APPENDIX B

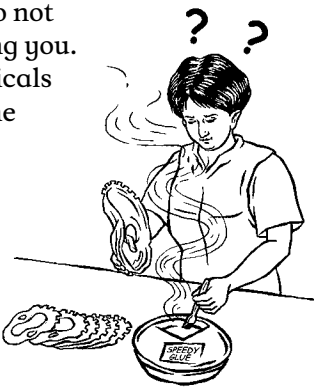
Common chemicals and materials

Many workers do not know the names of all the chemicals they come in contact with. Sometimes chemicals are put into small containers without labels. Other times employers hide the chemical information or call the chemical by other names and not its chemical name. Also, most factories do not track how chemicals applied earlier in the process can affect workers down the line or how much and what kind of byproducts are produced when a chemical is used. But all these chemicals can affect your health and you have a right to know about them.

The charts in this section will help you use the information you know about a chemical to identify it or learn more about its effects.

- **What are they?** will tell you what it looks, smells, or tastes like.
- **Do you work with them?** gives information about its uses in garment, shoe, or electronics factories.
- **When they come in contact with your body** gives information about how a chemical can hurt your eyes, skin, nose, lungs, mouth, and belly.
- **When you are exposed over time** explains how the chemical can hurt your body in the long term, for example, if it causes sexual and reproductive health problems or cancers.

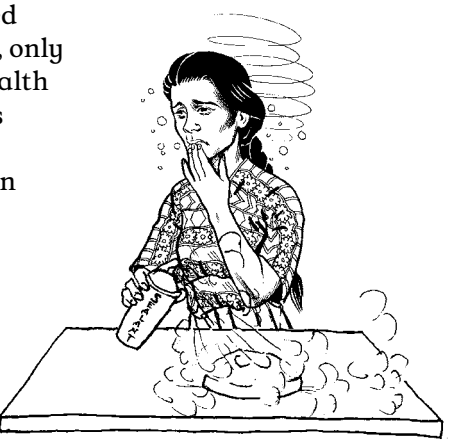
The charts include **what kind of protective equipment** you should wear if your factory does not have good ventilation, if the controls do not work well, or if you are concerned that they are not protecting you. The only real solution to chemical dangers is to not use chemicals that can harm people, but to substitute safer chemicals. In the meantime, it is important that people have ways to protect themselves. If you are concerned about the ventilation in your factory or workstation, see chapter 17 to learn how good ventilation keeps chemicals out of the air. If you are concerned about a chemical touching your skin or eyes, see chapter 18: Personal protective equipment.



Use these charts to talk with other workers about the health dangers they are experiencing or worrying about. The charts can help you organize to demand better protection from the chemicals you are using and to demand that the worst chemicals be banned and removed from your factory.

Too many chemicals, too little information

Coming in contact with chemicals makes it more likely that you will have health problems. However, there is too little information about how chemicals hurt people because they have not been studied enough. Of the 90,000 chemicals in use today, only a few thousand have been studied for **some** health effects! And although we know that chemicals are more harmful in combination with other chemicals than they are alone, there have been even fewer studies of how multiple chemicals affect us.



Until a chemical is studied for health effects (acute and chronic), how it affects the environment, and how it interacts with other chemicals, we should consider it dangerous. Many people believe that it is **not fair to chemicals** to say they are dangerous until proven safe. But we say it is **not fair to people,** to workers and their families, to work with chemicals not proven absolutely safe. If you cannot find information about a chemical, treat it as dangerous and protect yourself from coming in contact with it (see chapter 8: Chemical dangers, chapter 17: Ventilation, and chapter 18: Personal protective equipment).

These charts do not include information about how chemicals pollute the environment and harm people's health outside the factory. Often we are exposed multiple times to dangerous chemicals: first, inside the factory, and then again through polluted air, water, and soil in our communities. If you cannot find out if chemical wastes are being disposed of safely, assume that they are not. See chapter 33: Pollution from factories, for information about good disposal and how to organize against factory pollution.

These charts contain only about 100 common chemicals used in shoe, garment, and electronics factories. There are just too many in use to list them all. We did not include chemical mixes since mixes often change, are different from factory to factory and brand to brand, and their ingredients are often kept secret. To find out about a chemical not included in these charts, or for other information, see pages 178 to 184, and page 464 for other resources that can help you. You may know the same chemical by a different name; see the Index of chemical names on page 467.

Where did this information about chemicals come from?

Of the thousands of chemicals in use, few have been studied fully to know how they affect our health when used alone or when they mix with other chemicals. Concerns such as acute effects, flammability, and proper storage have been well-investigated and the information we have is mostly accurate and good. But we know little about long-term health and environmental effects.

In developing this book, we consulted many resources, including materials produced by international agencies that classify chemicals, government agencies that regulate chemicals, nonprofits that work to protect people from chemicals, and chemical companies that make and sell chemicals.

The information we found varied among all the trustworthy sources we consulted (see the list on page 464). The information we included in the book and in these charts is based on the following principles of when to recognize a danger:

- The chemical has been found to cause harm. Sometimes different health problems were listed in different resources. To be safe, we included all problems found in every source.
- The lowest level at which a chemical can cause harm, for example, when the smell of a chemical indicates a level of exposure. Levels of exposure considered to be safe vary from one country and one resource to another. When we include a level of exposure, we choose the lowest level that was found to be the border between safe and unsafe.
- The chemical has been found to be a probable or possible cause of cancer or reproductive health problems. If a chemical could possibly or probably cause cancer or reproductive health problems, or if it was found to cause them in animals, we say it "may cause" the problem.
- The chemical has been found to cause cancer or reproductive health problems. If any source said that it caused cancer in people, that is how we categorized it.

To find information about chemicals and materials, use these sources we consulted

Canadian Center for Occupational Health and Safety (CHEMINDEX), ccinfoweb.ccohs.ca/chemindex/search.html

Chemical Hazard and Alternatives Toolbox (ChemHAT), chemhat.org

European Chemicals Agency Information on Chemicals, echa.europa.eu/information-on-chemicals

International Agency for Research on Cancer (IARC), monographs.iarc.fr/ENG/Classification/index.php

International Labour Organization (ILO) International Chemical Safety Cards, ilo.org/safework/info/publications/WCMS_113134/lang--en/index.htm

International Programme on Chemical Safety (INCHEM), inchem.org

New Jersey (USA) Fact Sheets, web.doh.state.nj.us/rtkhsfs/search.aspx

PubMed, ncbi.nlm.nih.gov/pubmed

RISCTOX Database, istas.net/risctox/en

Toxipedia, toxipedia.org

ToxNet, toxnet.nlm.nih.gov

ToxTown, toxtown.nlm.nih.gov

US Agency for Toxic Substances and Disease Registry (ATSDR), www.atsdr.cdc.gov

US National Institute on Occupational Safety and Health (NIOSH), cdc.gov/niosh/npg

World Health Organization (WHO) International Program on Chemical Safety, who.int/ipcs/assessment/en

We also consulted Safety Data Sheets (SDS) produced by the manufacturers of individual chemicals.

Find a chemical in the charts

The chemicals and materials on the following pages are grouped in families. These families show you how similar chemicals relate to each other. If your boss adds or replaces a chemical with an unknown new one, look at what category it belongs to and see if the new chemical has any of the characteristics of other chemicals on the chart.

