers are potentially exposed. The Toxicology Data Bank of the National Library of Medicine was then searched for evidence (human and animal) of chronic or acute effects for all targets, and the 19 substances were chosen to illustrate the multiple target effects. Other data bases could suggest different target specificity.

Table 1: Selected High Volume Substances and Effects of Exposure

Substance	Kidney	Liver	Central Nervous System	Reproductive System	Pulmonary System	Skin
Acetone	x	x			x	x
Acrylonitrile					x	x
Ammonia	x	x			x	x
Asbestos					x	
Cresol	x	x	x		x	x
Dichloromethane	x	x	x		x	x
Diethylene glycol	x	x	x	x	x	x
2-Ethoxyethanol	x	x	x	x	x	x
Ethylene glycol	x	x			x	
Lead	x	x	x	x		
Methyl ethyl ketone	x	x	x		x	x
2-Methyl-2,4-pentanediol	x	x			x	x
Oxalic acid	x		x	x	x	x
Phenol	x	x	x		x	x
Sodium hydroxide					x	x
Sulfuric acid	x	x			x	x
Talc					x	x
1,1,1-Trichloroethane	x	x	x		x	x
Trichloroethylene	x	x	x		x	

Source: National Institute for Occupational Safety and Health, 1979

Each chemical covered in this volume has been discussed using the same outline or checklist of topics, and these have been filled in to the extent information was available.

Under the title of each substance, there are first four "bulleted" designations indicating whether the substance is:

- A carcinogen (the agency making such a determination, the nature of the carcinogenicity—whether human or animal and whether positive or suspected, and a literature reference are given in each case);
- A "hazardous substance" as defined by the U.S. Environmental Protection Agency primarily on the basis of toxicity to aquatic life (A-51).
- A "hazardous waste" or "hazardous waste constituent" as defined by the U.S. Environmental Protection Agency (A-52).

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Effects of Exposure

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Health, 1979

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U.S. Environmental toxicity to aquatic

onstituent" as de- ncy (A-52).

- A "priority toxic pollutant" as defined by the U.S. Environmental Protection Agency (A-53).

Then each substance has data furnished to the extent available, under each of the following categories:

Description
Code Numbers
DOT Designation
Synonyms
Potential Exposure
Incompatibilities
Permissible Exposure Limits in Air
Determination in Air
Permissible Concentration in Water
Determination in Water
Routes of Entry
Harmful Effects and Symptoms
Points of Attack
Medical Surveillance
First Aid
Personal Protective Methods
Respirator Selection
Disposal Method Suggested
References

In the pages which follow, these categories will be discussed with reference to scope, sources, nomenclature employed, and the like. Omission of a category indicates a lack of available information.

Description: The chemical formula, the color, the odor and the melting or boiling point are given. Structural formulas are given in the cases of complex molecules.

Code Numbers: Three different code numbers are given for each material if they have been assigned:

(1) The Chemical Abstract Service Registry number. It is simply given as CAS XXX-XX-X. It can be used to provide access to the MEDLARS® computerized literature retrieval services of the National Library of Medicine in Washington, DC.

(2) The NIOSH Registry of Toxic Effects of Chemical Substances (RTECS) number is simply given as RTECS ABXXXXXXX (A-49). It is a 9-digit number and can also be used to provide access to updated detailed printouts from the MEDLARS® services cited above.

(3) The United Nations numbers (A-46) for individual chemical commodities. These numbers are now being utilized by the U.S. Department of Transportation (A-50) to assist in the designation of hazardous materials. In some cases an NA number which is a North American identification number (A-50) is cited in parentheses when a UN number has not been assigned.

Use of these identification numbers for hazardous materials will (a) serve to verify descriptions of chemicals; (b) provide for rapid identification of materials when it might be inappropriate or confusing to require the display of lengthy chemical names on vehicles; (c) aid in speeding communication of information on materials from accident scenes and in the receipt of more accurate emergency response information; and (d) provide a means for quick access to immediate emergency response information in the Emergency Response Guidebook (A-56). In this latter volume, the various compounds are simply given "ID Numbers" or identification numbers which correspond closely (but not precisely) to the UN listing (A-46) and to the earlier DOT listing (A-50).

DOT Designation: The U.S. Department of Transportation (A-50) has published listings of chemical substances which give a hazard classification and required labels. The DOT designations are defined as follows:

Hazardous Material – A substance or material which has been determined by the U.S. Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated.

Explosive – Any chemical compound, mixture, or device, the primary or common purpose of which is to function by explosion, i.e., with substantially instantaneous release of gas and heat, unless such compound, mixture, or device is otherwise specifically classified.

Class A Explosive – Detonating or otherwise of maximum hazard. The nine types of Class A explosives are defined in Section 173.53 of CFR Title 49-*Transportation*.

Class B Explosive – In general, function by rapid combustion rather than detonation and include some explosive devices such as special fireworks, flash powders, etc. Flammable hazard.

Class C Explosive – Certain types of manufactured articles containing Class A or Class B explosives, or both, as components but in restricted quantities, and certain types of fireworks. Minimum hazard.

Blasting Agents – A material designed for blasting which has been tested and found to be so insensitive that there is very little probability of accidental initiation to explosion or of transition from deflagration to detonation.

Combustible Liquid – Any liquid having a flash point above 100°F and below 200°F.

Corrosive Material – Any liquid or solid that causes visible destruction of human skin tissue or a liquid that has a severe corrosive rate on steel.

Flammable Liquid – Any liquid having a flash point below 100°F.

Pyrophoric Liquid – Any liquid that ignites spontaneously in dry or moist air at or below 130°F.

Compressed Gas – Any material or mixture having in the container a pressure exceeding 40 psia at 70°F, or a pressure exceeding 104 psia at 130°F; or any liquid flammable material having a vapor pressure exceeding 40 psia at 100°F.

Flammable Gas – Any compressed gas meeting the requirements for lower flammability limit, flammability limit range, flame projection, or flame propagation criteria as specified in Section 173.300(b) of CFR Title 49.

Nonflammable Gas – Any compressed gas other than a flammable compressed gas.

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Flammable Solid – Any solid material, other than an explosive, which is liable to cause fires through friction, retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious transportation hazard.

Organic Peroxide – An organic compound containing the bivalent –O–O– structure and which may be considered a derivative of hydrogen peroxide where one or more of the hydrogen atoms have been replaced by organic radicals must be classed as an organic peroxide.

Oxidizer – A substance such as chlorate, permanganate, inorganic peroxide, or a nitrate, that yields oxygen readily to stimulate the combustion of organic matter.

Poison A – Extremely Dangerous Poisons: Poisonous gases or liquids of such nature that a very small amount of the gas, or vapor of the liquid, mixed with air is dangerous to life.

Poison B – Less Dangerous Poisons: Substances, liquids, or solids (including pastes and semisolids), other than Class A or Irritating Materials, which are known to be so toxic to man as to afford a hazard to health during transportation; or which, in the absence of adequate data on human toxicity, are presumed to be toxic to man.

Irritating Material – A liquid or solid substance which upon contact with fire or when exposed to air gives off dangerous or intensely irritating fumes, but not including any poisonous material, Class A.

Etiologic Agent – A viable microorganism, or its toxin which causes or may cause human disease.

Radioactive Material – Any material, or combination of materials, that spontaneously emits ionizing radiation, and having a specific activity greater than 0.002 microcuries per gram.

Other Regulated Materials – Any material that does not meet the definition of a hazardous material, other than a combustible liquid in packagings having a capacity of 110 gallons or less, and is specified as an ORM material or that possesses one or more of the characteristics described in ORM-A through E below. Note: an ORM with a flash point of 100° to 200°F, when transported with more than 110 gallons in one container shall be classed as a combustible liquid.

> ORM-A: A material which has an anesthetic, irritating, noxious, toxic, or other similar property and which can cause extreme annoyance or discomfort to passengers and crew in the event of leakage during transportation.
>
> ORM-B: A material (including a solid when wet with water) capable of causing significant damage to a transport vehicle or vessel from leakage during transportation. Materials meeting one or both of the following criteria are ORM-B materials: (a) a liquid substance that has a corrosion rate exceeding 0.250 inch per year (IPY) on aluminum (nonclad 7075-T6) at a test temperature of 130°F. An acceptable test is described in NACE Standard TM-01-69.
>
> ORM-C: A material which has other inherent characteristics not described as an ORM-A or ORM-B but which make it unsuitable

for shipment, unless properly identified and prepared for transportation.

ORM-D: A material such as a consumer commodity which, though otherwise subject to the regulations of this section, presents a limited hazard during transporation due to its form, quantity and packaging.

ORM-E: A material that is not included in any other hazard class. Materials in this class include: (a) hazardous waste; (b) hazardous substances, which means a quantity of a material offered for transportation in one package, or transport vehicle when the material is not packaged, that equals or exceeds the reportable quantity (RQ) specified for the material in EPA regulations at 40 CFR Parts 116 and 117. "Hazardous waste" means any material that is subject to the hazardous waste manifest requirements of the EPA specified in 40 CFR Part 262 or would be subject to these requirements absent an interim authorization to a state under 40 CFR Part 123, Subpart F.

The following are offered to explain additional terms used in preparation of hazardous materials for shipment.

Consumer Commodity – (See ORM-D.) A material that is packaged or distributed in a form intended and suitable for sale through retail sales agencies or instrumentalities for consumption by individuals for purposes of personal care or household use. This term also includes drugs and medicines.

Flash Point – The minimum temperature at which a substance gives off flammable vapors which in contact with spark or flame will ignite.

Forbidden – The hazardous material is one that must not be offered or accepted for transportation.

Limited Quantity – The maximum amount of a hazardous material; as specified in those sections applicable to the particular hazard class, for which there are specific exceptions from the requirements.

Spontaneously Combustible Material (Solid) – A solid substance (including sludges and pastes) which may undergo spontaneous heating or self-ignition under conditions normally incident to transportation or which may upon contact with the atmosphere undergo an increase in temperature and ignite.

Water Reactive Material (Solid) – Any solid substance (including sludges and pastes) which, by interaction with water, is likely to become spontaneously flammable or to give off flammable or toxic gases in dangerous quantities.

Synonyms: Some of the more commonly used synonyms are given for each compound as well as some of the more common registered trade names.

Potential Exposure: A brief indication is given of the nature of exposure to each compound in the industrial environment. Where pertinent, some indications are given of background concentration and occurrence from other than industrial discharges such as water purification plants. Obviously in a volume of this size, this coverage must be very brief. Additional information on numbers of workers exposed and specific occupations which may be exposed are available from the National Institute of Occupational Safety and Health.

It is of course recognized that nonoccupational exposures may be important

as well and the reader
(A-55) for more detail.

Incompatibilities: In
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Permissible Exposure
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as well and the reader is referred to an EPA review document on the topic (A-55) for more detail.

Incompatibilities: Important, potentially hazardous incompatibilities of each substance are listed where available. These are primarily drawn from information developed under the NIOSH Standards Completion Program (A-4).

Permissible Exposure Limits in Air: The permissible exposure limit (PEL), as found in 29 CFR 1910.1000 as of January 1977, has been cited as the Federal standard where one exists. Where NIOSH has published a recommended revision to the OSHA regulation, the NIOSH recommended level is also noted. Where the American Conference of Governmental Industrial Hygienists (ACGIH) has recommended revision of the OSHA regulation and NIOSH has not, the ACGIH revised threshold limit value (TLV®) is also noted.

Except where otherwise noted, the PELs are work-shift time-weighted average (TWA) levels. Ceiling levels and TWAs averaged over other than full work-shifts are noted.

Where the Federal standard and the ACGIH (1983/84) value are identical, the ACGIH designation is implied but not stated, in order to conserve space.

The short-term exposure limit (STEL) values are derived from the ACGIH publication (A-6). This value is the maximal concentration to which workers can be exposed for a period up to 15 minutes continuously without suffering from: irritation; chronic or irreversible tissue change; or narcosis of sufficient degree to increase accident proneness, impair self-rescue, or materially reduce work efficiency, provided that no more than four excursions per day are permitted, with at least 60 minutes between exposure periods, and provided that the daily TWA also is not exceeded.

The "Immediately Dangerous to Life or Health" (IDLH) concentration (A-4) is listed in either ppm or mg/m^3. This concentration represents a maximum level from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects.

Determination in Air: The citations to analytical methods are drawn from various sources, such as:

- The NIOSH "Pocket Guide" (A-4) which summarizes information from the Standards Completion Program. Where references are given to NIOSH Method Set letters or numbers, the complete methods may be found in PB reports available from the National Technical Information Service, Springfield, Virginia, using the following order numbers:

Set Code	NTIS No.	Set Code	NTIS No.
A	PB245850	G	PB265026
B	PB245851	H	PB265027
C	PB245852	I	PB265028
D	PB245935	J	PB263959
E	PB246148	K	PB254227
F	PB246149	L	PB250159
M	PB265029	T	PB262404
N	PB258433	U	PB262405
O	PB262402	V	PB262542
P	PB258434	W	PB262406
Q	PB258435		

Set Code	NTIS No.	Set Code	NTIS No.
R	PB262403	Set 1	PB271712
S	PB263871	Set 2	PB271464

- A publication of the DuPont Company (A-1) which summarizes in tabular form most of the ACGIH threshold limit values, sampling methods, sample sizes, suggested sampling rates and analytical techniques for airborne substances.

Permissible Concentrations in Water: The permissible concentrations in water are drawn from various sources also, including:

- The U.S. Environmental Protection Agency's "red book" published in 1976 (A-3).
- The National Academy of Sciences/National Research Council publication, *Drinking Water and Health* published in 1977 (A-2).
- The priority toxic pollutant criteria published by U.S. EPA in draft form in 1979 and in final form in 1980 (A-53).
- The multimedia environmental goals for environmental assessment study conducted by EPA (A-37). Values are cited from this source when not available from other sources.

Determination in Water: The sources of information in this area have been primarily U.S. EPA publications including the test procedures for priority pollutant analysis (A-54).

Routes of Entry: The toxicologically important routes of entry of each substance are listed. These are primarily taken from the NIOSH Pocket Guide (A-4) but are drawn from other sources as well (A-5).

Harmful Effects and Symptoms: These are primarily drawn from NIOSH publications (A-4) and (A-5) but are supplemented from information from the draft criteria documents for priority toxic pollutants (A-33) and from other sources. The other sources include:

- EPA Chemical Hazard Information Profiles (CHIPS) cited under individual entries.
- NIOSH Information Profiles cited under individual entries.
- EPA Health and Environmental Effect Profiles cited under individual entries.

Particular attention has been paid in this second revised edition to cancer as a "harmful effect" and special effort has been expended to include the latest data on carcinogenicity (A-62)(A-63)(A-64).

Points of Attack: This category is based in part on the "Target Organs" in the NIOSH Pocket Guide (A-4) but the title has been changed as many of the points of attack are not organs (blood, for example).

Medical Surveillance: This information is drawn primarily from a NIOSH publication (A-5). Where additional information is desired in areas of diagnosis, treatment and medical control, the reader is referred to a private publication (A-35) which is adapted from the products of the NIOSH Standards Completion Program.

First Aid: Simple first aid procedures are listed for response to eye contact, skin contact, inhalation, and ingestion of the toxic substance as drawn to a large

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(A-44)(A-48) and in Jap

Personal Protective M
publications (A-4)(A-5)
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CCROVDMF
CCROVDMFuPest

CCROVDMPest

CCROVDPest
CCROVF
CCROVFuHiE
CCROVFD
CCROVFDM
CCROVFDMFuPest

CCROVFDMPest

CCROVFDPest

CCROVFFuHiE

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Set Code	NTIS No.
Set 1	PB271712
Set 2	PB271464

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threshold limit values, sampling
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Health published in 1977 (A-2).

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extent from the NIOSH Pocket Guide (A-4) but supplemented by information from recent commercially available volumes in the U.S. (A-39), in the U.K. (A-44)(A-48) and in Japan (A-38).

Personal Protective Methods: This information is drawn heavily from NIOSH publications (A-4)(A-5) and supplemented by information from the U.S. (A-39), the U.K. (A-48) and Japan (A-38).

There are indeed other "personal protective methods" which space limitations prohibit describing here in full. One of these involves limiting the quantities of carcinogens to which a worker is exposed in the laboratory. Such numerical limits have been discussed in an N.I.H. publication (A-67).

Respirator Selection: Whereas in all the other categories, it has been attempted to provide guidance in brief readable English, it has been necessary in the interest of brevity to use hieroglyphics to designate respirator selection. A condensed table of allowable respirator use is provided from a NIOSH tabulation (A-4) when available. Each line of this item lists a maximum use concentration (in ppm, mg/m^3, μg/m^3, or mppcf) or condition (e.g., escape) followed by a series of codes representing classes of respirators. Individual respirator codes are separated by slanted (/) lines.

The recommendations for respirator use are based upon the OSHA permissible exposure level. Any approved respirator of a given category can be utilized at any concentration equal to, or less than, the category's listed maximum use concentration for the toxic substance of interest. Codes employed for the various categories of respirator are as follows:

CCR	Chemical cartridge respirator
CCRAG	Chemical cartridge respirator with acid gas cartridge(s)
CCRAGF	CCRAG with a full facepiece
CCRAGFHiE	CCRAG with a full facepiece and with a high-efficiency filter
CCROV	Chemical cartridge respirator with organic vapor cartridge(s)
CCROVAG	CCROV with acid gas cartridge(s)
CCROVAGF	CCROV with acid gas cartridge(s) and full facepiece
CCROVD	CCROV with dust filter
CCROVDM	CCROV with dust and mist filter
CCROVDMF	CCROV with dust and mist filter and full facepiece
CCROVDMFuPest	CCROV with dust, mist, and fume filter, including pesticide respirators meeting these requirements
CCROVDMPest	CCROV with dust and mist filter, including pesticide respirators meeting these requirements
CCROVDPest	CCROV with dust filter, including pesticide respirators
CCROVF	CCROV with full facepiece
CCROVFuHiE	CCROV with fume or high-efficiency filter
CCROVFD	CCROV with full facepiece and dust filter
CCROVFDM	CCROV with full facepiece and dust and mist filter
CCROVFDMFuPest	CCROV with full facepiece and dust, mist and fume filter, including pesticide respirators meeting these requirements
CCROVFDMPest	CCROV with full facepiece and dust and mist filter, including pesticide respirators meeting these requirements
CCROVFDPest	CCROV with dust filter and full facepiece, including pesticide respirators with full facepiece
CCROVFFuHiE	CCROV with full facepiece and fume or high-efficiency filter
CCROVFHiEP	CCROV with high-efficiency particulate filter and full facepiece

CCROVFS	CCROV with full facepiece providing protection against the specific compound of concern
CCROVHiEP	CCROV with high-efficiency particulate filter
CCROVHiEPest	CCROV with high-efficiency filter, including pesticide respirators meeting these requirements
CCROVS	CCROV providing protection against the specific compound of concern
D	Dust mask
DM	Dust and mist respirator
DMFu	Dust, mist, and fume respirator
DMXS	DM, except single-use respirators
DMXSPest	DM, except single-use respirators, including pesticide respirators
DMXSQ	DM, except single-use and quarter-mask respirators
DMXSQPest	DM, except single-use and quarter-mask respirators including pesticide respirators
DXS	Dust mask, except single-use
DXSPest	Dust mask, except single-use, including pesticide respirators
DXSQ	Dust mask, except single-use and quarter-mask respirators
FuHiEP	Fume or high-efficiency particulate respirator
FuHiEPS	FuHiEP providing protection against the specific compound of concern
GMAG	Gas mask with an acid gas canister (chin-style or front- or back-mounted canister)
GMAGHiE	GMAG with high-efficiency filter
GMAGP	GMAG with particulate filter
GMAGS	GMAG providing protection against the specific compound of concern
GMOV	Gas mask with organic vapor canister (chin-style or front- or back-mounted canister)
GMOVc	Chin-style GMOV
GMOVfb	Front- or back-mounted GMOV
GMOVAG	GMOV providing protection against acid gases
GMOVAGF	GMOV, with full facepiece, providing protection against acid gases
GMOVAGHiE	GMOV with high-efficiency filter and acid gas canister
GMOVAGP	GMOV with acid gas canister and particulate filter
GMOVD	GMOV with dust filter
GMOVDFuMPest	GMOV with dust, fume, and mist filter, including pesticide respirators meeting these requirements
GMOVDM	GMOV with dust and mist filter
GMOVDMPest	GMOV with dust and mist filter, including pesticide respirators
GMOVF	GMOV with full facepiece
GMOVFFuHiE	GMOV with full facepiece and fume or high-efficiency filter
GMOVFHiE	GMOV with full facepiece and high-efficiency filter
GMOVFP	GMOV with full facepiece and particulate filter
GMOVHiEP	GMOV with high-efficiency particulate filter
GMOVP	GMOV with particulate filter
GMOVPPest	GMOV with particulate filter, including pesticide respirators
GMPest	Gas mask with pesticide canister (chin-style or front- or back-mounted canister)
GMS	Gas mask with canister providing protection against the compound of concern (chin-style or front- or back-mounted canister)
GMSc	GMS with chin-mounted canister

GMSfb
GMSF
GMSHiE
GMSOVPPest

GMSP
HiEP
HiEPAG
HiEPF
HiEPFu
HiEPFPest

HiEPPest

MXS
MXSQ

PAPCCROVHiEP

PAPCCROVFHiEP
PAPCCROVFHiEPPest

PAPHiE
PAPHiEF
PAPHiEOV
PAPHiEOVF
PAPHiEPest

SA
SA:PD,PP,CF

SAF
SAF:PD,PP,CF

SCBA
SCBAF
SCBAF:PD,PP

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canister

GMSfb	GMS with front- or back-mounted canister
GMSF	GMS with full facepiece
GMSHiE	GMS with high-efficiency filter
GMSOVPPest	GMS with organic vapor canister and particulate filter, including pesticide respirators meeting these requirements
GMSP	GMS with particulate filter
HiEP	High-efficiency particulate respirator
HiEPAG	HiEP with acid gas cartridge
HiEPF	HiEP with full facepiece
HiEPFu	HiEP or a fume filter respirator
HiEPFPest	HiEP with full facepiece, including pesticide respirators meeting these requirements
HiEPPest	HiEP, including pesticide respirators meeting these requirements
MXS	Mist respirator, except single-use
MXSQ	Mist respirator, except single-use and quarter-mask respirator
PAPCCROVHiEP	Powered air-purifying respirator with organic vapor cartridge and high-efficiency particulate filter
PAPCCROVFHiEP	PAPCCROVHiEP with full facepiece
PAPCCROVFHiEPPest	PAPCCROVHiEP with full facepiece, including pesticide respirators meeting these requirements
PAPHiE	Powered air-purifying respirator with high-efficiency filter
PAPHiEF	PAPHiE with full facepiece
PAPHiEOV	PAPHiE with organic vapor cartridge
PAPHiEOVF	PAPHiE with organic vapor cartridge and full facepiece
PAPHiEPest	PAPHiE, including pesticide respirators meeting these requirements
SA	Supplied-air respirator
SA:PD,PP,CF	Type C SA operated in pressure-demand or other positive pressure or continuous-flow mode
SAF	SA with full facepiece, helmet, or hood
SAF:PD,PP,CF	Type C SA with full facepiece operated in pressure-demand or other positive pressure mode or with full facepiece, helmet, or hood operated in continuous-flow mode
SCBA	Self-contained breathing apparatus
SCBAF	SCBA with full facepiece
SCBAF:PD,PP	SCBA with full facepiece operated in pressure-demand or other positive pressure mode

Disposal Method Suggested: The disposal methods for various chemical substances have been drawn from earlier works by this author on disposal, incineration and landfill disposal (A-31) as well as a more recent volume (A-32) which treats pesticide disposal methods more specifically. Another source is a recent book on the degradation of chemical carcinogens (A-43). A still more recent source on disposal of chemicals from laboratories has been published by the National Research Council (A-66).

References: The general bibliography for this volume follows immediately. It includes general reference sources and references dealing with analytical methods.

The references at the end of individual product entries are generally restricted to:

- references dealing only with that particular compound;
- references which in turn contain bibliographies giving references to the original literature on toxicological and other behavior of the substance in question.

Contents

DOT Designation: Nonflammable gas.

Potential Exposures: Argon is used as an inert gas shield in arc weldin it is used to fill electric lamps. It is used as a blanketing agent in metals r fining (especially titanium and zirconium).

Permissible Exposure Limits in Air: There is no Federal standard. ACGI lists argon as a simple asphyxiant with no specified TLV.

Permissible Concentration in Water: No criteria set.

Routes of Entry: Inhalation and possibly skin contact with liquid argon.

Harmful Effects and Symptoms: The gas is a simple asphyxiant as note above. The liquid can cause frostbite.

Disposal Method Suggested: Vent to atmosphere.

References

(1) Sax, N.I., Ed., *Dangerous Properties of Industrial Materials Report, 1,* No. 5, 36-3 New York, Van Nostrand Reinhold Co. (1981).

ARSENIC AND ARSENIC COMPOUNDS

- Carcinogen (IARC) (11)
- Hazardous substances (Some compounds, EPA)
  Arsenic compounds classified by EPA as hazardous substances are: arsenic disulfide, arsenic pentoxide, arsenic trichloride, arsenic trioxide and arsenic trisulfide. Also the EPA has issued rebuttable presumptions against registration (RPAR's) for several arsenic-containing pesticides as follows: arsenic acid, cacodylic acid, calcium arsenate, DSMA, lead arsenate, MSMA and sodium arsenite.
- Hazardous waste constituents (EPA)
- Priority toxic pollutant (EPA)

Description: As, elemental arsenic, occurs to a limited extent in nature a steel-gray metal that is insoluble in water. Arsenic in this discussion includ the element and any of its inorganic compounds excluding arsine. Arsenic tr oxide (As_2O_3), the principal form in which the element is used, is frequentl designated as arsenic, white arsenic, or arsenous oxide. Arsenic is present an impurity in many other metal ores and is generally produced as arsen trioxide as a by-product in the smelting of these ores, particularly copper. Mo other arsenic compounds are produced from the trioxide.

Code Numbers: (Element) CAS 7440-38-2 RTECS CG0525000 UN 1558

Type of Compound/Label Designation: Poison.

Synonyms: None.

Potential Exposure: Arsenic compounds have a variety of uses. Arsenat and arsenites are used in agriculture as insecticides, herbicides, larvicides, ar pesticides. Arsenic trichloride is used primarily in the manufacture of phar aceuticals. Other arsenic compounds are used in pigment production, the man facture of glass as a bronzing or decolorizing agent, the manufacture of op glass and enamels, textile printing, tanning, taxidermy, and antifouling paint They are also used to control sludge formation in lubricating oils.

Medical Surveillance: In preemployment physical examinations, special attention should be given to past or present kidney disease, liver disease, and anemia. Periodic physical examinations should include tests to determine arsenic levels in the blood and urine. The general condition of the blood and the renal and liver functions should also be evaluated. Since arsine gas is a by-product of certain production processes, workers should be trained to recognize the symptoms of exposure and to use appropriate personal protective equipment.

First Aid: If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. Dimercaprol treatment is indicated and blood transfusions may be necessary (A-39).

Personal Protective Methods: In most cases, arsine poisoning cannot be anticipated except through knowledge of the production processes. Where arsine is suspected in concentrations above the acceptable standard, the worker should be supplied with a supplied air fullface respirator or a self-contained positive pressure respirator with full facepiece.

Respirator Selection:

0.5 ppm: SA/SCBA
2.5 ppm: SAF/SCBAF
6 ppm: SA:PD,PP,CF
Escape: GMS/SCBA

Disposal Method Suggested: Arsine may be disposed of by controlled burning. When possible, cylinders should be sealed and returned to suppliers.

References

(1) See Reference (A-60).
(2) Parmeggiani, L., Ed., *Encyclopedia of Occupational Health & Safety*, Third Edition, Vol. 1, pp 183-184, Geneva, International Labour Office (1983).

ASBESTOS

- Carcinogen (Human positive, IARC) (10) (A-62) (A-64)
- Hazardous waste (EPA)
- Priority toxic pollutant (EPA)

Description: Asbestos is a generic term that applies to a number of naturally occurring, hydrated mineral silicates incombustible in air and separable into filaments. The most widely used in industry in the United States is chrysotile, a fibrous form of serpentine. Other types include amosite, crocidolite, tremolite, anthophyllite, and actinolite.

Code Numbers:

CAS 1332-21-4	RTECS CI6475000	UN 2212 (Blue) 2590 (White)

DOT Designation: ORM-C.

Synonyms: None.

Potential Exposure: Most asbestos is used in the construction industry. Approximately 92% of the half million tons used in the U.S. construction industry is firmly bonded, i.e., the asbestos is "locked in" in such products as floor tiles, asbestos cements, and roofing felts and shingles; while the remaining 8% is friable or in powder form present in insulation materials, asbestos cement powders, and acoustical products.

arsenic and vinyl chloride). Such a standard should also prevent the development of asbestosis.

Since phase contrast microscopy is the only generally available and practical analytical technique at the present time, this level is defined as 100,000 fibers >5 μm in length/m^3 (0.1 fiber/cc), on an 8-hour-TWA basis with peak concentrations not exceeding 500,000 fibers >5 μm in length/m^3 (0.5 fiber/cc) based on a 15-minute sample period.

This recommended standard of 100,000 fibers >5 μm in length/m^3 is intended to (A) protect against the noncarcinogenic effects of asbestos, (B) materially reduce the risk of asbestos-induced cancer (only a ban can assure protection against carcinogenic effects of asbestos) and (C) be measured by techniques that are valid, reproducible, and available to industry and official agencies.

The ACGIH (1983/84) has categorized asbestos (all forms) as a human carcinogen but has specified TLV values as follows:

Amosite 0.5 fiber >5 μm/cc
Chrysotile 2.0 fibers >5 μm/cc
Crocidolite 0.2 fiber >5 μm/cc
Other forms 2.0 fibers >5 μm/cc

The economic impact of the proposed OSHA standard for asbestos has been assayed (4).

Determination in Air: Sampling and analytical techniques should be performed as specified by NIOSH publication USPHS/NIOSH Membrane Filter Method for Evaluating Airborne Asbestos Fibers—T.R. 84 (1976). The determination involves a microscopic fiber count. See also reference (A-10).

Permissible Concentration in Water: To protect freshwater and saltwater aquatic life—no criteria have been established due to insufficient data. To protect human health—preferably zero. A lifetime cancer risk of 1 in 100,000 corresponds to a concentration of 300,000 fibers/ℓ (5).

Routes of Entry: Inhalation and ingestion.

Harmful Effects and Symptoms: Available studies provided conclusive evidence (3)(13) that exposure to asbestos fibers causes cancer and asbestosis in man. Lung cancers and asbestosis have occurred following exposure to chrysotile, crocidolite, amosite, and anthophyllite.

Mesotheliomas, lung and gastrointestinal cancers have been shown to be excessive in occupationally exposed persons, while mesotheliomas have developed also in individuals living in the neighborhood of asbestos factories and near crocidolite deposits, and in persons living with asbestos workers. Asbestosis has been identified among persons living near anthophyllite deposits.

Likewise, all commercial forms of asbestos are carcinogenic in rats, producing lung carcinomas and mesotheliomas following their inhalation, and mesotheliomas after intrapleural or i.p. injection. Mesotheliomas and lung cancers were induced following even 1 day's exposure by inhalation.

The size and shape of the fibers are important factors; fibers less than 0.5 μm in diameter are most active in producing tumors. Other fibers of a similar size including glass fibers, can also produce mesotheliomas following intrapleural or i.p. injection.

There are data that show that the lower the exposure, the lower the risk of developing cancer. Excessive cancer risks have been demonstrated at all fiber concentrations studied to date. Evaluation of all available human data provides no evidence for a threshold or for a "safe" level of asbestos exposure.

Disposal Method Suggested: Chlordane is readily dehydrochlorinated in alkali to form "nontoxic" products, a reaction catalyzed by traces of iron. The environmental hazards of the products are uncertain. Chlordane is completely dechlorinated by sodium in isopropyl alcohol. The MCA recommends incineration methods for disposal of chlordane.