The chemical families appear in the order of the alphabet. The chemicals inside each family are also listed in the order of the alphabet. Chemicals that start with a number (such as 2-butanone) come before chemicals that start with letters (such as acetone):

1 2 3 4 A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Sometimes chemical names are very similar. The difference may be only a few letters or a number. But these small differences can make a great difference in how the chemical acts. To avoid confusion or mistakes, each chemical also has a unique number called a CAS number. The chart shows the CAS number for each chemical. A few chemicals in this list do not have CAS numbers because they represent a category of chemicals. There are many azo dyes, for example, and each one has a CAS number, but azo dyes as a category do not have a CAS number so you will not find one listed.

If the chemical name you want to look up is not in the chart, use the Index of chemical names on page 467 to see if it has a different name in the chart. For example, the chemical "chlorine bleach," used to acid-wash jeans, is sometimes called "Clorox" and sometimes called "sodium hypochlorite."

We have listed this chemical as "chlorine bleach" in the chart. If you look for "Clorox" in the Index of chemical names, you will find this:

If you look for "sodium hypochlorite" in the Index, you will find this:

If you cannot find a chemical, see pages 178 to 184, and page 464 for resources that can help you find more information.

What the symbols mean

The symbols below appear next to the chemical name at the top of the chart. They tell you which chemicals are more dangerous (more and darker symbols mean more danger). But even if a chemical does not have symbols it does not mean it is safe.

This symbol means that the chemical or material has been banned or is soon to be banned in one or more countries because it is harmful to people's health and the environment. If it is banned in one country, it should be banned in all.

This symbol means that the chemical or material is likely to catch on fire or explode. Pay attention to chemicals or materials it might react with, and keep it away from heat or a possible spark.

These 2 symbols mean that the chemical may or can cause reproductive health problems:

The man and woman with a **white background and a question mark** means that there is a possibility it may cause reproductive health problems.

The man and woman with a **black background** means that this chemical has been proven to cause reproductive health problems.

The chart text explains **what kind** of reproductive health problem it can cause, such as reduced fertility in men, women, or both, miscarriages, and damage to a baby inside the womb. For more information about reproductive health problems, see page 161 and chapter 26: Sexual and reproductive health.

These 2 symbols mean that the chemical may or can cause cancer:

The person in bed with a **white background and a question mark** means that there is a possibility it may cause cancer.

The person in bed with a **black background** means that this chemical has been proven to cause cancer.

The chart text explains what kinds of cancers it may or can cause, if that is known.

This symbol means that the chemical can cause immediate death if you are exposed to it. Although most of the chemicals can cause death if you are exposed to high doses or for a long time, we used this symbol only for the ones that would kill you immediately.

Index of chemical names

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Chemical charts

Acids

Acids come in liquid form and are used to clean electronic parts and metals, added to fabric dyes, and used in leather treatment.

Acids release fumes that can be toxic when inhaled, sometimes causing lung problems immediately. Absorbing acids through the skin is also a common and dangerous form of exposure. As a group, acids are very reactive chemicals and can be extremely harmful when they touch your body. Even small amounts or very diluted acids can cause severe burns and penetrate your skin.

The charts include only some of the acids that exist. See pages 178 to 184 and page 464 for how to find information about other acids. See the Index of chemical names on page 467 to find alternative names for acids.

Prevent or reduce exposure:

- Have ventilation systems that extract fumes and replace or dilute dirty air with clean air (see chapter 17: Ventilation).
- Enclose operations where possible.
- Do not mix or pour acids by hand.
- Wear acid-resistant gloves, acid-resistant long aprons, eye-protective glasses and a face shield. Wear correct respirators that fit you. All protective clothing should be clean, available each day, put on before work, and never taken home with you (see chapter 18: Personal protective equipment).
- Have an emergency plan for spills, splashes, and accidental exposures. The plan should include first aid treatment and protective equipment. Keep necessary supplies at the worksite, well stocked, and accessible to workers. For First aid for HF burns, see page 66.
- Work areas where acids are used, stored, and mixed need to be controlled for heat and monitored for concentration of fumes and vapors. They should also have alarms, fire extinguishers, and a fire emergency plan (see chapter 11: Fire).

Acids

Acetic acid – CAS No. 64-19-7

Formic acid – CAS No. 64-18-6

Hydrochloric acid (HCl) – CAS No. 7647-01-0

Hydrofluoric acid (HF) – CAS No. 7664-39-3

Nitric acid – CAS No. 7697-37-2

What are they?

Acids are colorless liquids with strong smells. **Acetic acid** has a vinegar-like smell. **Formic, hydrochloric**, **hydrofluoric,** and **nitric acid** have pungent, irritating odors. **Acids** release fumes. **Nitric acid** in fume form is red in color.

Do you work with them?

Acids are used in electronics and garment industries. **Formic acid** is used in dyeing and finishing textiles and treating leather. **Hydrochloric** and **hydrofluoric acid** are used to clean wafers, chips, and printed circuit boards. **Nitric acid** in fume form is used to dissolve, etch, and clean metals in the electronics industry.

When they come in contact with your body

Skin: They can severely irritate, burn the skin and cause a rash, pain, redness, ulceration and permanent scarring. When **hydrochloric acid** touches your skin, it will burn quickly, but the skin will feel cold and numb. Treat it quickly as a chemical burn (see pages 175). When **hydrofluoric acid** touches your skin it will burn quickly and deeply. However, **hydrofluoric** burns do not show right away, so it is important to immediately wash off any area that comes into contact with it. If it is absorbed through the skin it can be fatal. See First Aid on page 66.

Eyes: They severely irritate and burn the eyes and can lead to permanent eye damage, corneal scarring and blindness. See First Aid on page 175.

Nose/lungs: The fumes can irritate your nose, throat, and lungs, causing coughing, wheezing and difficulty breathing. Inhaling fumes can cause dizziness and headaches. It can also create a buildup of fluid in the lungs, called lung edema. **Hydrofluoric acid** may be fatal because it can cause irregular heartbeat. See First Aid on pages 66 and 174.

Mouth/belly: They can lead to injury of the gastrointestinal tract and stomach causing loss of appetite, nausea, vomiting, diarrhea and abdominal pain. **Hydrofluoric acid** can burn your mouth and throat and lower your heart rate and blood pressure. See First Aid on pages 66 and 176 and seek medical attention right away.

(continued)

Acids *(continued)*

When you are exposed over time:

Acids can harm your liver, kidneys, and lungs. They can cause chronic bronchitis and pneumonia.

Nitric acid can cause yellowing and erosion of the teeth.

Hydrochloric acid can cause yellowing and erosion of the teeth.

Hydrofluoric acid can cause digestive imbalance, irregular heartbeat, and affect your nervous system leading to seizures. It can also weaken or destroy your bones and cause skin problems.

If you are at risk of exposure:

Use butyl gloves, an apron, and eye/face protection to keep acids off your skin (see chapter 18: Personal protective equipment).

For **HCl**, use *Tychem* or teflon gloves.

For **HF**, use double nitrile gloves.

Wear a respirator that can filter **acid** fumes (see Respirators on pages 266 to 270).

Acid wash chemicals

Acid wash chemicals are used to make textiles appear worn and faded. The chemicals strip away the original color. Chlorine and potassium permanganate (PP) bleaches are the most common bleach solutions used for acid washing in textiles.

Chlorine and potassium permanganate are mixed with other chemicals and diluted to make liquid bleach solutions. Both chemicals release fumes.