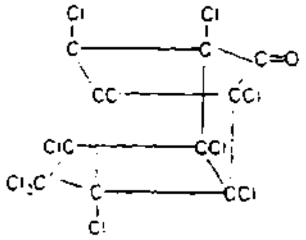
References

(1) U.S. Environmental Protection Agency, *Chlordane: Ambient Water Quality Criteria*, Washington, DC (1980).
(2) U.S. Environmental Protection Agency, *Chlordane*, Health and Environmental Effects Profile No. 35, Office of Solid Waste, Washington, DC (April 30, 1980).
(3) National Cancer Institute, *Bioassay of Chlordane for Possible Carcinogenicity*, Tech. Report Series No. 8, Bethesda, MD (1977).
(4) Sax, N.I., Ed., *Dangerous Properties of Industrial Materials Report, 1*, No. 2, 33-35, New York, Van Nostrand Reinhold Co. (1980).
(5) See Reference (A-61).
(6) Sax, N.I., Ed., *Dangerous Properties of Industrial Materials Report, 3*, No. 5, 94-99, New York, Van Nostrand Reinhold Co. (1983).
(7) United Nations Environment Programme, *IRPTC Legal File 1983*, Vol. II, pp VII/447-50, Geneva, Switzerland, International Register of Potentially Toxic Chemicals (1984).

CHLORDECONE

- Carcinogen (Potential Human, NIOSH)(A-5)(Animal Positive, IARC)(5)(7)
- Hazardous substance (EPA)
- Hazardous waste (EPA)

Description: $C_{10}Cl_{10}O$, is a crystalline solid with the structural formula:



which decomposes at 350°C.

Code Numbers: CAS 143-50-0 RTECS PC8575000 UN 2588

DOT Designation: –

Synonyms: Kepone®; ENT 16,391; 1,1a,3,3a,4,5,5,5a,5b,6-decachloro-octahydro-1,3,4-metheno-2H-cyclobuta[c,d]pentalen-2-one

Potential Exposures: NIOSH has identified fewer than 50 establishments processing or formulating pesticides using chlordecone and has estimated that 600 workers are potentially exposed to chlordecone. (NIOSH is unaware of any plant in the United States which is currently manufacturing chlordecone; the only known plant manufacturing it was closed in July 1975.)

Kepone was registered for the control of rootborers on bananas to a residue tolerance of 0.01 ppm. This constituted the only food or feed use of

Personal Protective Methods: Wear appropriate clothing to prevent repeated or prolonged skin contact. Employees should wash daily at the end of each work shift. Work clothing should be changed daily if it is possible that clothing is contaminated. Remove nonimpervious clothing promptly if wet or contaminated.

Respirator Selection:
0.75 mg/m^3: DXSPest
1.5 mg/m^3: DXSQ/HiEPPest/SA/SCBA
7.5 mg/m^3: HiEPFPest/SAF/SCBAF
150 mg/m^3: PAPHiEPest/SA:PD,PP,CF
300 mg/m^3: SAF:PD,PP,CF
Escape: DXSPest/SCBA

Disposal Method Suggested: Long-term storage in large, weatherproof, and sift-proof storage bins or silos; small amounts may be disposed of in a chemical waste landfill (A-31).

References

(1) Parmeggiani, L., Ed., *Encyclopedia of Occupational Health & Safety,* Third Edition, Vol. 2, pp 1205–1206, Geneva, International Labour Office (1983).
(2) United Nations Environment Programme, *IRPTC Legal File 1983,* Vol. I, pp VII/58-9, Geneva, Switzerland, International Register of Potentially Toxic Chemicals (1984).
(3) Also see "Arsenic and Arsenic Compounds."

LEAD–INORGANIC

- Hazardous substances (Various compounds, EPA)
  Lead compounds which are classified by EPA as hazardous substances include: lead acetate, lead arsenate (see separate entry), lead chloride, lead fluoborate, lead fluoride (see also "Fluorides"), lead iodide, lead nitrate, lead stearate, lead sulfate, lead sulfide, and lead thiocyanate.
- Hazardous waste constituents (EPA)
- Priority toxic pollutant (EPA)

Description: Pb, inorganic lead, includes lead oxides, metallic lead, lead salts, and organic salts such as lead soaps, but excludes lead arsenate and organic lead compounds. Lead is a blue-grey metal which is very soft and maleable. Commercially important lead ores are galena, cerussite, anglesite, crocoisite, wulfenite, pyromorphite, matlockite, and vanadinite. Lead is slightly soluble in water in presence of nitrates, ammonium salts, and carbon dioxide.

Code Numbers: Lead metal–CAS 7439-92-1 RTECS OF7525000

DOT Designation: –

Synonyms: None.

Potential Exposures: Metallic lead is used for lining tanks, piping, and other equipment where pliability and corrosion resistance are required such as in the chemical industry in handling corrosive gases and liquids used in the manufacture of sulfuric acid; in petroleum refining; and in halogenation, sulfonation, extraction, and condensation processes; and in the building industry.

It is also used as an ingredient in solder, a filler in the automobile industry, and a shielding material for x-rays and atomic radiation; in manufacture of tetraethyllead and organic and inorganic lead compounds, pigments for paints

Permissible Exposure Limits in Air: There is no Federal standard, however, ACGIH has set a threshold limit value for chlorpyrifos in air of 0.2 mg/m^3 as of 1983/84. The short-term exposure limit is 0.6 mg/m^3. Both limits bear the notation "skin" indicating that cutaneous absorption should be prevented so the threshold limit value is not invalidated.

Permissible Concentration in Water: No criteria set.

Routes of Entry: Skin absorption, inhalation of dusts, ingestion.

Harmful Effects and Symptoms: This compound is a plasma cholinesterase inhibitor. However, it has only moderate capacity to reduce red blood cell cholinesterase or cause cholinergic symptoms and little capacity to cause systemic injury (A-34).

Disposal Method Suggested: This compound is 50% hydrolyzed in aqueous MeOH solution at pH 6 in 1,930 days, and in 7.2 days at pH 9.96. Spray mixtures of <1% concentration are destroyed with an excess of 5.25% sodium hypochlorite in < 30 minutes at 100°C, and in 24 hours at 30°C. Concentrated (61.5%) mixtures are essentially destroyed by treatment with 100:1 volumes of the above sodium hypochlorite solution and steam in 10 minutes (A-32).

References

(1) United Nations Environment Programme, *IRPTC Legal File 1983*, Vol. II, pp VII/607-8, Geneva, Switzerland, International Register of Potentially Toxic Chemicals (1984).

CHROMIUM AND COMPOUNDS

- Carcinogen (varies with compound, see text)
- Hazardous substance (some compounds)
  Chromium compounds designated by EPA as hazardous substances include: chromic acetate, chromic acid, chromic sulfate and chromous chloride.
- Hazardous waste constituents (EPA)
- Priority toxic pollutant (EPA)

Description: This group includes chromium trioxide (CrO_3), and its aqueous solutions (1). Chromium may exist in one of three valence states in compounds, +2, +3, and +6. Chromic acid, along with chromates, is in the hexavalent form. Chromium trioxide is produced from chromite ore by roasting with alkali or lime (calcium oxide), leaching, crystallization of the soluble chromate or dichromate followed by reaction with sulfuric acid.

Code Numbers:

Elemental Cr	CAS 7440-47-3	RTECS GB4200000	
Chromic acid	CAS 7738-94-5	RTECS GB2450000	UN 1463

DOT Designations: Chromic acid - oxidizer

Synonyms: Chromium trioxide is also known as chromic anhydride, chromic acid and chromium(VI) oxide. Synonyms vary depending upon specific compound.

Potential Exposures: Chromium trioxide is used in chrome plating, copper stripping, aluminum anodizing, as a catalyst, refractories, in organic synthesis, and photography. An estimated 15,000 industrial workers are potentially

MERCURY–ELEMENTAL

- Hazardous waste (EPA)

Description: Hg is a silvery, mobile, odorless liquid. It boils at 356°-357°C.

Code Numbers: CAS 7439-97-6 RTECS OV4550000 UN 2809

DOT Designation: ORM-B

Synonyms: Quicksilver

Potential Exposure: Mercury is used as a liquid cathode in cells for the electrolytic production of caustic and chlorine. It is used in electrical apparatus (lamps, rectifiers and batteries) and in control instruments (switches, thermometers and barometers). NIOSH estimates annual worker exposure to mercury at 150,000.

Permissible Exposure Limits in Air: The Federal standard is 0.1 mg/m^3 as a ceiling value. NIOSH has recommended a value of 0.05 mg/m^3. ACGIH as of 1983/84 has proposed a TWA value of 0.05 mg/m^3 with the notation "skin" indicating the possibility of cutaneous absorption for mercury vapor but no STEL value. The IDLH level is 28 mg m^3.

Determination in Air: Adsorption on silvered Chromosorb P, thermal desorption, analysis by flameless atomic absorption spectrometry (A-10).

Permissible Concentration in Water: No criteria set. See Mercury–Inorganic

Routes of Entry: Inhalation, skin absorption, eye and skin contact.

Harmful Effects and Symptoms: Coughing, chest pains, dyspnea, bronchitis, pneumonia; tremors, insomnia, irritability, indecision; headaches, fatigue, weakness; stomatitis; salivation; gastrointestinal disturbance, anorexia, weight loss, proteinuria; irritation of eyes and skin.

Points of Attack: Skin, respiratory system, central nervous system, kidneys, eyes.

Medical Surveillance: Consider the points of attack in preplacement and periodic physical examinations.

First Aid: If this chemical gets into the eyes, irrigate immediately. If this chemical contacts the skin, wash with soap promptly. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once and perform artificial respiration. When this chemical has been swallowed, get medical attention. Give large quantities of water and induce vomiting. Do not make an unconscious person vomit.

Personal Protective Methods: Wear appropriate clothing to prevent repeated or prolonged skin contact. Employees should wash promptly when skin is wet or contaminated. Work clothing should be changed daily if it is possible that clothing is contaminated. Remove nonimpervious clothing promptly if wet or contaminated.

Respirator Selection:

1 mg/m^3: SA/SCBA
5 mg/m^3: SAF/SCBAF
28 mg/m^3: SA:PD,PP,CF
Escape: GMS/SCBA

Disposal Method Suggested: Accumulate for sale or for purification and reuse (A-38). See also (A-57)

Personal Protective Methods: Wear appropriate clothing to prevent any reasonable probability of skin contact. Wear eye protection to prevent any possibility of eye contact. Employees should wash immediately when skin is wet or contaminated. Work clothing should be changed daily if it is possible that clothing is contaminated. Remove nonimpervious clothing immediately if wet or contaminated. Provide emergency eyewash.

Respirator Selection:

15 mg/m^3: DMSXPest
30 mg/m^3: DMXSQPest/FuHiEP/SA/SCBA
150 mg/m^3: HiEPF/SAF/SCBAF
1,800 mg/m^3: PAPHiE/SA:PD,PP
Escape: DMXS/SCBA

Disposal Method Suggested: This pesticide is more stable to hydrolysis than dichlorvos (50% hydrolysis at pH 9 at 37.5°C in 301 minutes). It is unstable in alkaline conditions, in presence of iron, and is degraded by sunlight. About 10% hydrolysis per day is obtained in ambient water (A-32).

References

(1) U.S. Environmental Protection Agency, *Investigation of Selected Potential Environmental Contaminants: Haloalkyl Phosphates*, Report EPA 560/2-76-007, Wash., DC (Aug. 1976).

(2) United Nations Environment Programme, *IRPTC Legal File 1983*, Vol. II, pp VII/549-50, Geneva, Switzerland, International Register of Potentially Toxic Chemicals (1984).

NAPHTHALENE

- Hazardous substance (EPA)
- Hazardous waste (EPA)
- Priority toxic pollutant (EPA)

Description: $C_{10}H_8$, naphthalene, is a white crystalline solid with a characteristic "moth ball" odor. It melts at 74° to 80°C and boils at 218°C.

Code Numbers: CAS 91-20-3 RTECS QJ0525000 UN 1334 and 2304 (molten)

DOT Designation: ORM-A.

Synonyms: Naphthalin, moth flake, tar camphor, white tar, moth balls.

Potential Exposures: Naphthalene is used as a chemical intermediate or feedstock for synthesis of phthalic, anthranilic, hydroxyl (naphthols), amino (naphthylamines), and sulfonic compounds which are used in the manufacture of various dyes. Naphthalene is also used in the manufacture of hydronaphthalenes, synthetic resins, lampblack, smokeless powder, and celluloid. Naphthalene has been used as a moth repellent.

Approximately 100 million people worldwide have G6PD deficiency which would make them more susceptible to hemolytic anemia on exposure to naphthalene. At present, more than 80 variants of this enzyme deficiency have been identified. The incidence of this deficiency is 0.1% in American and European Caucasians, but can range as high as 20% in American blacks and greater than 50% in certain Jewish groups.

Newborn infants have a similar sensitivity to the hemolytic effects of naphthalene, even without G6PD deficiency.

X

XYLENES

- Hazardous substance (EPA)
- Hazardous waste (EPA)

Description: $C_6H_4(CH_3)_2$, xylene, exists in three isomeric forms, ortho-, meta- and para-xylene. Commercial xylene is a mixture of these three isomers and may also contain ethylbenzene as well as small amounts of toluene, trimethylbenzene, phenol, thiophene, pyridine, and other nonaromatic hydrocarbons. m-Xylene is predominant in commercial xylene and shares physical properties with o-xylene in that both are mobile, colorless, flammable liquids. p-Xylene, at a low temperature (13° to 14°C), forms colorless plates or prisms.

Code Numbers: CAS 1330-20-7 RTECS ZE2100000 UN 1307

DOT Designation: Flammable liquid.

Synonyms: Xylol, dimethylbenzene.

Potential Exposures: Xylene is used as a solvent, as a constituent of paint, lacquers, varnishes, inks, dyes, adhesives, cements, cleaning fluids and aviation fuels; and as a chemical feedstock for xylidines, benzoic acid, phthalic anhydride, isophthalic, and terephthalic acids, as well as their esters (which are specifically used in the manufacture of plastic materials and synthetic textile fabrics). Xylene is also used in the manufacture of quartz crystal oscillators, hydrogen peroxide, perfumes, insect repellants, epoxy resins, pharmaceuticals, and in the leather industry.

NIOSH estimates that 140,000 workers are potentially exposed to xylene.

Incompatibilities: Strong oxidizers.

Permissible Exposure Limits in Air: The Federal standard and the ACGIH 1983/84 TWA value is 100 ppm (435 mg/m^3) for all isomers. NIOSH recommends adherence to the present Federal standard of 100 ppm as a time-weighted average for up to a 10-hour workday, 40-hour workweek. NIOSH also recommends a ceiling concentration of 200 ppm as determined by a sampling period of 10 minutes. The STEL value is 150 ppm (655 mg/m^3). The notation "skin" is added to indicate the possibility of cutaneous absorption. The IDLH level is 10,000 ppm.

Determination in Air: Adsorption on charcoal, workup with CS_2, analysis by gas chromatography. See NIOSH Methods, Set U. See also reference (A-10).

Permissible Concentration in Water: No criteria set but EPA (A-37) has suggested a permissible ambient goal of 6,000 μg/ℓ based on health effects.

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Characterization of Selected Chem-
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9-210k, Washington, DC (Decem-

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4D, pp 76-85 (October 1977).
V.W. Burse, *Induction of Liver Tu-*
rominated Biphenyls, J. Nat. Cancer

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Mixture (Firemaster FF-1), Technical
82-1300, Research Triangle Park,

Legal File 1983, Vol. II, pp VII/371,
otentially Toxic Chemicals (1984).

POLYCHLORINATED BIPHENYLS (PCBs)

- Carcinogens (Animal positive, IARC) (4)
- Hazardous materials (EPA)
- Hazardous waste constituents (EPA)
- Priority toxic pollutants (EPA)

Description: $C_{12}H_{10-x}Cl_x$, diphenyl rings in which one or more hydrogen atoms are replaced by a chlorine atom. Most widely used are chlorodiphenyl (42% chlorine), containing 3 chlorine atoms in unassigned positions, and chlorodiphenyl (54% chlorine) containing 5 chlorine atoms in unassigned positions. These compounds are light, straw-colored liquids with typical chlorinated aromatic odors; 42% chlorodiphenyl is a mobile liquid and 54% chlorodiphenyl is a viscous liquid.

Polychlorinated biphenyls are prepared by the chlorination of biphenyl and hence are complex mixtures containing isomers of chlorobiphenyls with different chlorine contents. It should be noted that there are 209 possible compounds obtainable by substituting chlorine for hydrogen on from one to ten different positions on the biphenyl ring system. An estimated 40 to 70 different chlorinated biphenyl compounds can be present in each of the higher chlorinated commercial mixtures. For example, Arochlor 1254 contains 69 different molecules, which differ in the number and position of chlorine atoms.

It should also be noted that certain PCB commercial mixtures produced in the United States and elsewhere (e.g., France, Germany, and Japan) have been shown to contain other classes of chlorinated derivatives, e.g., chlorinated naphthalenes and chlorinated dibenzofurans. The possibility that naphthalene and dibenzofuran contaminate the technical biphenyl feedstock used in the preparation of the commercial PCB mixtures cannot be excluded.

Code Numbers: CAS 1336-36-3 RTECS TQ1350000 UN 2315

DOT Designation: ORM-E.

Synonyms: PCBs, chlorodiphenyls, Aroclurs®, Kanechlors®.

Potential Exposures: Chlorinated diphenyls are used alone and in combination with chlorinated naphthalenes. They are stable, thermoplastic, and nonflammable, and find chief use in insulation for electric cables and wires in the production of electric condensers, as additives for extreme pressure lubricants, and as a coating in foundry use.

Polychlorinated biphenyls (PCBs, first introduced into commercial use more than 45 years ago) are one member of a class of chlorinated aromatic organic compounds which are of increasing concern because of their apparent ubiquitous dispersal, persistence in the environment, and tendency to accumulate in food chains, with possible adverse effects on animals at the top of food webs, including man.

Incompatibilities: Strong oxidizers.

Permissible Exposure Limits in Air: The Federal standards and 1983/84 ACGIH TWA values for chlorodiphenyl (42% Cl) and chlorodiphenyl (54% Cl) are 1 mg/m^3 and 0.5 mg/m^3, respectively. NIOSH has recommended a level of 1.0 μg/m^3 on a 10-hour TWA basis for both compounds. The STEL values adopted by ACGIH are 2 mg/m^3 and 1.0 mg/m^3, respectively. The IDLH levels are 10 mg/m^3 and 5 mg/m^3, respectively.

Determination in Air: For the 42% Cl compound, use of a filter plus bubbler

Table 6. Household, Family, and Group Quarters Characteristics: 1990

[illegible] definitions of terms and meanings of symbols, see text]

[illegible]te County Place and [In Selected States] County Subdivision	Persons in households	All households	Family households			Nonfamily households	Householder living alone			Persons per		Persons in group quarters		
			Total	Married-couple family	Female householder, no husband present	Total	Total	65 years and over Total	65 years and over Female	Household	Family	Total	Institutionalized persons	Other persons in group quarters
The State	11 143 646	4 202 240	2 924 880	2 271 962	505 745	1 277 360	1 081 113	423 740	333 926	2.65	3.23	286 956	149 842	137 114
COUNTY														
Adams County	63 676	25 515	17 682	14 776	2 374	7 833	7 060	3 524	2 880	2.50	3.06	2 414	1 789	625
Alexander County	10 416	4 234	2 870	1 973	763	1 364	1 264	680	525	2.46	3.07	210	104	106
Bond County	14 292	5 652	4 118	3 536	434	1 534	1 417	780	618	2.53	3.03	699	230	469
Boone County	30 449	10 950	8 488	7 183	910	2 462	2 052	947	769	2.78	3.18	357	293	64
Brown County	4 881	1 991	1 366	1 204	122	625	582	341	268	2.45	3.05	955	955	-
Bureau County	35 168	13 790	9 917	8 533	1 054	3 873	3 559	2 079	1 673	2.55	3.08	520	520	-
Calhoun County	5 245	2 048	1 511	1 343	106	537	501	308	250	2.56	3.06	77	77	-
Carroll County	16 543	6 638	4 784	4 139	481	1 854	1 683	934	723	2.49	2.99	262	262	-
Cass County	13 120	5 195	3 708	3 134	432	1 487	1 329	725	571	2.53	3.04	317	317	-
Champaign County	155 008	63 900	38 604	31 644	5 363	25 296	18 329	4 692	3 791	2.43	3.02	18 017	1 393	16 624
Christian County	33 816	13 591	9 610	8 091	1 143	3 981	3 668	2 188	1 820	2.49	3.03	602	602	-
Clark County	15 672	6 394	4 573	3 936	484	1 821	1 681	997	793	2.45	2.96	249	247	2
Clay County	14 108	5 708	4 116	3 513	452	1 592	1 492	892	733	2.47	2.98	352	209	143
Clinton County	31 912	11 583	8 765	7 488	927	2 818	2 572	1 414	1 107	2.76	3.26	2 032	1 555	477
Coles County	45 736	18 957	11 947	9 982	1 537	7 010	5 337	2 341	1 944	2.41	2.96	5 908	815	5 093
Cook County	5 021 054	1 879 488	1 248 468	878 032	289 381	631 020	530 253	184 123	141 440	2.67	3.33	84 013	46 069	37 944
Crawford County	19 133	7 792	5 587	4 840	573	2 205	2 052	1 139	936	2.46	2.96	331	301	30
Cumberland County	10 612	4 029	2 963	2 560	299	1 066	971	567	464	2.63	3.14	58	58	-
DeKalb County	67 721	26 413	17 035	14 418	1 934	9 378	6 657	2 247	1 812	2.56	3.10	10 211	873	9 338
De Witt County	16 269	6 488	4 652	3 955	518	1 836	1 658	897	739	2.51	3.01	247	233	14
Douglas County	19 158	7 206	5 372	4 674	507	1 834	1 658	908	748	2.66	3.15	306	291	15
DuPage County	771 807	279 344	208 804	181 206	20 398	70 540	57 064	16 232	13 343	2.76	3.24	9 859	5 445	4 414
Edgar County	19 263	7 859	5 508	4 585	696	2 351	2 186	1 294	1 027	2.45	2.99	332	317	15
Edwards County	7 358	3 016	2 161	1 902	193	855	805	513	414	2.44	2.96	82	82	-
Effingham County	31 249	11 465	8 482	7 209	964	2 983	2 723	1 364	1 103	2.73	3.26	455	425	30
Fayette County	19 526	7 719	5 529	4 736	591	2 190	2 012	1 197	926	2.53	3.05	1 367	1 314	53
Ford County	13 928	5 602	3 997	3 468	399	1 605	1 493	854	728	2.49	3.01	347	347	-
Franklin County	39 787	16 564	11 408	9 435	1 526	5 156	4 783	2 977	2 384	2.40	2.96	537	505	32
Fulton County	36 562	14 893	10 528	8 774	1 332	4 365	3 994	2 358	1 865	2.45	2.97	1 518	1 497	21
Gallatin County	6 745	2 784	1 972	1 646	248	812	747	457	343	2.42	2.95	164	164	-
Greene County	15 125	5 910	4 271	3 585	483	1 639	1 526	946	755	2.56	3.08	192	176	16
Grundy County	32 002	11 979	8 871	7 696	816	3 108	2 737	1 247	981	2.67	3.18	335	317	18
Hamilton County	8 388	3 476	2 468	2 134	251	1 008	967	631	506	2.41	2.95	111	111	-
[illegible]cock County	20 999	8 409	6 061	5 237	608	2 348	2 160	1 196	973	2.50	3.01	374	315	59
[illegible]din County	4 973	2 049	1 451	1 180	210	598	568	320	237	2.43	2.96	216	216	-
[illegible]nderson County	8 061	3 237	2 307	2 000	203	930	846	466	356	2.49	3.01	35	35	-
[illegible]enry County	50 521	19 514	14 374	12 351	1 538	5 140	4 681	2 657	2 151	2.59	3.08	638	580	58
Iroquois County	30 188	11 788	8 643	7 513	844	3 145	2 839	1 671	1 353	2.56	3.04	599	535	64
Jackson County	54 004	23 466	12 847	10 194	2 096	10 619	7 529	2 194	1 761	2.30	2.96	7 063	613	6 450
Jasper County	10 530	3 962	2 976	2 652	245	986	904	556	451	2.66	3.14	79	79	-
Jefferson County	36 591	14 606	10 387	8 557	1 471	4 219	3 845	2 006	1 594	2.51	3.03	429	360	69
Jersey County	19 651	7 344	5 541	4 728	596	1 803	1 614	845	666	2.68	3.15	888	339	549
Jo Daviess County	21 672	8 371	6 106	5 290	587	2 265	2 002	1 131	865	2.59	3.09	149	147	2
Johnson County	9 231	3 725	2 777	2 438	249	948	897	512	377	2.48	2.93	2 116	2 114	2
Kane County	311 327	107 176	81 218	66 736	10 569	25 958	21 358	8 389	6 793	2.90	3.37	6 144	4 540	1 604
Kankakee County	92 670	34 623	24 922	19 477	4 336	9 701	8 401	3 838	2 976	2.68	3.20	3 585	2 348	1 237
Kendall County	39 160	13 301	10 753	9 443	931	2 548	2 142	866	700	2.94	3.32	253	151	102
Knox County	52 983	21 909	14 957	12 226	2 093	6 952	6 190	2 985	2 409	2.42	2.96	3 410	2 247	1 163
Lake County	495 311	173 966	134 570	114 146	15 202	39 396	32 207	10 730	8 496	2.85	3.27	21 107	5 302	15 805
La Salle County	104 531	41 284	29 312	24 575	3 591	11 972	10 880	5 855	4 637	2.53	3.07	2 382	2 247	135
Lawrence County	15 355	6 320	4 449	3 716	570	1 871	1 730	1 030	840	2.43	2.95	617	602	15
Lee County	32 253	12 475	8 936	7 554	1 004	3 539	3 128	1 582	1 286	2.59	3.10	2 139	2 110	29
Livingston County	35 455	13 737	9 981	8 545	1 074	3 756	3 395	1 757	1 422	2.58	3.09	3 846	3 768	78
Logan County	27 423	11 033	7 758	6 526	954	3 275	2 970	1 593	1 330	2.49	3.02	3 375	2 118	1 257
McDonough County	28 846	12 255	7 587	6 422	914	4 668	3 627	1 646	1 336	2.35	2.92	6 398	412	5 986
McHenry County	181 595	62 940	49 778	43 457	4 467	13 162	10 631	4 318	3 410	2.89	3.28	1 646	1 096	550
McLean County	117 891	46 796	30 305	25 318	3 905	16 491	12 702	4 061	3 318	2.52	3.04	11 289	1 300	9 989
Macon County	114 378	45 996	32 330	25 885	5 237	13 666	12 130	5 244	4 237	2.49	3.01	2 828	1 681	1 147
Macoupin County	46 543	18 176	13 344	11 206	1 612	4 832	4 418	2 719	2 172	2.56	3.05	1 136	771	365
Madison County	245 745	94 857	68 426	54 911	10 600	26 431	22 677	10 631	8 662	2.59	3.08	3 493	3 042	451
Marion County	40 847	16 272	11 530	9 315	1 745	4 742	4 343	2 323	1 901	2.51	3.04	714	675	39
Marshall County	12 572	4 900	3 639	3 205	294	1 261	1 156	698	552	2.57	3.05	274	246	28
Mason County	16 088	6 342	4 643	3 937	502	1 699	1 537	853	653	2.54	3.01	181	181	-
Massac County	14 407	5 908	4 234	3 470	605	1 674	1 578	889	702	2.44	2.94	345	334	11
Menard County	10 969	4 199	3 193	2 746	337	1 006	922	518	474	2.61	3.06	195	177	18
Mercer County	17 056	6 572	4 930	4 318	447	1 642	1 500	905	717	2.60	3.05	234	234	-
Monroe County	22 104	8 189	6 242	5 576	528	1 947	1 721	881	690	2.70	3.16	318	318	-
Montgomery County	29 024	11 480	8 264	7 024	923	3 216	2 963	1 873	1 467	2.53	3.05	1 704	1 669	35
Morgan County	33 397	13 678	9 283	7 725	1 201	4 395	3 910	1 918	1 555	2.44	3.02	3 000	1 595	1 405
Moultrie County	13 349	5 122	3 862	3 390	360	1 260	1 178	684	562	2.61	3.07	581	551	30
Ogle County	45 369	17 132	12 774	11 068	1 213	4 358	3 800	1 645	1 473	2.65	3.11	588	534	54
Peoria County	176 490	70 797	47 815	37 169	8 684	22 982	19 879	7 988	6 391	2.49	3.06	6 337	3 111	3 226
Perry County	21 098	8 306	6 019	5 041	756	2 287	2 121	1 257	1 024	2.54	3.06	314	275	39
Piatt County	15 309	5 934	4 500	3 984	383	1 434	1 288	690	587	2.58	3.02	239	225	14
Pike County	17 305	7 016	4 999	4 328	487	2 017	1 857	1 179	930	2.47	2.99	272	182	90
Pope County	3 953	1 611	1 158	1 008	117	453	424	232	164	2.45	2.95	420	216	204
Pulaski County	7 460	2 957	2 025	1 516	418	932	868	519	389	2.52	3.13	63	63	-
Putnam County	5 729	2 204	1 657	1 443	149	547	504	269	204	2.60	3.06	1	1	-
Randolph County	30 672	11 949	8 651	7 370	997	3 298	3 023	1 656	1 282	2.57	3.09	3 911	3 869	42
Richland County	16 216	6 503	4 674	3 967	529	1 829	1 692	897	752	2.49	3.00	329	242	87
[illegible]ock Island County	144 838	59 317	39 934	31 421	6 803	19 383	16 985	7 488	5 981	2.44	3.01	3 885	2 363	1 522
St. Clair County	258 243	95 333	68 748	49 626	15 646	26 585	23 229	9 809	7 713	2.71	3.24	4 609	3 167	1 442
[illegible]aline County	25 620	10 839	7 365	6 010	1 087	3 474	3 263	2 006	1 617	2.36	2.94	931	913	18
Sangamon County	175 573	72 146	47 543	37 408	8 118	24 603	21 218	8 159	6 695	2.43	3.04	2 813	1 902	911
Schuyler County	7 386	3 002	2 168	1 895	209	834	755	442	350	2.46	2.94	112	112	-
Scott County	5 586	2 190	1 609	1 366	185	581	532	325	268	2.55	3.04	58	58	-
Shelby County	22 050	8 563	6 435	5 660	521	2 128	1 941	1 224	968	2.58	3.03	211	196	15
Stark County	6 414	2 512	1 831	1 610	156	681	636	372	308	2.55	3.08	120	120	-
Stephenson County	47 368	18 920	13 296	11 240	1 574	5 624	4 922	2 405	1 930	2.50	3.03	684	641	43
Tazewell County	122 226	47 171	34 962	29 844	3 894	12 209	10 769	4 867	3 924	2.59	3.06	1 466	1 406	60

Table 6. Household, Family, and Group Quarters Characteristics: 1990—Con.