If chlorine comes in contact with ammonia, it will produce toxic vapors that can explode. Potassium permanganate will produce toxic vapors and can explode if it comes in contact with acids and powdered metals. Acid wash chemicals release very toxic fumes when they catch on fire. Do not store these chemicals near other chemicals or near heat.

The charts include only some of the acid washes that exist. See pages 178 to 184 and page 464 for how to find information about other acid washes. See the Index of chemical names on page 467 to find alternative names for acid wash chemicals.

Prevent or reduce exposure:

- Use ventilation systems that extract fumes and replace or dilute dirty air with clean air (see chapter 17: Ventilation).
- Enclose operations where possible.
- Do not mix or pour acid wash chemicals by hand.
- Wear acid-resistant gloves, acid-resistant long aprons, eye-protective glasses and a face shield. Wear correct respirators that fit you. All protective clothing should be clean, available each day, put on before work, and never taken home with you (see chapter 18: Personal protective equipment).
- Have an emergency plan for spills, splashes, and accidental exposures that includes first aid treatment and protective equipment. Keep necessary supplies emergency at the worksite, well stocked, and accessible to workers.
- Work areas where acid washes are used, stored, and mixed need to be controlled for heat and monitored for concentration of fumes and vapors. They should also have alarms, fire extinguishers, and a fire emergency plan (see chapter 11: Fire).

Acid wash chemicals

Chlorine bleach – CAS No. 7782-50-5 

Potassium permanganate bleach – CAS No. 7722-64-7 

What are they?

Acid wash chemicals are found in liquid bleaches. **Chlorine bleach** is a pale yellow liquid with a strong smell. **Potassium permanganate bleach** is a purple liquid.

Do you work with them?

Acid wash chemicals are used to make jeans look worn and faded.

When they come in contact with your body

Skin: They irritate and burn your skin. You may develop a skin rash, redness, and dryness. Your skin might start peeling, itching, and cracking. Over time, the skin may swell up and blister. See First Aid on page 175.

Eyes: They irritate and burn your eyes. They can cause conjunctivitis. Signs of conjunctivitis are watery eyes and discomfort. Large amount of acid wash chemicals may permanently damage your eyes and cause blindness. See First Aid on page 175.

Nose/lungs: The fumes can irritate your nose, throat, and lungs, causing congestion, coughing, wheezing, shortness of breath, and chest pain. Inhaling **chlorine bleach** and **potassium permanganate bleach** fumes can cause dizziness, headaches, and create buildup of fluid in the lungs, called lung edema. See First Aid on page 174.

Mouth/belly: If they get into your mouth and belly, they can burn your stomach, cause nausea, vomiting, and diarrhea. See First Aid on page 176 and seek medical attention.

When you are exposed over time:

Acid wash chemicals can make your nose and lungs very sensitive and cause bronchitis, pneumonia, and chronic asthma. Chronic asthma means that even if you stop working with acid wash chemicals, you may still have asthma.

Potassium permanganate bleach damages your liver and kidneys. If it gets in your mouth periodically over a long time period, it can damage your heart and the nervous system. It may decrease fertility in men and women.

If you are at risk of exposure:

Use elbow-length, butyl rubber or nitrile gloves, an apron, and eye protection (see chapter 18: Personal protective equipment).

Use a supplied-air respirator (see pages 268 to 270).

Safer substitutes:

It is better to not add any **acid wash chemicals** to the washing machine and instead use pumice stones by themselves.

Ammonia and ammonium compounds

Ammonia and ammonium compounds come in liquid, gas, and solid forms. Pure ammonia is a gas, but if you're working with cold ammonia, it will be in liquid form. Ammonia and ammonium compounds are used in the electronics, garment, and shoe-making industries. They are used in electroplating, to make rubber, as a solvent to make plastics, and in dyes and fabric finish treatments.

Containers of ammonia may explode when exposed to heat. Store ammonia in pressure-controlled, enclosed containers.

When any amount of ammonia touches any part of your body, rinse it off immediately with cool water for at least 15 minutes. See First Aid on page 175.

The charts include only some of the ammonia compounds that exist. See pages 178 to 184 and page 464 for how to find information about other ammonia compounds. See the Index of chemical names on page 467 to find alternative names for ammonia and ammonium compounds.

Prevent or reduce exposure:

- Use ventilation systems that extract fumes and replace or dilute dirty air with clean air (see chapter 17: Ventilation).
- Enclose operations where possible.
- Do not mix or pour ammonia or ammonium compounds by hand.
- Wear gloves. Wear correct respirators that fit you. All protective clothing should be clean, available each day, put on before work, and never taken home with you (see chapter 18: Personal protective equipment).
- Have an emergency plan that includes first aid treatment and protective equipment for spills, splashes, and accidental exposures. Keep necessary emergency supplies at the work site well stocked and accessible to workers.
- Work areas where ammonia compounds are used, stored, and mixed need to be controlled for heat and monitored for concentration of fumes and vapors. They should also have alarms, fire extinguishers, and a fire emergency plan (see chapter 11: Fire).

Ammonia and ammonium compounds

Ammonia – CAS No. 7664-41-7

Ammonium chloride – CAS No. 12125-02-9

Ammonium hydroxide – CAS No. 1336-21-6

What are they?

Ammonia is a colorless gas or liquid with a strong, irritating smell. It smells even at low amounts. **Ammonium hydroxide** is a colorless liquid mixture of ammonia and water. It has a strong smell. If you smell ammonium hydroxide, you are exposed to amounts that may harm you. **Ammonium chloride** is a solid white powder with no smell.

Do you work with them?

Ammonium compounds are used in electronics, shoes, and garment production. **Ammonia** is used in making silicon layers. Liquid **ammonia** is used in fabric treatment and in dyes. **Ammonium hydroxide** is used in the preparation of dyes and rubber. **Ammonium chloride** is used to make batteries and in electroplating.

When they come in contact with your body

Skin: They irritate and burn your skin. You may develop a skin rash, redness, and dryness. Your skin might start peeling, itching, and cracking. If liquid **ammonia** touches you, it will burn quickly, but the skin will feel cold and numb. See First Aid on page 175.

Eyes: They irritate and burn your eyes. Contact with large amounts can lead to blindness. See First Aid on page 175.

Nose/lungs: The fumes irritate your nose, throat, and lungs, causing congestion, coughing, wheezing, shortness of breath, and chest tightness. If you continue to be exposed, it can cause severe asthma attacks. Inhaling high amounts of fumes can create buildup of fluid in the lungs, called lung edema. See First Aid on page 174.

Mouth/belly: They can burn your mouth, throat, and stomach and cause nausea, vomiting, and diarrhea. See First Aid on page 176 and seek medical attention.

When you are exposed over time:

Ammonium compounds irritate your respiratory tract and can cause bronchitis, pneumonia, and asthma.

Ammonia and **ammonium chloride** can make your nose and lungs very sensitive and cause chronic asthma.

Ammonium chloride may affect your kidneys. It may damage a baby in the womb.

(continued)

Ammonia and ammonium compounds *(continued)*

If you are at risk of exposure:

Use elbow-length, butyl rubber or nitrile gloves, an apron, and eye/face protection (see chapter 18: Personal protective equipment).

Use a supplied-air respirator (see pages 268 to 270).

Safer substitutes:

Ammonium hydroxide is diluted and is a little safer than pure **ammonia**.