[For definitions of terms and meanings of symbols, see text]

State County Place and [In Selected States] County Subdivision	Persons in households	All households	Family households			Nonfamily households				Persons per		Persons in group quarters		
							Householder living alone							
								65 years and over						
			Total	Married-couple family	Female householder, no husband present	Total	Total	Total	Female	Household	Family	Total	Institutionalized persons	Other persons in group quarters
COUNTY—Con.														
Union County	16 608	6 838	4 854	4 114	550	1 984	1 847	1 051	842	2.43	2.95	1 011	864	147
Vermilion County	85 273	34 072	23 904	19 058	3 802	10 168	9 209	4 624	3 774	2.50	3.03	2 984	2 893	91
Wabash County	12 887	5 032	3 602	3 071	397	1 430	1 273	698	557	2.56	3.09	224	224	-
Warren County	18 358	7 393	5 177	4 368	622	2 216	2 031	1 103	878	2.48	3.03	823	268	555
Washington County	14 652	5 658	4 134	3 644	330	1 524	1 432	857	649	2.59	3.13	313	313	-
Wayne County	17 070	6 935	5 061	4 433	493	1 874	1 762	1 102	904	2.46	2.95	171	154	17
White County	16 150	6 845	4 811	4 137	501	2 034	1 915	1 137	928	2.36	2.87	372	326	46
Whiteside County	59 177	22 740	16 737	14 197	1 891	6 003	5 369	2 672	2 175	2.60	3.09	1 009	843	166
Will County	348 652	116 933	92 631	77 289	11 520	24 302	20 679	7 995	6 307	2.98	3.40	8 661	6 535	2 126
Williamson County	56 304	23 120	16 113	13 380	2 169	7 007	6 361	3 399	2 788	2.44	2.97	1 429	1 342	87
Winnebago County	248 483	96 727	68 691	55 702	10 524	28 036	23 721	9 208	7 275	2.57	3.08	4 430	3 003	1 427
Woodford County	31 703	11 395	8 951	7 984	686	2 444	2 217	1 202	954	2.78	3.21	950	540	410
PLACE AND COUNTY SUBDIVISION														
Abingdon city, Knox County	3 529	1 383	979	807	129	404	358	202	170	2.55	3.08	68	68	-
Addieville village, Washington County	257	107	76	60	10	31	28	19	13	2.40	2.91	-	-	-
Addison village, Du Page County	31 923	10 722	8 416	6 849	1 107	2 306	1 871	442	351	2.98	3.39	135	35	100
Adeline village, Ogle County	141	45	38	34	3	7	6	1	-	3.13	3.39	-	-	-
Albany village, Whiteside County	835	308	238	213	18	70	64	31	24	2.71	3.17	-	-	-
Albers village, Clinton County	700	233	180	163	16	53	49	28	20	3.00	3.57	-	-	-
Albion city, Edwards County	2 070	911	576	485	70	335	319	203	169	2.27	2.93	46	46	-
Aledo city, Mercer County	3 453	1 444	973	845	99	471	434	299	253	2.39	2.99	226	228	-
Alexis village	908	368	247	211	32	121	117	72	55	2.47	3.14	-	-	-
Mercer County	382	144	108	93	14	36	34	20	17	2.65	3.14	-	-	-
Warren County	526	224	139	118	18	85	83	52	38	2.35	3.14	-	-	-
Algonquin village	11 663	3 875	3 268	2 990	201	607	483	117	90	3.01	3.32	-	-	-
Kane County	1 469	453	407	389	14	46	36	4	4	3.24	3.46	-	-	-
McHenry County	10 194	3 422	2 861	2 601	187	561	447	113	86	2.98	3.29	-	-	-
Alhambra village, Madison County	557	224	166	143	17	58	55	38	31	2.49	2.98	152	152	-
Allendale village, Wabash County	476	181	134	116	14	47	45	24	20	2.63	3.15	-	-	-
Allenville village, Moultrie County	166	64	45	40	3	19	18	12	9	2.59	3.20	-	-	-
Allerton village	274	113	86	75	5	27	27	16	14	2.42	2.85	-	-	-
Champaign County	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vermilion County	274	113	86	75	5	27	27	16	14	2.42	2.85	-	-	-
Alma village, Marion County	388	157	103	75	26	54	51	34	28	2.47	3.07	-	-	
Alorton village, St. Clair County	2 956	886	701	233	410	185	154	42	26	3.34	3.69	4	-	
Alpha village, Henry County	753	314	227	192	28	87	86	45	39	2.40	2.92	-	-	
Alsey village, Scott County	253	104	75	66	5	29	27	21	17	2.43	2.96	-	-	
Alsip village, Cook County	18 187	6 716	4 787	3 809	737	1 929	1 611	525	419	2.71	3.28	40	-	40
Altamont city, Effingham County	2 201	867	616	497	97	251	234	126	97	2.54	3.10	95	95	-
Alton city, Madison County	32 074	12 969	8 463	6 016	2 002	4 506	3 951	1 979	1 618	2.47	3.10	831	655	176
Altona village, Knox County	559	213	154	136	16	59	54	26	22	2.62	3.19	-	-	-
Alto Pass village, Union County	417	157	122	97	18	35	32	24	18	2.66	3.07	-	-	-
Alvin village, Vermilion County	339	113	92	77	12	21	19	11	10	3.00	3.35	-	-	-
Amboy city, Lee County	2 302	901	599	483	83	302	275	151	125	2.55	3.22	75	75	-
Anchor village, McLean County	178	65	51	43	6	14	12	7	5	2.74	3.06	-	-	-
Andalusia village, Rock Island County	1 052	372	309	257	39	63	53	21	18	2.83	3.17	-	-	-
Andover village, Henry County	579	202	163	142	16	39	36	22	17	2.87	3.28	-	-	-
Anna city, Union County	4 457	2 131	1 285	1 006	231	846	813	492	417	2.09	2.75	348	290	58
Annawan town, Henry County	802	335	226	195	22	109	102	59	51	2.39	3.00	-	-	-
Antioch village, Lake County	6 096	2 234	1 617	1 285	250	617	503	243	195	2.73	3.24	9	-	9
Apple River village, Jo Daviess County	414	162	111	87	16	51	44	29	18	2.56	3.14	-	-	-
Arcola city, Douglas County	2 565	1 009	710	607	70	299	263	153	127	2.54	3.06	113	98	15
Arenzville village, Cass County	432	172	121	115	3	51	49	31	23	2.51	3.11	-	-	-
Argenta village, Macon County	940	354	284	246	32	70	68	39	31	2.66	3.02	-	-	-
Arlington village, Bureau County	200	81	54	43	8	27	27	14	12	2.47	3.07	-	-	-
Arlington Heights village, Cook County	74 326	28 810	20 644	18 272	1 789	8 166	6 836	2 412	2 026	2.58	3.11	1 134	1 057	77
Armington village, Tazewell County	348	140	102	89	8	38	36	25	20	2.49	2.99	-	-	-
Aroma Park village, Kankakee County	672	246	195	163	27	51	42	20	13	2.73	3.08	18	18	-
Arrowsmith village, McLean County	313	106	88	80	6	18	18	13	12	2.95	3.31	-	-	-
Arthur village	2 045	858	609	529	59	249	235	146	121	2.38	2.90	67	67	-
Douglas County	1 365	570	408	357	37	162	154	98	82	2.39	2.91	-	-	-
Moultrie County	680	288	201	172	22	87	81	48	39	2.36	2.89	67	67	-
Ashkum village, Iroquois County	650	259	187	166	15	72	67	50	39	2.51	3.03	-	-	-
Ashland village, Cass County	1 257	483	357	308	37	126	116	62	49	2.60	3.11	-	-	-
Ashley city, Washington County	583	247	158	125	21	89	87	58	47	2.36	3.04	-	-	-
Ashmore village, Coles County	800	300	224	195	23	76	68	35	24	2.67	3.14	-	-	-
Ashton village, Lee County	1 042	408	296	247	35	112	98	53	48	2.55	3.05	-	-	-
Assumption city, Christian County	1 244	535	353	298	46	182	173	116	99	2.33	2.95	-	-	-
Astoria village, Fulton County	1 153	493	319	265	40	174	161	110	90	2.34	2.94	52	52	-
Athens city, Menard County	1 404	552	393	329	53	159	143	84	74	2.54	3.09	-	-	-
Atkinson town, Henry County	950	403	275	243	24	128	123	77	62	2.36	2.92	-	-	-
Atlanta city, Logan County	1 616	629	457	377	66	172	160	97	81	2.57	3.10	-	-	-
Atwood village	1 253	505	377	314	51	128	115	59	51	2.48	2.92	-	-	-
Douglas County	602	243	177	143	26	66	60	24	21	2.48	2.98	-	-	-
Piatt County	651	262	200	171	25	62	55	35	30	2.48	2.87	-	-	-
Auburn city, Sangamon County	3 655	1 330	1 010	799	177	320	274	136	117	2.75	3.20	69	69	-
Augusta village, Hancock County	614	285	176	152	18	109	101	57	48	2.15	2.78	-	-	-
Aurora city	97 722	33 710	24 302	18 659	4 122	9 408	7 667	2 629	2 130	2.90	3.45	1 859	1 157	702
Du Page County	14 687	5 430	4 075	3 668	292	1 355	1 011	52	39	2.70	3.15	174	124	-
Kane County	83 035	28 280	20 227	14 991	3 830	8 053	6 656	2 577	2 091	2.94	3.51	1 735	1 033	702
[illegible]va city, Jackson County	674	289	190	165	18	99	92	61	47	2.33	2.95	-	-	
[illegible]viston village, Clinton County	842	301	231	200	20	70	67	40	28	2.80	3.32	82	69	
Avon village, Fulton County	957	379	253	205	36	126	120	65	50	2.53	3.19	-	-	
Baldwin village, Randolph County	426	158	125	96	21	33	32	21	19	2.70	3.10	-	-	-
Banner village, Fulton County	160	62	45	40	2	17	15	9	5	2.58	3.09	-	-	-
Bannockburn village, Lake County	921	301	271	259	7	30	21	4	1	3.06	3.22	467	-	467
Bardolph village, McDonough County	301	113	82	65	12	31	29	15	12	2.66	3.20	-	-	-
Barrington village	9 399	3 508	2 672	2 316	287	836	724	336	290	2.68	3.12	105	105	-
Cook County	5 054	1 989	1 441	1 219	185	548	471	221	193	2.54	3.03	105	105	-
Lake County	4 345	1 519	1 231	1 097	102	288	253	115	97	2.86	3.23	-	-	-

Toxicological Profile for

GREAT LAKES CONTAINER
CORP - ST LOUIS SITE
ESI REFERENCE 26
MOD086827359

BARIUM

U.S. DEPARTMENT OF HEALTH & HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry

TP-91/03

TOXICOLOGICAL PROFILE FOR
BARIUM AND COMPOUNDS

Prepared by:

Clement International Corporation
Under Contract No. 205-88-0608

Prepared for:

Agency for Toxic Substances and Disease Registry
U.S. Public Health Service

July 1992

1. PUBLIC HEALTH STATEMENT

This Statement was prepared to give you information about barium and to emphasize the human health effects that may result from exposure to it. The Environmental Protection Agency (EPA) has identified 1,177 sites on its National Priorities List (NPL). Barium has been found at 154 of these sites. However, we do not know how many of the 1,177 NPL sites have been evaluated for barium. As EPA evaluates more sites, the number of sites at which barium is found may change. The information is important for you because barium may cause harmful health effects and because these sites are potential or actual sources of human exposure to barium.

When a chemical 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 as a chemical emission. This emission, which is also called a release, does not always lead to exposure. You can be exposed to a chemical only when you come into contact with the chemical. You may be exposed to it in the environment by breathing, eating, or drinking substances containing the chemical or from skin contact with it.

If you are exposed to a hazardous substance such as barium, several factors will determine whether harmful health effects will occur and what the type and severity of those health effects will be. These factors include the dose (how much), the duration (how long), the route or pathway by which you are exposed (breathing, eating, drinking, or skin contact), the other chemicals to which you are exposed, and your individual characteristics such as age, sex, nutritional status, family traits, life style, and state of health.

1.1 WHAT IS BARIUM?

Barium is a silvery-white metal that occurs in nature in many different forms called compounds. These compounds are solids and they do not burn well. Two forms of barium, barium sulfate and barium carbonate, are often found in nature as underground ore deposits. Barium is sometimes found naturally in drinking water and food. Because certain forms of barium (barium sulfate and barium carbonate) do not mix well with water, the amount of barium usually found in drinking water is of a small quantity. Other barium compounds, such as barium chloride, barium nitrate, and barium hydroxide, are manufactured from barium sulfate. Barium compounds such as barium acetate, barium carbonate, barium chloride, barium hydroxide, barium nitrate, and barium sulfide dissolve more easily in water than barium sulfate and barium carbonate.

Barium and barium compounds are used for many important purposes. Barium sulfate ore is mined and used in several industries. It is used mostly by the oil and gas industries to make drilling muds. Drilling muds make it easier to drill through rock by keeping the drill bit lubricated. Barium sulfate is also used to make paints, bricks, tiles, glass, rubber, and other barium compounds. Some barium compounds, such as barium carbonate, barium chloride. and barium hydroxide, are used to make ceramics, insect and rat poisons, additives for oils and fuels, and many other useful products. Barium sulfate is sometimes used by doctors to perform medical tests and take x-ray photographs of the stomach and intestines.

The length of time that barium will last in the environment following release to air, land, and water depends on the form of barium released. Barium compounds that do not dissolve well in water, such as barium sulfate and barium carbonate, can last a long time in the environment. Barium compounds that dissolve easily in water usually do not last a long time in the environment. Barium that is dissolved in water quickly combines with sulfate or carbonate ions and becomes the longer lasting forms (barium sulfate and barium carbonate). Barium sulfate and barium carbonate are the forms of barium most commonly found in the soil and water. If barium sulfate and barium carbonate are released onto land, they will combine with particles of soil. More information on the chemical and physical properties, use, and environmental fate of barium is found in Chapters 3, 4, and 5.

1.2 HOW MIGHT I BE EXPOSED TO BARIUM?

Background levels of barium in the environment are very low. The air that most people breathe contains about 0.0015 parts of barium per billion parts of air (ppb). The air around factories that release barium compounds into the air has only abour 0.33 ppb or less of barium. Most surface water and public water supplies contain only about 0.38 parts of barium per million parts of water (ppm) or less. In some areas that have underground water wells, drinking water may contain more barium than the 1 ppm limit set by EPA. The highest amount measured from these water wells has been 10 ppm. The highest amount of barium found in soil is about 100 to 3,000 ppm. Some foods, such as Brazil nuts, seaweed, fish, and certain plants, may contain high amounts of barium. The amount of barium found in food and water usually is not high enough to be a health concern. However, information is still being collected to find out if long-term exposure to low levels of barium causes any health problems.

Barium waste may be released to air, land, and water during industrial operations. Barium is released into the air during the mining and processing of ore and during manufacturing operations. Some industries dump wastes containing barium compounds onto land or into the ocean and other bodies of water. Barium compounds are found in more than 150 hazardous waste sites in the United States. We do not know the exact number of hazardous waste sites containing barium because not all waste sites have been examined for barium.

People with the greatest known risk of exposure to high levels of barium are those working in industries that make or use barium compounds. Most of these exposed persons breathe air that contains barium sulfate or barium carbonate. Sometimes they are exposed to one of the more harmful forms of barium (for example, barium chloride or barium hydroxide) by breathing the dust from these compounds or by getting them on their skin. Many hazardous waste sites contain barium compounds, and these sites may be a source of exposure for people living and working near them. Exposure near hazardous waste sites may occur by breathing dust, eating soil or plants, or drinking water that is polluted with barium. People near these sites may also get soil or water that contains barium on their skin. More information on how you might be exposed to barium is found in Chapter 5.

1.3 HOW CAN BARIUM ENTER AND LEAVE MY BODY?

Barium enters your body when you breathe air, eat food, or drink water containing barium. It may also enter your body to a small extent when you have direct skin contact with barium compounds. Barium that you breathe seems to enter the bloodstream very easily. Barium does not seem to enter the bloodstream as well from the stomach or intestines. How much barium actually gets into your bloodstream depends on how much barium you breathe, eat, or drink and how easily the form of barium you breathe dissolves in the fluids in your body. Some barium compounds (for example, barium chloride) can enter your body through your skin, but this is very rare and usually occurs in industrial accidents at factories where they make or use barium compounds. Barium at hazardous waste sites may enter your body if you breathe dust, eat soil or plants, or drink water polluted with barium. Barium can also enter your body if polluted soil or water touches your skin.

Barium that enters your body by breathing, eating, or drinking is removed mainly in feces and urine. Most of the barium that enters your body is removed within a few days, and almost all of it is gone within 1-2 weeks. Most barium that stays in your body goes into the bones and teeth. We do not know the long-term health effects of the barium that stays in your body. More information on how barium enters and leaves your body is found in Chapter 2.

1.4 HOW CAN BARIUM AFFECT MY HEALTH?

The health effects of the different barium compounds depend on how well the specific barium compound dissolves in water. For example, barium sulfate does not dissolve well in water and has few adverse health effects. Doctors sometimes give barium sulfate orally or by placing it directly in the rectum of patients for purposes of making x-rays of the stomach or intestines. The use of this particular barium compound in this type of medical test is not harmful to people. Barium compounds such as barium acetate, barium carbonate, barium chloride, barium hydroxide, barium nitrate, and barium sulfide that dissolve in water can cause adverse health effects. Most of what we know comes from studies in which a small number of individuals were exposed to fairly large amounts of barium for short periods. Eating or drinking very large amounts of barium compounds that dissolve in water may cause paralysis or death in a few individuals. Some people who eat or drink somewhat smaller amounts of barium for a short period may potentially have difficulties in breathing, increased blood pressure, changes in heart rhythm, stomach

UPDATE
UPDATE
UPDATE

Toxicological Profile for

GREAT LAKES CONTAINER
CORP - ST LOUIS SITE
ESI REFERENCE 27
MOD086827359

CADMIUM

U.S. DEPARTMENT OF HEALTH & HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry

TP-92/06

TOXICOLOGICAL PROFILE FOR CADMIUM

Prepared by:

Life Systems, Inc.
Under Subcontract to:

Clement International Corporation
Under Contract No. 205-88-0608

Prepared for:

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry

April 1993

1. PUBLIC HEALTH STATEMENT

This Statement was prepared to give you information about cadmium and to emphasize the human health effects that may result from exposure to it. The Environmental Protection Agency (EPA) has identified 1,300 sites on its National Priorities List (NPL). Cadmium has been found in at least 388 of these sites. However, we do not know how many of the 1,300 NPL sites have been evaluated for cadmium. As EPA evaluates more sites, the number of sites at which cadmium is found may change. This information is important for you to know because cadmium may cause harmful health effects and because these sites are potential or actual sources of human exposure to cadmium.