Dopant gases

Dopant gases are used to add layers (implant ions) to the wafer so the wafer will conduct electricity better. Arsine, diborane, and phosphine are the most commonly used dopant gases. Arsine gas comes from the element arsenic, diborane from boron, and phosphine from phosphorous.

As gases they are more dangerous than as solids because they can get on and inside you easily. Arsine, diborane, and phosphine gases are stored in containers that also contain their liquid forms. While most exposure occurs by breathing in fumes, a leak from a container can be liquid or gas.

Workers who load and unload wafers, replace gas cylinders, and clean and maintain the ion implantation machines can come into contact with dopant gases. So can other workers in the area.

If you accidentally swallow a dopant liquid, it can be released in your stomach as a gas and damage your digestive tract.

The charts include only some of the dopant gases that exist. See pages 178 to 184 and page 464 for how to find information about other dopant gases. See the Index of chemical names on page 467 to find alternative names for dopant gases.

Prevent or reduce exposure:

- Use ventilation systems that extract fumes and replace or dilute dirty air with clean air. Machines need exhaust vents inside so that no gases escape (see chapter 17: Ventilation).
- Enclosed equipment that is remotely controlled reduces workers' exposure where the possibility of an accident is greatest.
- Wear protective equipment such as chemical goggles, gloves, chemical splash aprons, and respirators especially when in direct contact with gas cylinders and parts of the ion implanting machine, such as vacuum pumps and the ion source (see chapter 18: Personal protective equipment).
- Have an emergency plan that includes first aid treatment and protective equipment for spills, splashes, and accidental exposures. Keep necessary emergency supplies at the worksite, well stocked, and accessible to workers.
- All dopants are extremely flammable and can explode. Areas where they are stored and used must be kept cool and the air must be monitored. The areas should also have alarms, fire extinguishers, and an emergency plan (see chapter 11: Fire).

Dopant gases

Arsine – CAS No. 7784-42-1		
Diborane – CAS No. 19287-45-7		
Phosphine– CAS No. 7803-51-2		

What are they?

Dopants are colorless gases. **Arsine** and **phosphine** smell unpleasantly like garlic or rotten fish. **Diborane** has an unpleasant sweet smell. If you can smell them, you are being exposed to amounts high enough to harm you.

Do you work with them?

Dopants are used in the electronics industry, in the process called "ion implantation" to make wafers conduct electricity better.

When they come in contact with your body

Skin: They may irritate your skin. In gas form they are not toxic to the skin, but if the liquid form touches you, it will burn quickly, even though the skin will feel cold and numb. Treat it quickly as a chemical burn. See First Aid on page 175.

Eyes: The fumes may irritate your eyes. The liquid form can cause severe eye burns. See First Aid on page 175.

Nose/lungs: The fumes can irritate your nose, throat, and lungs, causing coughing and wheezing. Breathing in these gases can cause you to feel weak, dizzy, lightheaded, short of breath, and pass out. Some signs are similar to "metal fume fever," which feels like a flu with a combination of these signs: headache, fever and chills, body aches, chest tightness, and cough. Higher exposures can also create a buildup of fluid in the lungs, called lung edema. See First Aid on page 174.

Mouth/belly: A **dopant** gas can be released in your stomach and cause damage to your digestive tract and lead to abdominal pain, nausea, vomiting, and diarrhea. See First Aid on page 176 and seek medical attention.

When you are exposed over time:

All **dopants** can harm your liver, kidneys and the nervous system causing weakness, muscle cramps, and poor coordination in the limbs.

Arsine kills red blood cells (hemolysis), which leads to anemia. Continuing to breathe **arsine** kills more red blood cells and can result in kidney failure. Skin and eyes that become yellow are danger signs and you should seek medical attention immediately. **Arsine** may cause skin, liver, kidney, lung, and bladder cancer.

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Dopant gases *(continued)*

Diborane can harm your lungs and cause chronic bronchitis and breathing problems.

Phosphine can harm your lungs and cause chronic bronchitis and breathing problems. High amounts of **phosphine** at once can cause heart and kidney failure. Skin and eyes that become yellow are danger signs and you should seek medical attention immediately.

If you are at risk of exposure:

Use both neoprene and nitrile gloves, an apron, and eye/face protection when changing vacuum pump oils and gas containers (see chapter 18: Personal protective equipment). This equipment must be well-cleaned or disposed of after use.

Use a supplied-air respirator if you are cleaning the ion source, changing vacuum pumps, or doing other maintenance work on the machine, or if you are replacing gas containers (see Respirators on pages 268 to 270).

Safer substitutes:

Mono ethyl arsine is a less toxic substitute for **arsine**.

Dyes

Dyes give color to fabric. Dyes consist of many groups of chemicals and each group has many individual chemicals. Azo is the largest group of dyes. Twenty-two of the hundreds of azo dyes are banned because there is no doubt that they severely harm people's health.

Solvents, acids, bases, metals, and other toxic chemicals are often added to dyes to help fabric take in the coloring. Some dyes come in powder form and must be mixed with a solvent before dyeing the cloth.

There are two ways dyes can be classified and identified: based on their application or based on their chemical structure. Application-based dyes are acid, basic, direct, disperse, mordant, reactive, pigment, and vat dyes. Different dyes are used for different fabrics and dye processes. Structure-based dyes include nitro, azo, carotenoid, triarylmethane, xanthene, acridine, quinoline, indamine, sulphur, amino- and hydroxyl- ketones, anthraquinone, indigoid, phthalocyanine, inorganic pigment, and others. Most dyes are identified with a "color index" (CI) name and number.

Dyes create dust and fumes that are easily inhaled and that can harm your mouth, throat, and lungs.

The charts include only some of the dyes that exist. See pages 178 to 184 and page 464 for how to find information about other dyes. See the Index of chemical names on page 467 to find alternative names for dyes.

Prevent or reduce exposure:

- Use ventilation systems that extract fumes and replace or dilute dirty air with clean air (see chapter 17: Ventilation).
- Enclose operations where possible.
- Do not mix or pour dyes by hand.
- Wear gloves. Wear correct respirators that fit you. All protective clothing should be clean, available each day, put on before work, and never taken home with you (see chapter 18: Personal protective equipment).
- Have an emergency plan that includes first aid treatment and protective equipment for spills, splashes, and accidental exposures. Keep necessary emergency supplies at the work site, stocked, and accessible to workers.
- Work areas where dyes are used, stored, and mixed need to be controlled for heat and monitored for concentration of fumes and vapors. The areas should also have alarms, fire extinguishers, and a fire emergency plan (see chapter 11: Fire).
- Wash hands only with soap and water. Do not use solvents on skin to remove dye stains.

Dyes

Anthraquinone dyes	
Azo dyes	
Indigoid dyes	
Sulfur dyes	
Triarylmethane dyes	

What are they?

Dyes are liquid or solid chemicals that come in different colors. **Solid dyes** usually come as sand-like powders or crystals. Some **dyes** have a strong smell, but others have no smell at all. Some **azo dyes** release toxic aromatic amine chemicals that have an unpleasant, fishy smell.

Do you work with them?

Dyes are used in the garment and shoe industries to dye cloth, fur, and leather. **Anthraquinone dyes** are most commonly used for violet, blue, and green colors. **Azo dyes** are used on cotton, wool, silk, and nylon to make them red, orange, and yellow. **Indigoid** dyes are used for dark colors and are often used to dye jeans. **Sulfur dyes** are used on cotton and rayon. They are commonly used for dark colors such as black, brown, dark blue, and violet. **Triarylmethane dyes** make very bright colors.

When they come in contact with your body

Skin: They irritate and dye your skin. You may develop a skin rash, redness, and dryness. Your skin might start peeling, itching, and cracking. Most often, a rash appears between your fingers or on the back of hands and wrists. See First Aid on page 175.

Eyes: They irritate and burn your eyes. They can cause itching, watery eyes, and swelling of the eyelids. See First Aid on page 175.

Nose/lungs: The dust and fumes can irritate your nose, throat, and lungs, causing congestion, coughing, wheezing, shortness of breath, and chest tightness. The longer you are exposed the more sensitive your nose and lungs become, which can lead to severe asthma attacks. Inhaling high amounts of pigment and dye dust and fumes can create buildup of fluid in the lungs, called lung edema. See First Aid on page 174.

Mouth/belly: They cause nausea, vomiting, and diarrhea. See First Aid on page 176 and seek medical attention.

(continued)

Dyes *(continued)*

When you are exposed over time:

Dyes harm your immune system, liver, kidneys, and urinary tract. They can make your nose and lungs very sensitive and cause chronic asthma. **Dyes** damage your red blood cells so they can no longer deliver oxygen to your organs. This is called methemoglobinemia. Signs of methemoglobinemia are blue skin and lips, headache, weakness, difficulty breathing, and lack of energy. If it's not treated, you may go into a coma and your heart may stop.

Azo dyes may affect fertility. They can cause liver cancer and especially bladder cancer.

Anthraquinone dyes may cause liver, colon, kidney, and bladder cancer.

Triarylmethane dyes may cause cancer.

If you are at risk of exposure:

Use elbow-length, butyl rubber gloves and eye/face protection (see chapter 18: Personal protective equipment).

Use a supplied-air respirator (see pages 268 to 270).

Safer substitutes:

Dyes that do not create dust are safer, such as **granular** or **liquid-form dyes**. **Natural dyes** are usually safer than **synthetic dyes**.

Flame retardants

Flame retardants are added to plastics, electronic parts, wire coverings, rubber, textiles, wood, and furniture to make them less likely to burn. There are two classes of flame-retardants: halogenated and non-halogenated. Sometimes a flame retardant is used by itself, and sometimes in combination with other flame retardants.

Halogenated flame retardants contain chlorine or bromine. Bromine-based flame-retardants are used more often because they are cheap.

Non-halogenated flame retardants contain nitrogen, phosphorous, or metals such as aluminum, magnesium, and antimony. The nitrogen-based and phosphorous-based flame retardants are often used in combination with each other.

Halogenated flame retardants are considered more dangerous to people's health than non-halogenated ones. Several have been banned in many countries. However, many non-halogenated flame retardants are just as dangerous to your health.

The chart includes only some of the flame retardants that exist. See pages 178 to 184 and page 464 for how to find information about other flame retardants. See the Index of chemical names on page 467 to find alternative names for flame retardants.

Prevent or reduce exposure:

- Use ventilation systems that extract fumes and replace or dilute dirty air with clean air (see chapter 17: Ventilation).
- Enclose operations whenever possible.
- Do not mix or pour flame retardants by hand.
- Use gloves when handling flame retardants. Wear correct respirators that fit you. All protective clothing should be clean, available each day, put on before work, and never taken home with you (see chapter 18: Personal protective equipment).
- Have an emergency plan that includes first aid treatment and protective equipment for spills, splashes, and accidental exposures. Keep necessary emergency supplies at the work site, stocked, and accessible to workers.
- Work areas where flame retardants are used, stored, and mixed need to be controlled for heat and monitored for concentration of fumes and vapors. The areas should also have alarms, fire extinguishers, and a fire emergency plan (see chapter 11: Fire).

Halogenated flame retardants

BROMINATED FLAME RETARDANTS

⊘ **Polybrominated biphenyl (PBB) – CAS No. 59536-65-1**

Polybrominated diphenyl ether (PBDE)

Tetrabromobisphenol A (TBBPA) – CAS No. 79-94-7

CHLORINATED FLAME RETARDANTS

⊘ **Polychlorinated biphenyl (PCB) – CAS No. 1336-36-3**

What are they?

Polybrominated biphenyls are white powders. **Polybrominated diphenyl ethers** are pale yellow or white powders. **TBBPA** is a white, sandy powder. **Polychlorinated biphenyls** are light yellow or colorless thick, oily liquids.

Do you work with them?

Halogenated flame retardants are added to fabric in garment factories. They are used in electronics factories in plastics, electronic coatings, and wires.

When they come in contact with your body

Skin: They may irritate your skin. You may develop a skin rash, redness, and dryness. Your skin might start peeling, itching, and cracking. See First Aid on page 175.

Eyes: They may irritate your eyes. See First Aid on page 175.

Nose/lungs: The fumes may irritate your nose, throat, and lungs, causing congestion, coughing, wheezing, shortness of breath, and chest pain. See First Aid on page 174.

Mouth/belly: They can cause nausea, vomiting, and diarrhea. See First Aid on page 176 and seek medical attention.

When you are exposed over time:

Halogenated flame retardants damage your immune system, mental development, and lower your memory and learning ability. They may damage your thyroid. Signs of hypothyroidism include constipation, sensitivity to cold, weakness, thin hair and nails, and weight gain.

Polybrominated biphenyls may reduce fertility in men and women and slow down a child's development. They may cause cancer.

Polybrominated diphenyl ethers can reduce fertility in men and women, enter into mother's milk and pass to a baby through breastfeeding, and slow down a child's development. They may cause cancer.

(continued)

Halogenated flame retardants *(continued)*

Tetrabromobisphenol A may reduce fertility in men and women.

Polychlorinated biphenyls can reduce fertility in men and women and slow down a child's development. They can cause cancer.

If you are at risk of exposure:

Use elbow-length, nitrile gloves, an apron, and eye/face protection (see chapter 18: Personal protective equipment).

Use a supplied-air respirator (see pages 268 to 270).

Safer substitutes:

Non-halogenated flame retardants are safer alternatives to **halogenated flame retardants. Tetrabromobisphenol A (TBBPA)** is one of the less dangerous **halogenated flame retardants**.

Non-halogenated flame retardants

INORGANIC FLAME RETARDANTS

Aluminium hydroxide – CAS No. 21645-51-2

Antimony trioxide – CAS No. 1309-64-4

NITROGEN-BASED FLAME RETARDANTS

Melamine cyanurate – CAS No. 37640-57-6

PHOSPHOROUS-BASED FLAME RETARDANTS

Red phosphorus – CAS No. 7723-14-0

Triphenyl phosphate (TPP) – CAS No. 115-86-6

What are they?

Aluminium hydroxide is a white powder similar to flour without smell. **Antimony trioxide** and **melamine cyanurate** are powders like sand without smell. **Red phosphorus** is red powder without smell. **Triphenyl phosphate (TPP)** is a white, crystalline powder with a sweet smell.

Do you work with them?

Phosphorous-based and **nitrogen-based flame retardants** are added to fabric in garment factories. They are also added to circuit board coatings and electronic parts. **Inorganic flame retardants** are added to plastics during melting and extrusion.

When they come in contact with your body

Skin: They may irritate your skin. You may develop a skin rash, redness, and dryness. Your skin might start peeling, itching, and cracking. See First Aid on page 175.

Eyes: They may irritate your eyes. **Red phosphorus** may damage the cornea (the tissue that covers the front of the eye). See First Aid on page 175.