When a chemical 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 as a chemical emission. This emission, which is also called a release, does not always lead to exposure. You can be exposed to a chemical only when you come into contact with the chemical. You may be exposed to it in the environment by breathing, eating, or drinking substances containing the chemical or from skin contact with it.

If you are exposed to a hazardous chemical such as cadmium, several factors will determine whether harmful health effects will occur and what the type and severity of those health effects will be. These factors include the dose (how much), the duration (how long), the route or pathway by which you are exposed (breathing, eating, drinking, or skin contact), the other chemicals to which you are exposed, and your individual characteristics such as age, sex, nutritional status, family traits, life style, and state of health.

1.1 WHAT IS CADMIUM?

Cadmium is an element that occurs naturally in the earth's crust. Pure cadmium is a soft, silver-white metal; however, cadmium is not usually found in the environment as a metal. It is usually found as a mineral combined with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfate, cadmium sulfide). These compounds are solids that may dissolve in water but do not evaporate or disappear from the environment. All soils and rocks, including coal and mineral fertilizers, have some cadmium in them. Cadmium is often found as part of small particles present in air. You cannot tell by smell or taste that cadmium is present in air or water, because it does not have any definite taste or odor.

Most cadmium used in this country is extracted during the production of other metals such as zinc, lead, or copper. Cadmium has many uses in industry and consumer products, mainly batteries, pigments, metal coatings, and plastics.

More information on the properties and uses of cadmium may be found in Chapters 3 and 4.

1.2 WHAT HAPPENS TO CADMIUM WHEN IT ENTERS THE ENVIRONMENT?

Cadmium can enter the environment in several ways. It can enter the air from the burning of coal and household waste, and metal mining and refining processes. It can enter water from disposal of waste water from households or industries. Fertilizers often have some cadmium in them and fertilizer use causes cadmium to enter the soil. Spills and leaks from hazardous waste sites can also cause cadmium to enter soil or water. Cadmium attached to small particles may get into the air and travel a long way before coming down to earth as dust or in rain or snow. Cadmium does not break down in the environment but can change into different forms. Most cadmium stays where it enters the environment for a long time. Some of the cadmium that enters water will bind to soil but some will remain in the water. Cadmium in soil can enter water or be taken up by plants. Fish, plants, and animals take up cadmium from the environment.

More information on how cadmium behaves in the environment may be found in Chapters 4 and 5.

1.3 HOW MIGHT I BE EXPOSED TO CADMIUM?

Food and cigarette smoke are the largest potential sources of cadmium exposure for members of the general population. Average cadmium levels in U.S. foods range from 2 to 40 parts of cadmium per billion parts of food (ppb) (1,000 ppb equals one part per million). Average cadmium levels in cigarettes range from 1,000 to 3,000 ppb. Air levels in U.S. cities are low, ranging from 5 to 40 nanograms per cubic meter (ng/m^3) (one million ng/m^3 equals one milligram per cubic meter). The level of cadmium in most drinking water supplies is less than 1 ppb. In the United States, the average person eats food with about 30 micrograms (μg) of cadmium in it each day. About 1-3 μg per day of cadmium is absorbed from food, and smokers absorb an additional 1-3 μg per day from cigarettes. Smoke from other people's cigarettes probably does not cause nonsmokers to take in much cadmium. Cadmium is found at hazardous waste sites at average concentrations of about 4 ppb in soil and 5 ppb in water. Workers can be exposed to cadmium in air from making cadmium products such as batteries or paints. Workers can also be exposed from working with metal by soldering or welding. Each year almost 90,000 workers are exposed to cadmium in the United States.

More information on how you might be exposed to cadmium is given in Chapter 5.

1.4 HOW CAN CADMIUM ENTER AND LEAVE MY BODY?

Cadmium can enter your body from food you eat, water you drink, or particles you breathe in. Very little cadmium enters through your skin. Your body rapidly takes in about one-quarter of the cadmium you breathe, and about one-twentieth of the cadmium you eat. The rest of the cadmium is breathed out or excreted in feces. If you do not eat foods that contain enough iron or other nutrients, you are likely to take up more cadmium from your food than usual. Cigarette smoke has cadmium in it and so smokers breathe in cadmium. Other people who breathe in cadmium are people who work with cadmium, and people who live near hazardous waste sites or factories that release cadmium into the air. The general population and people living near hazardous waste sites may eat or drink cadmium in food, dust, or water.

Cadmium that enters your body stays in your liver and kidneys. Cadmium leaves your body slowly, in urine and feces. Your body keeps most cadmium in a form that is not harmful, but too much cadmium can overload your kidneys' storage system and cause health damage.

More information on how cadmium enters and leaves the body is given in Chapter 2.

1.5 HOW CAN CADMIUM AFFECT MY HEALTH?

Cadmium has no known good effects on your health. Breathing air with very high levels of cadmium severely damages the lungs and can cause death. Breathing lower levels for years leads to a build-up of cadmium in the kidneys that can cause kidney disease. Other effects that may occur after breathing cadmium for a long time are lung damage and fragile bones. Workers who inhale cadmium for a long time may have an increased chance of getting lung cancer. No proof has been found that mice or hamsters that breathe in cadmium get lung cancer. However, some rats that breathe in cadmium do develop lung cancer. We do not know if breathing cadmium can affect your ability to have children or can harm unborn babies. Female rats and mice that breathe high levels of cadmium have fewer litters and the pups may have more birth defects than usual. Breathing cadmium causes liver damage and changes in the immune system in rats and mice. We do not know if breathing cadmium harms the liver, heart, nervous system, or immune system in humans.

Eating food or drinking water with very high cadmium levels severely irritates the stomach, leading to vomiting and diarrhea. The only people who have died from drinking cadmium are people who used cadmium to commit suicide. Eating lower levels of cadmium over a long period of time leads to a build-up of cadmium in the kidneys. This cadmium build-up causes kidney damage, and also causes bones to become fragile and break easily. We know that if female rats or mice eat or drink cadmium, their litters may be harmed. We do not know if eating cadmium affects your ability to have children or harms unborn babies. Animals eating or drinking cadmium sometimes get high blood pressure, iron poor blood, liver disease, and nerve or brain damage. We do not know if humans eating or drinking cadmium get any of these diseases. Studies of humans or animals that eat or drink cadmium have not found increases in cancer. These studies were not strong enough to show that eating or drinking cadmium definitely does not cause cancer. The Department of Health and Human Services has determined that cadmium and cadmium compounds may reasonably be anticipated to be carcinogens. The International Agency for Research on Cancer has determined that cadmium is probably carcinogenic to humans. The EPA has determined that cadmium is a probable human carcinogen by inhalation. Skin contact with cadmium is not known to cause health effects in humans or animals.

More information on how cadmium can affect your health is given in Chapter 2.

1.6 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO CADMIUM?

You may be tested for exposure to cadmium in several ways. The amount of cadmium in your blood, urine, hair, or nails may be measured in some medical laboratories. The amount of cadmium in your blood shows your recent exposure to cadmium. The amount in your urine shows both your recent and your past exposure. It is not known how reliable cadmium levels are in hair or nails. Tests are also available to measure the amount of cadmium inside your liver or kidneys. The results of these tests can help a doctor evaluate your risk of kidney disease. However, these tests are too costly and inconvenient for routine use. Your urine can be tested to see if your kidneys are damaged. These tests do not prove that cadmium caused the kidney disease.

More information on how cadmium can be measured in exposed humans is presented in Chapters 2 and 6.

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

The government has taken steps to protect humans from excessive cadmium exposure. The EPA now allows 10 ppb of cadmium in drinking water, and plans to reduce the limit to 5 ppb. The EPA limits how much cadmium can be put into lakes, rivers, dumps, and cropland. The EPA does not allow cadmium in pesticides. The Food and Drug Administration (FDA) limits the amount of cadmium in food colors to 15 ppm.

EAT LAKES CONTAINER
ORP - ST LOUIS SITE
ESI REFERENCE 28
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TOXICOLOGICAL PROFILE FOR CHROMIUM

Prepared by:

Syracuse Research Corporation
Under Subcontract to:

Clement International Corporation
Under Contract No. 205-88-0608

Prepared for:

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry

April 1993

CONTENTS

1. PUBLIC HEALTH STATEMENT

This Statement was prepared to give you information about chromium and to emphasize the human health effects that may result from exposure to it. The Environmental Protection Agency (EPA) has identified 1,300 sites on its National Priorities List (NPL). Chromium in its oxidized form has been found in at least 115 of these sites. However, we do not know how many of the 1,300 NPL sites have been evaluated for hexavalent chromium. As EPA evaluates more sites, the number of sites at which hexavalent chromium is found may change. This information is important for you to know because the hexavalent form of chromium may cause harmful health effects and because these sites are potential or actual sources of human exposure to hexavalent chromium.

When a chemical 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 as a chemical emission. This emission, which is also called a release, does not always lead to exposure. You can be exposed to a chemical only when you come into contact with the chemical. You may be exposed to it in the environment by breathing, eating, or drinking substances containing the chemical or from skin contact with it.

If you are exposed to chromium or chromium compounds, several factors will determine whether harmful health effects will occur and what the type and severity of those health effects will be. These factors include the dose (how much), the duration (how long), the route or pathway by which you are exposed (breathing, eating, drinking, or skin contact), the other chemicals to which you are exposed, and your individual characteristics such as age, sex, nutritional status, family traits, lifestyle, and state of health.

1.1 WHAT IS CHROMIUM?

Chromium is a naturally occurring element found in rocks, animals, plants, soil, and in volcanic dust and gases. Chromium is present in the environment in several different forms. The most common forms are chromium(0), trivalent [or chromium(III)], and hexavalent [or chromium(VI)]. Chromium(III) occurs naturally in the environment and is an essential nutrient required by the human body to promote the action of insulin in body tissues so that sugar, protein, and fat can be used by the body. Chromium(VI) and chromium(0) are generally produced by industrial processes. No known taste or odor is associated with chromium compounds. The metal chromium, which is the chromium(0) form, is a steel-gray solid with a high melting point. It is used mainly for making steel and other alloys. The naturally occurring mineral chromite in the chromium(III) form is used as brick lining for high-temperature industrial furnaces, for making metals and alloys (mixtures of metals), and chemical compounds. Chromium compounds, mostly in chromium(III) or chromium(VI) forms, produced by the chemical industry are used for chrome plating, the manufacture of dyes and pigments, leather tanning, and wood preserving. Smaller amounts are used in drilling muds, rust and corrosion inhibitors, textiles, and toner for copying machines. For more information on the physical and chemical properties and on the production and use of chromium, see Chapters 3 and 4.

1.2 WHAT HAPPENS TO CHROMIUM WHEN IT ENTERS THE ENVIRONMENT?

Chromium enters the air, water, and soil mostly in the chromium(III) and chromium(VI) forms as a result of natural processes and human activities. Emissions from burning coal and oil, and steel production can increase chromium(III) levels in air. Stainless steel welding, chemical manufacturing, and use of compounds containing chromium(VI) can increase chromium(VI) levels in air. Waste streams from electroplating can discharge chromium(VI). Leather tanning and textile industries as well as those that make dyes and pigments can discharge both chromium(III) and chromium(VI) into waterways. The levels of both chromium(III) and chromium(VI) in soil increase mainly from disposal of commercial products containing chromium, chromium waste from industry, and coal ash from electric utilities.

In air, chromium compounds are present mostly as fine dust particles. This dust eventually settles over land and water. Rain and snow help remove chromium from air. Chromium compounds will usually remain in the air for less than 10 days. Although most of the chromium in water binds to dirt and other materials and settles to the bottom, a small amount may dissolve in the water. Soluble chromium compounds can remain in water for years before settling to the bottom. Fish do not accumulate much chromium in their bodies from water. Most of the chromium in soil does not dissolve easily in water and can attach strongly to the soil. A very small amount of the chromium in soil, however, will dissolve in water and can move deeper in the soil to underground water. The movement of chromium in soil depends on the type and condition of the soil and other environmental factors. For more information about the fate and movement of chromium compounds in the environment, see Chapters 4 and 5.

1.3 HOW MIGHT I BE EXPOSED TO CHROMIUM?

You can be exposed to chromium by breathing air, drinking water, or eating food containing chromium or through skin contact with chromium or chromium compounds. The level of chromium in air and water is generally low. The concentration of total chromium in air [both chromium(III) and chromium(VI)] generally ranges between 0.01 and 0.03 microgram (μg) (1 μg equals 1/1,000,000 of a gram) per cubic meter of air (μg/m^3). Chromium concentrations in drinking water [mostly as chromium(III)] are generally very low, less than 2 parts of chromium in a billion parts of water (2 ppb). Contaminated well water may contain chromium(VI). For the general population, eating foods that contain chromium is the most likely route of chromium exposure. Chromium(III) occurs naturally in many fresh vegetables, fruits, meat, yeast, and grain. Various methods of processing, storage, and preparation can alter the chromium content of food. Acidic foods in contact with stainless steel cans or cooking utensils might contain higher levels of chromium because of leaching from stainless steel. Refining processes used to make white bread or sugar can decrease chromium levels. Chromium(III) is an essential nutrient for humans. On the average, adults in the United States take in an estimated 60 µg of chromium daily from food. You may also be exposed to chromium from using consumer products such as household utensils, wood preservatives, cement, cleaning products, textiles, and tanned leather.

People who work in industries that process or use chromium or chromium compounds can be exposed to higher-than-normal levels of chromium. An estimated 305,000 workers in the United States are potentially exposed to chromium and chromium-containing compounds in the workplace.

Occupational sources of chromium exposure (with chemical forms of interest shown in parentheses) may occur in the following industries:

- Stainless steel welding [chromium(VI)]
- Chromate production [chromium(VI)]
- Chrome plating [chromium(VI)]
- Ferrochrome industry [chromium(III) and chromium(VI)]
- Chrome pigments [chromium(III) and chromium(VI)]
- Leather tanning [mostly chromium(III)]

Examples of other occupations that may involve chromium exposure include:

- Painters [chromium(III) and chromium(VI)]
- Workers involved in the maintenance and servicing of copying machines, and the disposal of some toner powders from copying machines [chromium(VI)]
- Battery makers [chromium(VI)]
- Candle makers [chromium(III) and chromium(VI)]
- Dye makers [chromium(III)]
- Printers [chromium(III) and chromium(VI)]
- Rubber makers [chromium(III) and chromium(VI)]
- Cement workers [chromium(III) and chromium(VI)]

A list of other industries that may be sources of occupational exposure is given in Section 5.5.

You may be exposed to higher-than-normal levels of chromium if you live near the following:

- Landfill sites with chromium-containing wastes
- Industrial facilities that manufacture or use chromium and chromium-containing compounds
- Cement-producing plants, because cement contains chromium
- Industrial cooling towers that use chromium as rust inhibitors
- Waterways that receive industrial discharges from electroplating, leather tanning, and textile industries
- Busy roadways, because emissions from automobile brake lining and catalytic converters contain chromium

In addition, you may be exposed to higher levels of chromium if you use tobacco products, since tobacco contains chromium. For additional information about chromium exposure, see Chapter 5.