Nose/lungs: The dust may irritate your nose, throat, and lungs, causing congestion, coughing, wheezing, shortness of breath, and chest pain. Inhaling **antimony trioxide** can cause throat ulcers. See First Aid on page 174.

Mouth/belly: They can cause stomach pain, nausea, and vomiting. **Antimony trioxide** can cause metallic taste in the mouth. See First Aid on page 176 and seek medical attention.

(continued)

Non-halogenated flame retardants *(continued)*

When you are exposed over time:

Non-halogenated flame retardants damage your liver and kidneys.

Aluminium hydroxide dust can scar your lungs, cause pneumoconiosis, weaken your muscles and soften your bones. Signs of pneumoconiosis are cough and shortness of breath.

Antimony trioxide damages your heart and lungs. It may reduce fertility in men and women, cause miscarriages, and hurt a baby in the womb. It may cause lung cancer.

Melamine cyanurate affects your urinary tract and may cause bladder stones.

Red phosphorus damages your heart and lungs. It can cause bronchitis and anemia.

Triphenyl phosphate may affect the nervous system, causing weakness and poor coordination in the arms and legs.

If you are at risk of exposure:

Use elbow-length, butyl rubber gloves, an apron, and eye/face protection (see chapter 18: Personal protective equipment).

Use a respirator with a particle filter designed for solid particle filtration (see pages 266 to 270).

Safer substitutes:

Alternative materials for computer devices and plastics that do not require **flame retardants** at all, such as glass, metal, and low voltage wires, should be used.

Fluxes

Flux chemicals are used to clean electronic parts during the soldering, brazing, and welding of metal parts. When clean, metal parts stick together much better.

Different fluxes are used for different metals. Rosin and ammonium chloride are used with tin and tin/lead in electronics. Hydrochloric acid and zinc chloride are used with zinc-coated iron. Sodium borate is used with any metal containing iron. Flux chemicals are sometimes dissolved in other chemicals, such as isopropyl alcohol, to make a liquid flux solution.

Lead solder was very common before it was banned by the European Union. Water-soluble fluxes are used with lead-free solders.

Fluxes release dangerous fumes when heated during soldering. Extractors must be close to the soldering source to remove all the fumes.

Many chemicals are used in fluxes. For more on ammonium chloride, see Ammonia and Ammonium Compounds on page 479; for hydrochloric acid, see Acids on page 474.

The chart includes only some of the flux chemicals that exist. See pages 178 to 184 and page 464 for how to find information about other fluxes. See the Index of chemical names on page 467 to find alternative names for fluxes.

Prevent or reduce exposure:

- Use extraction ventilation to remove flux fumes as close to the soldering process as possible. Use ventilation systems that extract fumes and replace or dilute dirty air with clean air (see chapter 17: Ventilation).
- Enclose operations whenever possible.
- Avoid manual hand soldering if there is an alternative automated manufacturing process available.
- Do not mix or pour fluxes by hand.
- Use gloves when handling fluxes. Wear correct respirators that fit you. All protective clothing should be clean, available each day, put on before work, and never taken home with you (see chapter 18: Personal protective equipment).
- Have an emergency plan that includes first aid treatment and protective equipment for spills, splashes, and exposures. Keep necessary emergency supplies at the work site well stocked and accessible to workers.
- Work areas where fluxes are used, stored, and mixed need to be controlled for heat and monitored for concentration of fumes and vapors. The areas should also have alarms, fire extinguishers, and a fire emergency plan (see chapter 11: Fire).

Fluxes

Ammonium chloride – CAS No. 12125-02-9

Hydrochloric acid (HCl) – CAS No. 7647-01-0

Rosin – CAS No. 8050-09-7

Sodium tetraborate decahydrate – CAS No. 1303-96-4

Zinc chloride – CAS No. 7646-85-7

What are they?

Ammonium chloride is a solid white powder that has no smell. **Hydrochloric acid** is a colorless liquid with a sharp smell. **Rosin** is a yellow-orange powder and can have a slight pine smell or no smell at all. **Sodium tetraborate decahydrate** and **zinc chloride** are white, sand-like powders with no smell.

Do you work with them?

Flux chemicals are used in the electronics industry during soldering, welding, and brazing of electronic parts.

When they come in contact with your body

Skin: They irritate your skin. You may develop a skin rash, redness, dryness, and blisters. Your skin might start peeling, itching, and cracking. When **hydrochloric acid** touches your skin, it will burn quickly, but the skin will feel cold and numb. Treat it quickly as a chemical burn. **Zinc chloride** causes burns and ulcers. See First Aid on page 175.

Eyes: They irritate your eyes. Your eyes become watery and red. See First Aid on page 175.

Nose/Lungs: They irritate your nose, throat, and lungs, causing coughing, wheezing, shortness of breath, and chest pain. **Sodium tetraborate decahydrate** causes sore throats and nosebleeds. **Zinc chloride** can create buildup of fluid in the lungs, called lung edema. See First Aid on page 174.

Mouth/Belly: If ingested, they can cause nausea, stomach pain, vomiting, and diarrhea. Swallowing **sodium tetraborate decahydrate** can cause weakness and convulsions. **Zinc chloride** burns your digestive tract. See First Aid on page 176 and seek medical attention.

(continued)

Fluxes *(continued)*

When you are exposed over time:

Ammonium chloride and **rosin** can make your nose and lungs very sensitive and cause chronic asthma. Even after you stop working with these chemicals, they can give you an asthma attack.

Ammonium chloride may affect your kidneys and may damage a baby inside the womb.

Hydrochloric acid can damage and cause yellowing of the teeth.

Sodium tetraborate decahydrate can damage your liver, kidneys, and nervous system. It may damage a baby inside the womb and may reduce fertility in men and women.

Zinc chloride can scar your lungs and may damage a baby inside the womb.

If you are at risk of exposure:

Use gloves and a face shield when soldering and handling **flux** chemicals (see chapter 18: Personal protective equipment).

Use a respirator with a filter (see pages 266 to 270).

Safer substitutes:

Sometimes soldering and the need for **flux** can be eliminated by using screws and wire to join metal parts. Use no-clean, rosin-free, and water-soluble flux alternatives if possible.

Formaldehyde

Formaldehyde is a gas with a very suffocating smell. It often comes as a liquid mixture of formaldehyde, water, and methanol called "formalin." For more information about methanol, see Alcohol solvents on page 518.

Formaldehyde is used in the electronics, shoe, and garment industries. It is used to keep fabric from wrinkling. It is also commonly used in plastics, glues, and coatings to make them stronger.

Formaldehyde is extremely flammable! It also reacts strongly with acids. Keep formaldehyde away from acids, other chemicals, and heat. See the Index of chemical names on page 467 to find alternative names for formaldehyde.

Prevent or reduce exposure:

- Use ventilation systems that extract fumes and replace or dilute dirty air with clean air (see chapter 17: Ventilation).
- Enclose operations whenever possible.
- Do not mix or pour formaldehyde by hand.
- Use gloves when handling formaldehyde. Wear correct respirators that fit you. All protective clothing should be clean, available each day, put on before work, and never taken home with you (see chapter 18: Personal protective equipment).
- Have an emergency plan that includes first aid treatment and protective equipment for spills, splashes, and exposures. Keep necessary emergency supplies at the work site well stocked and accessible to workers.
- Work areas where formaldehyde is used, stored, and mixed need to be controlled for heat and monitored for concentration of fumes and vapors. The areas should also have alarms, fire extinguishers, and a fire emergency plan (see chapter 11: Fire).

Formaldehyde

Formaldehyde – CAS No. 50-0-0

What is it?

Formaldehyde is a colorless gas that has a very strong, sharp smell. The smell is so strong that it is difficult to breathe. It often comes mixed with water and methanol. If you can smell it strongly in the air, you are exposed to a dose high enough to harm you.

Do you work with it?

Formaldehyde is used in garment factories in dyes, fabric treatments, and pressing. It is used in shoe factories in plastic production and glues. It is used in electronics in coatings of circuit boards.

When it comes in contact with your body

Skin: It irritates your skin. You may develop a skin rash, redness, dryness, and pain. Your skin might start peeling, itching, and cracking. See First Aid on page 175.

Eyes: It severely irritates and burns your eyes. It may cause watery and red eyes, pain, and blurred vision. Direct contact with a large enough amount may cause blindness. See First Aid on page 175.

Nose/lungs: It irritates your nose, throat, and lungs, causing sore throat, coughing, wheezing, shortness of breath, and chest pain. It can create buildup of fluid in the lungs, called lung edema. See First Aid on page 174.

Mouth/belly: If it gets into your mouth and belly, it can cause severe pain, vomiting, and diarrhea, and can be fatal. See First Aid on page 176 and seek medical attention.

When you are exposed over time:

Formaldehyde damages your lungs and can cause bronchitis. It can irritate your throat and lungs and cause chronic asthma. It may damage a baby inside the womb, may cause miscarriages and may reduce fertility in women. It can cause blood cancer and cancers of the nose and throat.

If you are at risk of exposure:

Use natural or butyl rubber, nitrile or neoprene gloves, an apron, and eye/face protection (see chapter 18: Personal protective equipment).

Use a respirator that can filter **formaldehyde** (see pages 266 to 270).

Safer substitutes:

Silicone-based fabric finishing treatments for pressing are considered a safer alternative to **formaldehyde.**

Isocyanates

Isocyanates are liquids used in glues, rubber, and coatings in shoe manufacturing. Isocyanate (water-based) glues were once considered safer than solvent-based glues, but more and more health problems in workers show that these glues are not safe. The most common and dangerous isocyanates are diisocyanates. In the chart on the next page we only list diisocyanates.

Mixing isocyanates and water or acids in a closed container can be very dangerous. It can create high pressure that might explode the container.

Isocyanates are often combined with other chemicals such as alcohols, acids, and polyurethanes. They are mixed with alcohols to create polyurethane plastic and with acids to make polyurea coatings. For more information on alcohols, see page 518. For acids, see page 474. For polyurethane, see page 512.

One of the biggest health problems caused by working with isocyanates is asthma. If you feel chest tightness, difficulty breathing, or begin to have asthma attacks, leave the work area and stop working with the isocyanates. If you continue to work with isocyanates, you might have a more serious asthma attack that could kill you. Talk to a health worker and try to transfer to a different job in your factory.

The charts include only some of the isocyanates that exist. See pages 178 to 184 and page 464 for how to find information about other isocyanates. See the Index of chemical names on page 467 to find alternative names for isocyanates.

Prevent or reduce exposure:

- Use ventilation systems that extract fumes and replace or dilute dirty air with clean air (see chapter 17: Ventilation).
- Enclose equipment where possible.
- Do not mix or pour isocyanates by hand.
- Wear butyl rubber gloves. Wear correct respirators that fit you. (See chapter 18: Personal protective equipment.)
- Have an emergency plan that includes first aid treatment and protective equipment for spills, splashes, and exposures. Keep necessary emergency supplies at the worksite, well stocked, and accessible to workers.
- Work areas where isocyanates are used, stored, and mixed need to be controlled for heat and monitored for concentration of fumes and vapors. The work areas should also have alarms, fire extinguishers, and a fire emergency plan (see chapter 11: Fire).

Isocyanates

Isophorone diisocyanate (IPDI) – CAS No. 4098-71-9

Methylene bisphenyl diisocyanate (MDI) – CAS No. 101-68-8

Naphthalene diisocyanate (NDI) – CAS No. 3173-72-6

Toluene diisocyanate (TDI) – CAS No. 26471-62-5

Hexamethylene diisocyanate (HDI) – CAS No. 822-06-0

What are they?

Isocyanates are clear, colorless, or slightly yellow liquids that have a strong, fruity smell. If you can smell them, they can harm you.

Do you work with them?

Isocyanates are used in shoe making in glues, rubber, and finish coatings.

When they come in contact with your body

Skin: They irritate and burn the skin. You may develop a rash, redness, and dryness. Your skin might start peeling, itching, and cracking. Your skin may become so sensitive that even a very small amount causes skin irritation. See First Aid on page 175.

Eyes: They irritate and burn your eyes. They cause conjunctivitis: watery eyes and discomfort. High amounts of **isocyanate** can permanently damage your eyes. See First Aid on page 175.

Nose/lungs: The fumes can irritate your nose, throat, and lungs, causing congestion, coughing, wheezing, shortness of breath, and chest tightness. The longer you are exposed, the more sensitive you become, which can lead to severe asthma attacks. Inhaling a lot of **isocyanate** fumes can create buildup of fluid in the lungs, called lung edema. See First Aid on page 174.

Mouth/belly: They can irritate your gastrointestinal tract, and cause nausea and vomiting. See First Aid on page 176 and seek medical help.

When you are exposed over time:

Isocyanates can make your nose and lungs sensitive and cause chronic asthma and pneumonitis. After some time you may develop chronic asthma that continues even if you stop working with **isocyanates**.

Toluene diisocyanate may cause cancer.

(continued)

Isocyanates *(continued)*

If you are at risk of exposure:

Use elbow-length, butyl rubber gloves, an apron, and eye/face protection (see chapter 18: Personal protective equipment).

Use a supplied-air respirator. Negative pressure air-purifying respirators are not recommended for **isocyanates** (see Respirators on pages 266 to 270).

Safer substitutes:

Methylene bisphenyl diisocyanate and **naphthalene diisocyanate** are safer than other **isocyanates** because they evaporate more slowly.

Mercapto-based rubber accelerators

Rubber accelerators are used to make rubber material more durable and flexible. They are added to the rubber used to make shoe soles.

Accelerators that contain sulfur are called mercapto-based accelerators. Sulfur acts as a type of glue that makes the rubber more compact and keeps it from breaking easily. Rubber accelerators often come in a mix. Since there may be several mercapto-based accelerator chemicals in a mix, it can be difficult to know which chemicals are present and how much of each you are working with.

Mercapto-based rubber accelerators release very toxic fumes when they burn. Do not store these chemicals near heat or near acids.

The charts include only some of the mercapto-based rubber accelerators that exist. See pages 178 to 184 and page 464 for how to find information about other accelerators. See the Index of chemical names on page 467 to find alternative names for mercapto-based rubber accelerators.