1.4 HOW CAN CHROMIUM ENTER AND LEAVE MY BODY?

Chromium can enter your body when you breathe air, eat food, or drink water containing chromium. Chromium(VI) enters the body more easily than chromium(III), but once inside the body, chromium(VI) is changed to chromium(III). When you breathe air containing chromium, chromium particles can be deposited in the lungs. Particles that are deposited in the upper part of the lungs are likely to be coughed up and swallowed. Particles deposited deep in the lungs are likely to remain long enough for some of the chromium to pass through the lining of the lungs and enter your bloodstream. Once in the bloodstream, chromium is distributed to all parts of the body, then will pass through the kidneys, and be eliminated in the urine within a few days. Everyone normally eats or drinks a small amount of chromium daily. Most of the chromium that you swallow leaves your body within a few days through the feces and never enters your blood. A small amount (about 0.4% to 2.1%) will pass through the lining of the intestines and enter the bloodstream. Once in the bloodstream, chromium is distributed to all parts of the body where it is used to carry out essential functions. Chromium will then pass through the kidneys and be eliminated in the urine in a few days. Chromium(III) present in food can attach to other compounds that make it easier for chromium to enter your bloodstream from your stomach and intestines. This form of chromium is used by your body to carry out essential body functions. If your skin comes into contact with chromium, very little will enter your body unless your skin is damaged. For more information, please read Chapter 2.

GREAT LAKES CONTAINER
CORP - ST LOUIS SITE
ESI REFERENCE 29
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TOXICOLOGICAL PROFILE FOR LEAD

Prepared by:

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
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1. PUBLIC HEALTH STATEMENT

This Statement was prepared to give you information about lead and to emphasize the human health effects that may result from exposure to it. The Environmental Protection Agency (EPA) has identified 1,300 sites on its National Priorities List (NPL). Lead has been found in at least 922 of these sites. However, we do not know how many of the 1,300 NPL sites have been evaluated for lead. As EPA evaluates more sites, the number of sites at which lead is found may change. This information is important for you to know because lead may cause harmful health effects and because these sites are potential or actual sources of human exposure to lead.

When a chemical 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 as a chemical emission. This emission, which is also called a release, does not always lead to exposure. You can be exposed to a chemical only when you come into contact with the chemical. You may be exposed to it in the environment by breathing, eating, or drinking substances containing the chemical or from skin contact with it.

If you are exposed to a hazardous chemical such as lead, several factors will determine whether harmful health effects will occur and what the type and severity of those health effects will be. These factors include the dose (how much), the duration (how long), the route or pathway by which you are exposed (breathing, eating, drinking, or skin contact), the other chemicals to which you are exposed, and your individual characteristics such as age, sex, nutritional status, family traits, life style, and state of health.

1.1 WHAT IS LEAD?

Lead is a naturally occurring bluish-gray metal found in small amounts in the earth's crust. It has no characteristic taste or smell. Metallic lead does not dissolve in water and does not burn. Some natural and man-made substances contain lead, but do not look like lead in its metallic form. Some of these substances can burn.

Lead has many different uses. Its most important use is in the production of some types of batteries. Other uses include the production of ammunition, in some kinds of metal products (such as sheet lead, solder, and pipes) and in ceramic glazes. Some chemicals containing lead, such as tetraethyl lead and tetramethyl lead, are used as gasoline additives. However, the use of these lead-containing chemicals in gasoline is much less than it used to be because the last producer of these additives in the United States stopped making them in early 1991. Other chemicals containing lead are used in paint. The amount of lead added to paints and ceramic products, caulking, gasoline additives, and solder has also been reduced in recent years because of lead's harmful effects in humans and animals. However, the use of lead in ammunition and roofing has actually increased in recent years. Lead is also used for radiation shields for protection against X-rays and in a large variety of medical (electronic ceramic parts of ultrasound machines, intravenous pumps, fetal monitors, and other surgical equipment), scientific (circuit boards for computers and other electronic circuitry), and military equipment (jet turbine engine blades, military tracking systems).

Most lead used by industry comes from mined ores ("primary") or from recycled scrap metal or batteries ("secondary"). Human activities (such as use of "leaded" gasoline) have spread lead and substances that contain lead to all parts of the environment. For example, lead is in air, drinking water, rivers, lakes, oceans, dust, and soil. Lead is also in plants and animals that humans may eat. Please see Chapter 3 for more information on the physical and chemical properties of lead. Chapter 4 contains more information on the production and use of lead.

1.2 WHAT HAPPENS TO LEAD WHEN IT ENTERS THE ENVIRONMENT?

Lead occurs naturally in the environment. However, most of the lead dispersed throughout the environment comes from human activities. Before the use of leaded gasoline was limited, most of the lead released into the U.S. environment came from car exhaust. Since the EPA has limited the use of leaded gasoline, the amount of lead released into the air has decreased. In 1979, cars released 94.6 million kilograms (kg) of lead into the air in the United States. In contrast, in 1989 cars released only 2.2 million kg to the air. Other sources of lead released to the air include burning fuel, such as coal or oil, industrial processes, and burning solid waste.

The release of lead to air is now less than the release of lead to soil. Most of the lead in inner city soils comes from landfills and leaded paint. Landfills contain waste from lead ore mining, ammunition manufacturing, and from other industrial activities such as battery production. Very little lead goes directly into water.

Higher levels of lead from car exhausts can be measured near roadways. Very low levels of lead from car exhausts are found at distances of 25 meters (about 80 feet) from the road edge. However, once lead goes into the atmosphere, it may travel thousands of miles if the lead particles are small or if the lead compounds are volatile. Lead is removed from the air by rain as well as by particles falling to the ground or into surface water. Once lead deposits on soil, it usually sticks to soil particles. Small amounts of lead may enter rivers, lakes, and streams when soil particles are displaced by rainwater. Lead may remain stuck to soil particles in water for many years. Movement of lead from soil particles into underground water or drinking water is unlikely unless the water is acidic or "soft."

Some of the chemicals that contain lead are broken down by sunlight, air, and water to other forms of lead. Lead compounds in water may combine with different chemicals depending on the acidity and temperature of the water. The lead atom cannot be broken down.

The levels of lead may build up in plants and animals from areas where air, water, or soil are contaminated with lead. If animals eat contaminated plants or animals, most of the lead that they eat will pass through their bodies. It is the small amount absorbed that can cause harmful effects. Chapters 4 and 5 contain more information on the environmental fate of lead.

1.3 HOW MIGHT I BE EXPOSED TO LEAD?

People living near hazardous waste sites can be exposed to lead and chemicals that contain lead by breathing air, drinking water, eating foods, or swallowing or touching dust or dirt that contains lead. For people who do not live near hazardous waste sites, most exposure to lead occurs by eating foods that contain lead, occupationally in brass/bronze foundries, or in areas where leaded paints exist. Foods such as fruits, vegetables, meats, grains, seafood, soft drinks, and wine may have lead in them. Cigarettes also contain small amounts of lead. In general, very little lead is in drinking water. More than 99% of all drinking water contains less than 0.005 part of lead per million parts of water (ppm). However, the amount of lead taken into your body through drinking water can be higher in communities with acidic water supplies. Acidic water can make the lead found in lead pipes, solder, and brass faucets enter water. Eating lead-based paint chips or dust is another way you can be exposed to lead. These two latter routes are particularly relevant to children in lower-income urbanized populations. For occupationally exposed individuals, the predominant route of exposure is the inhalation of lead particles.

Exposure to gasoline additives that contain lead can happen while you are pumping leaded gasoline, from sniffing leaded gasoline, and possibly during the use of some do-it-yourself fuel additives. For people who are exposed to lead at work, the largest source of exposure comes from breathing air that contains lead. Breathing or swallowing dust and dirt that has lead in it is another way you can be exposed to lead. Children, especially those who are preschool age, can have a lot of lead exposure because they put many things into their mouths. Their hands, toys, and other items may have lead-containing dirt on them. In some cases, children swallow nonfood items such as paint chips and dirt ("pica"). These items may contain very large amounts of lead, particularly in and around older houses that were painted with lead-based paint. The paint in these houses often chips off and mixes with dust and dirt. Some old paint (when it is dry) is 5-40% lead. Skin contact with dust and dirt containing lead occurs every day. However, not much lead can get into your body through your skin. During normal use of lead-containing products, very little lead gets on your skin.

The burning of gasoline has been the single largest source (90%) of lead in the atmosphere since the 1920s. A lot less lead in the air comes from gasoline now because EPA reduced the amount of lead that can be used in gasoline. Less than 35% of the lead released to the air now comes from gasoline. Other sources of lead in the air include releases to the air from industries involved in iron and steel production, lead-acid-battery manufacturing, brass foundries, and manufacturing of tetraethyl and tetramethyl lead, the latter two being very volatile. Lead released into air may also come from burning of solid waste, windblown dust, volcanoes, exhaust from workroom air, burning or weathering of lead-painted surfaces, and cigarette smoke.

Sources of lead in drinking water include lead that can come out of lead pipes, faucets, and solder used in plumbing. Lead-containing plumbing may be found in public drinking water systems, in houses, apartment buildings, and public buildings. Sources of lead in surface water or sediment include deposits of lead-containing dust from the atmosphere, waste water from industries that handle lead (primarily iron and steel industries and lead producers), and urban runoff..

Sources of lead in food and beverages include deposition of lead-containing dust from the atmosphere on crops and during food processing and uptake of lead from soil by plants. Lead may also enter foods when foods are put into improperly glazed pottery and ceramic dishes and leaded-crystal glassware. Illegal whiskey made using stills that contain lead-soldered parts (such as truck radiators) may also contain lead. The potential for exposure to lead in canned food from lead-soldered containers is greatly reduced because the content of lead in canned foods has decreased 87% from 1980 to 1988. Lead may also be released from soldered joints in kettles used to boil water for beverages.

Sources of lead in dust and soil include deposition of atmospheric lead and weathering and deterioration of lead-based paint. Lead in dust may also come from windblown soil. Disposal of lead in municipal and hazardous waste dump sites also adds lead to soil.

Exposure to lead occurs in many jobs. People employed in lead smelting and refining industries, brass/bronze foundries, rubber products and plastics industries, soldering, steel welding and cutting operations, battery manufacturing plants, and alkyl lead manufacturing industries may be exposed to lead. People who work at gasoline stations, in construction work, and at do-it-yourself renovations, or who work at municipal waste incinerators, pottery and ceramics industries, radiator repair shops, and other industries that use lead solder may also be exposed. Between 0.5 and 1.5 million workers are exposed to lead in the workplace; in California alone over 200,000 workers are exposed to lead. Families of workers may be exposed to elevated levels of lead when workers bring home lead dust on their work clothes. You may also be exposed to lead in the home if you work with stained glass as a hobby, or if you are involved in home renovation that involves the removal of old lead-based paint. Chapter 5 contains further information on sources of exposure to lead.

1.4 HOW CAN LEAD ENTER AND LEAVE MY BODY?

Some of the lead that enters your body comes from breathing in lead dust or chemicals that contain lead. Once this lead gets into your lungs, it goes quickly to other parts of the body in your blood.

You may swallow a lot of lead by eating food and drinking liquids that contain it. Most of the lead that enters your body comes through swallowing, even though very little of the amount you swallow actually enters your blood and other parts of your body. The amount that gets into your body from your stomach partially depends on when you ate your last meal. It also depends on how old you are and how well the lead particles you ate dissolved in your stomach juices. Experiments in adult volunteers showed that the amount of lead that got into the body from the stomach was only about 6% in adults who had just eaten. In adults who had not eaten for a day, about 60–80% of the lead from the stomach got into their blood. On the other hand, 50% of the lead swallowed by children enters the blood and other body parts even if their stomachs are full.

Frequent skin contact with lead in the form of lead-containing dusts and soil can result in children swallowing lead through hand-to-mouth behavior. In adults, only a small portion of the lead will pass through your skin and enter your body if it is not washed off after skin contact. More lead can pass through your skin if it is damaged. Certain types of lead compounds, however, may penetrate your skin.

Shortly after lead gets into your body, lead travels in the blood to the "soft tissues," (such as the liver, kidneys, lungs, brain, spleen, muscles, and heart). After several weeks most of the lead then moves into your bones and teeth. In adults, about 94% of the total amount of lead in the body is contained in their bones and teeth. Children, on the other hand, have only about 73% of the lead in their bodies stored in their bones. The rest is in their soft tissues and blood. Part of the lead can stay in your bones for decades. Part of the lead can leave your bones and may reenter your blood and organs at a later time.

Your body does not change lead atoms into any other form. Once it is taken in and distributed to your organs, the lead that is not stored in your bones leaves your body in your urine or your feces. About 99% of the amount of lead that you take into your body will leave in your waste within a couple of weeks, but only about 32% of the lead taken into the body of children will leave in the waste. For more information on how lead can enter and leave your body, please refer to Chapter 2.

1.5 HOW CAN LEAD AFFECT MY HEALTH?

Exposure to lead can be particularly dangerous for unborn children because of their great sensitivity during development. Exposure to lead can also be dangerous for young children because they swallow more lead through normal mouthing activity, take more of the lead that they swallow into their bodies, and are more sensitive to its effects. Unborn children can be exposed to lead through their mothers. This may cause premature births, smaller babies, and decreased mental ability in the infant. Lead exposure may also decrease intelligence quotient (IQ) scores and reduce the growth of young children. These effects have been seen more often following exposure to high levels of lead, than following exposure to low levels of lead.

In adults, lead exposure may decrease reaction time and possibly affect the memory. Lead exposure may also cause weakness in your fingers, wrists, or ankles. Lead exposur may increase blood pressure in middle-aged men. It is not known whether lead has an effect on blood pressure in women. Lead exposure may also cause anemia, a disorder of the blood. The connection between the occurrence of these effects and low lead exposures is not certain. At high levels of exposure, lead can severely damage the brain and kidneys in adults or children. In addition, high levels of exposure to lead may cause abortion and damage the male reproductive system (the organs responsible for sperm production). The effects of lead are the same regardless of whether it enters the body through breathing or swallowing.

Kidney tumors have developed in rats and mice given large doses of lead. We have no proof that lead causes cancer in humans. Furthermore, the animal studies have been criticized by a panel of EPA scientists because of the very high doses used, among other things, and should not be used to predict what may happen in humans. The Department of Health and Human Services has determined that lead acetate and lead phosphate may reasonably be anticipated to be carcinogens based on these studies in animals, but that there is inadequate evidence for the carcinogenicity of these lead compounds in humans. Please see Chapter 2 for more information on the health effects of lead.

1.6 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO LEAD?

The amount of lead in the blood can be measured to determine if exposure to lead ha. occurred. This test can give a rough measure of how much lead one has been exposed to. Methods to measure lead in teeth or bones by X-ray techniques, although not widely accessible, also are available. Exposure to lead in the blood can be evaluated by measuring erythrocyte protoporphyrin (EP). EP is a part of red blood cells known to increase when the amount of lead in the blood is high. This method is commonly used to screen children for potential chronic lead poisoning. The Centers for Disease Control and Prevention (CDC) considers children to have an elevated level if the amount of lead in the blood is at least 10 micrograms per deciliter (μg/dL). Medical treatment to lower blood levels has been done if the lead concentrations in blood are higher than 55 μg/dL in children or higher than 70 μg/dL in adults. For more information on tests to measure lead in the body, see Chapters 2 and 6.

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

The CDC recommends that all children should be screened for lead poisoning at least once a year. This is especially important for children between the ages of 6 months and 6 years. A child with an EP level of 35 μg/dL or greater should be tested for blood lead level. A child with a blood lead level of 20 μg/dL or greater should be tested by their doctors for symptoms of lead poisoning.

EPA requires that the concentration of lead in air that the public breathes shall not exceed 1.5 micrograms per cubic meter ($\mu g/m^3$) averaged over 3 months. EPA regulations now limit the level of lead in leaded gasoline to 0.1 grams per gallon (0.1 g/gal) and the level in unleaded gasoline to 0.05 g/gal. According to the Clean Air Act Amendments (CAAA) of 1990, the sale of leaded gasoline will be illegal as of December 31, 1995.

EPA regulations also limit lead in drinking water to 0.015 milligrams per liter (mg/L). The Consumer Product Safety Commission (CPSC), EPA, and the states are required by the 1988 Lead Contamination Control Act to deal with the problem of lead in drinking water coolers by requiring that water coolers containing lead be recalled or repaired and that new coolers be lead-free. In addition, drinking water in schools must be tested for lead and the sources of lead in this water must be removed.

To help protect small children, the CPSC requires that the concentration of lead in most paints available through normal consumer channels be not more than 0.06%. The CDC recommends that inside and outside painted surfaces of dwellings be tested for lead, and that surfaces containing lead equal to or greater than 0.7 milligram per square centimeter (mg/cm^2) of surface area be stripped and repainted according to a four-step paint removal and replacement protocol. This is necessary because stripping can release fine particles of lead that can cause lead poisoning.

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- Toxicological Profile 9.3MB

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June 1999

ToxFAQs™ for Cadmium

(Cadmio)

CAS# 7440-43-9

This fact sheet answers the most frequently asked health questions about cadmium. For more information, you may call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to cadmium happens mostly in the workplace where cadmium products are made. The general population is exposed from breathing cigarette smoke or eating cadmium contaminated foods. Cadmium damages the lungs, can cause kidney disease, and may irritate the digestive tract. This substance has been found in at least 776 of the 1,467 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What is cadmium?

Cadmium is a natural element in the earth's crust. It is usually found as a mineral combined with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfate, cadmium sulfide).

All soils and rocks, including coal and mineral fertilizers, contain some cadmium. Most cadmium used in the United States is extracted during the production of other metals like zinc, lead, and copper. Cadmium does not corrode easily and has many uses, including batteries, pigments, metal coatings, and plastics.

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What happens to cadmium when it enters the environment?

- Cadmium enters air from mining, industry, and burning coal and household wastes.
- Cadmium particles in air can travel long distances before falling to the ground or water.

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- It enters water and soil from waste disposal and spills or leaks at hazardous waste sites.
- It binds strongly to soil particles.
- Some cadmium dissolves in water.
- It doesn't break down in the environment, but can change forms.
- Fish, plants, and animals take up cadmium from the environment.
- Cadmium stays in the body a very long time and can build up from many years of exposure to low levels.

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How might I be exposed to cadmium?

- Breathing contaminated workplace air (battery manufacturing, metal soldering or welding).
- Eating foods containing it; low levels in all foods (highest in shellfish, liver, and kidney meats).
- Breathing cadmium in cigarette smoke (doubles the average daily intake).
- Drinking contaminated water.
- Breathing contaminated air near the burning of fossil fuels or municipal waste.

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How can cadmium affect my health?

Breathing high levels of cadmium severely damages the lungs and can cause death. Eating food or drinking water with very high levels severely irritates the stomach, leading to vomiting and diarrhea. Long-term exposure to lower levels of cadmium in air, food, or water leads to a buildup of cadmium in the kidneys and possible kidney disease. Other long-term effects are lung damage and fragile bones.

Animals given cadmium in food or water had high blood pressure, iron-poor blood, liver disease, and nerve or brain damage.

We don't know if humans get any of these diseases from eating or drinking cadmium. Skin contact with cadmium is not known to cause health effects in humans or animals.

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How likely is cadmium to cause cancer?

The Department of Health and Human Services (DHHS) has determined that cadmium and cadmium compounds may reasonably be anticipated to be carcinogens.

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How does cadmium affect children?

The health effects in children are expected to be similar to those in adults (kidney, lung and intestinal damage).

We don't know if cadmium causes birth defects in people. Cadmium does not readily go from a pregnant woman's body into the developing child, but some portion can cross the placenta. It can also be found in breast milk. The babies of animals exposed to high levels of cadmium during pregnancy had changes in behavior and learning ability. Cadmium may also affect birth weight and the skeleton in developing animals.

Animal studies also indicate that more cadmium is absorbed into the body if the diet is low in calcium, protein, or iron, or is high in fat. A few studies show that younger animals absorb more cadmium and are more likely to lose bone and bone strength than adults.

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How can families reduce the risk of exposure to cadmium?

In the home, store substances that contain cadmium safely, and keep nickel-cadmium batteries out of reach of young children. If you work with cadmium, use all safety precautions to avoid carrying cadmium-containing dust home from work on your clothing, skin, hair, or tools.

A balanced diet can reduce the amount of cadmium taken into the body from food and drink.

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Is there a medical test to show whether I've been exposed to cadmium?

Tests are available in some medical laboratories that measure cadmium in blood, urine, hair, or nails. Blood levels show recent exposure to cadmium, and urine levels show both recent and earlier exposure. The reliability of tests for cadmium levels in hair or nails is unknown.

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Has the federal government made recommendations to protect human health?

The EPA has set a limit of 5 parts of cadmium per billion parts of drinking water (5 ppb). EPA doesn't allow cadmium in pesticides.

The Food and Drug Administration (FDA) limits the amount of cadmium in food colors to 15 parts per million (15 ppm).

The Occupational Safety and Health Administration (OSHA) limits workplace air to 100 micrograms cadmium per cubic meter (100 $\mu g/m^3$) as cadmium fumes and 200 μg cadmium/m^3 as cadmium dust.

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References

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. Toxicological Profile for cadmium. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

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Where can I get more information?

ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

For more information, contact:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop F-32
Atlanta, GA 30333
Phone: 1-888-42-ATSDR (1-888-422-8737)
FAX: (770)-488-4178
Email: ATSDRIC@cdc.gov

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U.S. Department of Health and Human Services

ATSDR
AGENCY FOR TOXIC SUBSTANCES
AND DISEASE REGISTRY

August 2005

Public Health Statement for Zinc

(Cinc)

CAS# 7440-66-6

This Public Health Statement is the summary chapter from the Toxicological Profile for zinc. It is one in a series of Public Health Statements about hazardous substances and their health effects. A shorter version, the ToxFAQs™, is also available. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present. For more information, call the ATSDR Information Center at 1-888-422-8737.

This public health statement tells you about zinc and the effects of exposure to it. Zinc is an essential element needed by your body and is commonly found in nutritional supplements. However, taking too much zinc into the body can affect your health.

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. Zinc has been found in at least 985 of the 1,662 current or former NPL sites. Although the total number of NPL sites evaluated for zinc is not known, the possibility exists that the number of sites at which zinc is 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 zinc 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 zinc, 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

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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 is zinc?

Zinc is one of the most common elements in the Earth's crust. Zinc is found in the air, soil, and water and is present in all foods. In its pure elemental (or metallic) form, zinc is a bluish-white, shiny metal. Powdered zinc is explosive and may burst into flames if stored in damp places. Metallic zinc has many uses in industry. A common use for zinc is to coat steel and iron as well as other metals to prevent rust and corrosion; this process is called galvanization. Metallic zinc is also mixed with other metals to form alloys such as brass and bronze. A zinc and copper alloy is used to make pennies in the United States. Metallic zinc is also used to make dry cell batteries.

Zinc can also combine with other elements, such as chlorine, oxygen, and sulfur, to form zinc compounds. Zinc compounds that may be found at hazardous waste sites are zinc chloride, zinc oxide, zinc sulfate, and zinc sulfide. Most zinc ore found naturally in the environment is in the form of zinc sulfide. Zinc compounds are widely used in industry. Zinc sulfide and zinc oxide are used to make white paints, ceramics, and other products. Zinc oxide is also used in producing rubber. Zinc compounds, such as zinc acetate, zinc chloride, and zinc sulfate, are used in preserving wood and in manufacturing and dyeing fabrics. Zinc chloride is also the major ingredient in smoke from smoke bombs. Zinc compounds are used by the drug industry as ingredients in some common products, such as vitamin supplements, sun blocks, diaper rash ointments, deodorants, athlete's foot preparations, acne and poison ivy preparations, and antidandruff shampoos.

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1.2 What happens to zinc when it enters the environment?

Zinc enters the air, water, and soil as a result of both natural processes and human activities. Most zinc enters the environment as the result of mining, purifying of zinc, lead, and cadmium ores, steel production, coal burning, and burning of wastes. These activities can increase zinc levels in the atmosphere. Waste streams from zinc and other metal manufacturing and zinc chemical industries, domestic waste water, and run-off from soil containing zinc can discharge zinc into waterways. The level of zinc in soil increases mainly from disposal of zinc wastes from metal manufacturing industries and coal ash from electric utilities. Sludge and fertilizer also contribute to increased levels of zinc in the soil. In air, zinc is present mostly as fine dust particles. This dust eventually settles over land and water. Rain and snow aid in removing zinc from air. Most of the zinc in lakes or rivers settles on the bottom. However, a small amount may remain either dissolved in water or as fine suspended particles. The level of dissolved zinc in water may increase as the acidity of water increases. Fish can collect zinc in their bodies from the water they swim in and from the food they eat. Most of the zinc in soil is bound to the soil and does not dissolve in water. However, depending on the type of soil, some zinc may reach groundwater, and contamination of groundwater has occurred from hazardous waste sites. Zinc may be taken up by animals eating soil or drinking water containing zinc. Zinc is also a trace mineral nutrient and as such, small amounts of zinc are needed in all animals.

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1.3 How might I be exposed to zinc?

Zinc is an essential element needed by your body in small amounts. We are exposed to zinc compounds in food. The average daily zinc intake through the diet in this country ranges from 5.2 to 16.2 milligrams (milligram=0.001 gram). Food may contain levels of zinc ranging from approximately 2 parts of zinc per million (2 ppm) parts of foods (e.g., leafy vegetables) to 29 ppm (meats, fish, poultry). Zinc is also present in most drinking water. Drinking water or other beverages may contain high levels of zinc if they are stored in metal containers or flow through pipes that have been coated with zinc to resist rust. If you take more than the recommended daily amount of supplements containing zinc, you may have higher levels of zinc exposure.

In general, levels of zinc in air are relatively low and fairly constant. Average levels of zinc in the air throughout the United States are less than 1 microgram of zinc per cubic meter ($\mu g/m^3$) of air, but range from 0.1 to 1.7 $\mu g/m^3$ in areas near cities.

Air near industrial areas may have higher levels of zinc. The average zinc concentration for a 1-year period was 5 $\mu g/m^3$ in one area near an industrial source.

In addition to background exposure that all of us experience, about 150,000 people also have a source of occupational exposure to zinc that might elevate their total exposure significantly above the average background exposure. Jobs where people are exposed to zinc include zinc mining, smelting, and welding; manufacture of brass, bronze, or other zinc-containing alloys; manufacture of galvanized metals; and manufacture of machine parts, rubber, paint, linoleum, oilcloths, batteries, some kinds of glass and ceramics, and dyes. People at construction jobs, automobile mechanics, and painters are also exposed to zinc.

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1.4 How can zinc enter and leave my body?

Zinc can enter the body through the digestive tract when you eat food or drink water containing it. Zinc can also enter through your lungs if you inhale zinc dust or fumes from zinc-smelting or zinc-welding operations on your job. The amount of zinc that passes directly through the skin is relatively small. The most likely route of exposure near NPL waste sites is through drinking water containing a high amount of zinc. Zinc is stored throughout the body. Zinc increases in blood and bone most rapidly after exposure. Zinc may stay in the bone for many days after exposure. Normally, zinc leaves the body in urine and feces.

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1.5 How can zinc 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.

Inhaling large amounts of zinc (as zinc dust or fumes from smelting or welding) can cause a specific short-term disease called metal fume fever, which is generally reversible once exposure to zinc ceases. However, very little is known about the long-term effects of breathing zinc dust or fumes.

Taking too much zinc into the body through food, water, or dietary supplements can also affect health. The levels of zinc that produce adverse health effects are much higher than the Recommended Dietary Allowances (RDAs) for zinc of 11 mg/day for men and 8 mg/day for women. If large doses of zinc (10-15 times higher than the RDA) are taken by mouth even for a short time, stomach cramps, nausea, and vomiting may occur. Ingesting high levels of zinc for several months may cause anemia, damage the pancreas, and decrease levels of high-density lipoprotein (HDL) cholesterol.

Eating food containing very large amounts of zinc (1,000 times higher than the RDA) for several months caused many health effects in rats, mice, and ferrets, including anemia and injury to the pancreas and kidney. Rats that ate very large amounts of zinc became infertile. Rats that ate very large amounts of zinc after becoming pregnant had smaller babies. Putting low levels of certain zinc compounds, such as zinc acetate and zinc chloride, on the skin of rabbits, guinea pigs, and mice caused skin irritation. Skin irritation from exposure to these chemicals would probably occur in humans. EPA has determined that because of lack of information, zinc is not classifiable as to its human carcinogenicity.

Consuming too little zinc is at least as important a health problem as consuming too much zinc. Without enough zinc in the diet, people may experience loss of appetite, decreased sense of taste and smell, decreased immune function, slow wound healing, and skin sores. Too little zinc in the diet may also cause poorly developed sex organs and retarded growth in young men. If a pregnant woman does not get enough zinc, her babies may have birth defects.

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1.6 How can zinc affect children?

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

Zinc is essential for proper growth and development of young children. Mothers who did not eat enough zinc during pregnancy had a higher frequency of birth defects and gave birth to smaller children (lower birth weight) than mothers whose zinc levels were sufficient. Very young children who did not receive enough zinc in the diet were smaller, both in length and in body weight, than children who ate enough zinc. Some foods, such as soy-based formulas, contain high levels of phytate, which can result in a decreased absorption of zinc in the diet. Too much of these foods may result in effects similar to those that occur when children receive too little zinc in the diet.

Little is known about whether children who eat too much zinc will react differently from adults who have ingested large amounts of zinc. A child who accidentally drank a large amount of a caustic zinc solution was found to have damage to his mouth and stomach, and later to his pancreas, but similar effects have been seen in adults who accidentally drank the same solution.

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1.7 How can families reduce the risk of exposure to zinc?

If your doctor finds that you have been exposed to substantial amounts of zinc, 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 zinc are likely to be exposed to higher environmental levels of zinc through breathing, drinking contaminated drinking water, touching soil, and eating contaminated soil. It is unlikely that a child would ingest enough zinc from eating soil to cause harmful effects. However, parents should supervise to see that children avoid eating soil and wash their hands frequently, especially before eating. Parents should consult their family physicians about whether (and how) hand-to-mouth behaviors in their children might be discouraged.

Children and adults require a certain amount of zinc in the diet in order to remain healthy. However, overuse of some medicines or vitamin supplements containing zinc might be harmful; these medicines should always be used appropriately. If you are accidentally exposed to large amounts of zinc, consult a physician immediately.

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1.8 Is there a medical test to determine whether i have been exposed to zinc?

Medical tests can determine whether your body fluids contain high levels of zinc. Samples of blood or feces can be collected in a doctor's office and sent to a laboratory that can measure zinc levels. It is easier for most laboratories to measure zinc in blood than in feces. The presence of high levels of zinc in the feces can mean recent high zinc exposure. High levels of zinc in the blood can mean high zinc consumption and/or high exposure. High zinc levels in blood or feces reflect the level of exposure to zinc. Measuring zinc levels in urine and saliva also may provide information about zinc exposure. Tests to measure zinc in hair may provide information on long-term zinc exposure; however, no useful correlation has been found between hair zinc levels and zinc exposure and these tests are not routinely used. Since zinc levels can be affected by dietary deficiency and cell stress, these results may not be directly related to current zinc exposure.

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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 zinc include the following:

The federal government has set standards and guidelines to protect individuals from the potential health effects of excessive zinc. EPA has stated that drinking water should contain no more than 5 mg of zinc per liter of water (5 mg/L or 5 ppm) because of taste. Furthermore, any release of more than 1,000 pounds (or in some cases 5,000 pounds) of zinc or its compounds into the environment (i.e., water, soil, or air) must be reported to EPA.

The National Academy of Sciences (NAS) estimates an RDA for zinc of 11 mg/day (men). Eleven mg/day is the same as 0.16 mg per kilogram (kg) of body weight per day for an average adult male (70 kg). An RDA of 8 mg/day, or 0.13 mg per kg of body weight for an average adult female (60 kg), was established for women because they usually weigh less than men. Lower zinc intake was recommended for infants (2-3 mg/day) and children (5-9 mg/day) because of their lower average body weights. The RDA provides a level of adequate nutritional status for most of the population. Extra dietary levels of zinc are recommended for women during pregnancy and lactation. An RDA of 11-12 mg/day was set for pregnant women. Women who nurse their babies need 12-13 mg/day.

To protect workers, OSHA has set an average legal limit of 1 mg/m^3 for zinc chloride fumes and 5 mg/m^3 for zinc oxide (dusts and fumes) in workplace air during an 8 hour workday, 40 hour work week. This regulation means that the workroom air should contain no more than an average of 1 mg/m^3 of zinc chloride over an 8 hour working shift of a 40 hour work week. NIOSH similarly recommends that the level of zinc oxide in workplace air should not exceed an average of 1 mg/m^3 over a 10 hour period of a 40 hour work week.

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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 F-32
Atlanta, GA 30333

Information line and technical assistance:

Phone: 888-422-8737
FAX: (770)-488-4178

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 703-605-6000

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References

Agency for Toxic Substances and Disease Registry (ATSDR). 2005. Toxicological profile for zinc. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

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ATSDR Information Center / ATSDRIC@cdc.gov / 1-888-422-8737

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