Prevent or reduce exposure:

- Use ventilation systems that extract fumes and replace or dilute dirty air with clean air (see chapter 17: Ventilation).
- Enclose operations where possible.
- Wear gloves when handling rubber accelerator compounds. It is very important to avoid skin contact with these chemicals because mercapto-based rubber accelerators are known to severely irritate your skin and cause allergic reactions. Wear correct respirators that fit you (see chapter 18: Personal protective equipment).
- Do not mix or pour mercapto-based rubber accelerators by hand.
- Have an emergency plan that includes first aid treatment and protective equipment for spills, splashes, and exposures. Keep necessary emergency supplies at the work site well stocked and accessible to workers.
- Work areas where mercapto-based rubber accelerators are used, stored, and mixed need to be controlled for heat and monitored for concentration of fumes and vapors. Work areas should also have alarms, fire extinguishers, and a fire emergency plan (see chapter 11: Fire).

Mercapto-based rubber accelerators

2-Mercaptobenzothiazole (MBT) – CAS No. 149-30-4

2,2-Mercaptodibenzothiazyl disulphide (MBTS) CAS No. 120-78-5

Zinc-2-mercaptobenzothiazole (ZMBT) CAS No. 155-04-4

What are they?

MBT comes in yellow crystals. **MBTS** and **ZMBT** are pale yellow powders. **Mercapto-based rubber accelerators** have an unpleasant, rotten-egg smell, or no smell at all. They have a bitter taste.

Do you work with them?

Mercapto-based rubber accelerators are used in rubber for shoe soles. They make natural and synthetic rubber more durable and flexible .

When they come in contact with your body

Skin: They irritate and burn your skin. You may develop a skin rash, redness, and dryness. Your skin might start peeling, itching, and cracking. See First Aid on page 175.

Eyes: They irritate and burn your eyes. See First Aid on page 175.

Nose/lungs: The dust can irritate your nose, throat, and lungs, causing sore throat, congestion, and coughing. Inhaling the dust can cause headaches and dizziness. See First Aid on page 174.

Mouth/belly: They can irritate your gastrointestinal tract and cause nausea, vomiting, and diarrhea. If you swallow **mercapto-based rubber accelerators**, take activated charcoal with water if available. See First Aid on page 176 and seek medical help.

When you are exposed over time:

Mercapto-based rubber accelerators can make your skin very sensitive and cause skin allergies after repeated contact. You can have a skin reaction if you come in contact with even very small amounts of these chemicals.

MBT may cause colon, bladder, and bone marrow cancer.

If you are at risk of exposure:

Use elbow-length, butyl rubber gloves, an apron, and eye/face protection (see chapter 18: Personal protective equipment).

Use a supplied-air respirator (see pages 268 to 270).

Safer substitutes:

Benzoyl peroxide is a less harmful rubber additive than **mercapto-based accelerators**, but this alternative is not completely safe either.

Metals

Metals usually are solids, although mercury is a metal that is a liquid. Larger amounts of metals are harmful. Heavy metals are dangerous at any level of exposure because they accumulate in your body. Even though you might be exposed to only small amounts each day, it adds up over time to dangerous levels.

Toxic exposure to metals occurs primarily through inhaling metal dust and fumes when metals are heated, soldered, or cut. After you work with them, particles of metal or metal dust on your fingers and hands may also rub off onto food or drop into water and get into your body. Metals are most heavily used in the electronics industry in batteries, welding, recycling, and coatings. In the garment and shoe industries, metals are used in dyeing fabrics and tanning leather.

The charts include only some of the metals that exist. See pages 178 to 184 and page 464 for how to find information about other metals. See the Index of chemical names on page 467 to find alternative names for metals.

Prevent or reduce exposure:

- Use ventilation systems that extract fumes and replace or dilute dirty air with clean air (see chapter 17: Ventilation).
- Enclose operations where possible.
- Wear metalworking gloves when working with metals. Use a face shield when heating, soldering, or cutting metals. Wear correct respirators that fit you, especially when heating metals. All protective clothing should be clean, available each day, put on before work, and never taken home with you (see chapter 18: Personal protective equipment).
- Have an emergency plan that includes first aid treatment and protective equipment for spills, splashes, and accidental exposures. Keep necessary emergency supplies at the worksite, well stocked, and accessible to workers.
- Wash your hands and face carefully before eating, drinking, or smoking.

Metals

⊘ **Cadmium (Cd) – CAS No. 7440-43-9**			
⊘ **Chromium hexavalent (Cr(VI))– CAS No. 18540-29-9**			
⊘ **Copper (Cu) – CAS No. 7440-50-8**			
⊘ **Lead (Pb) – CAS No. 7439-92-1**			
Mercury (Hg) – CAS No. 7439-97-6			
Nickel (Ni) – CAS No. 7440-02-0			
Tin (Sn)– CAS No. 7440-31-5			

What are they?

Metals are usually solids of various colors and without odors. But some metals, such as **mercury,** are liquid. Others, such as **chromium hexavalent** can be solid or liquid. Solid **chromium hexavalent** is usually yellow, orange, or red. **Cadmium** is blue-tinged and shiny. **Copper** is red-orange and turns a dull, brown color when exposed to air. **Lead** is blue-white and turns a grey color when exposed to air. **Mercury** is a silver-white, heavy, and odorless liquid. **Nickel** is a shiny silver metal. **Tin** is a silvery-white solid or a grey-green powder.

Do you work with them?

Metals are used in electronic, garment, and shoe industries. **Cadmium**, **chromium hexavalent**, **copper**, and **lead** are used in electronics and in dyes in garments and shoes. **Mercury**, **nickel**, and **tin** are used in electronics. **Nickel** is also used in metal buttons on jeans, buckles, zippers, and clasps.

When they come in contact with your body

Skin: They can irritate your skin. **Copper**, **mercury**, and **nickel** cause rashes and itching. **Mercury** might discolor your skin grey or brown. See First Aid on page 175.

Eyes: They irritate the eyes. **Chromium hexavalent** can damage the eyes. See First Aid on page 175.

(continued)

Metals *(continued)*

Nose/lungs: They can irritate your nose, throat, and lungs, causing coughing, wheezing, and difficulty breathing. Breathing **chromium hexavalent** can cause a burning sensation. Inhaling fumes can cause dizziness and headaches. They can also create a buildup of fluid in the lungs, called lung edema. Inhaling fumes may cause "metal fume fever," which feels like a short-lived flu. **Lead** can cause severe irritability, chest pain, reduced memory, disturbed sleep, and mood and personality changes. Severe **mercury** poisoning results in shaking, memory loss, difficulty concentrating, weight loss, personality changes, and hallucinations. See First Aid on page 174.

Mouth/belly: They can damage the gastrointestinal tract and stomach. Some signs include loss of appetite, nausea, vomiting, diarrhea, and abdominal pain. Increased salivation and metallic taste are also signs of exposure to **metals**. See First Aid on page 176 and seek medical attention.

When you are exposed over time:

All metals can harm your liver, kidneys, bones, and lungs.

Cadmium and **lead** can cause hypertension (high blood pressure). **Cadmium** can also cause bronchitis, anemia, loss of the sense of smell, and discolored teeth. It can damage the baby in the womb and damage men and women's reproductive systems. It can cause kidney, prostate, and lung cancer.

Chromium hexavalent can cause lung cancer. It can damage the respiratory tract causing nose sores and nose bleeds. It can cause skin blisters and ulcers.

Copper can cause discoloration of the skin, hair, and teeth, and may reduce fertility in men and women.

Lead may cause birth defects and harm the baby in the womb. It may reduce fertility in men and women. It can cause lung, stomach, brain, and kidney cancers.

Mercury causes permanent psychological and neurological problems. It may cause miscarriages, reduce fertility in men and women, and harm the baby in the womb.

Nickel may cause lung cancer.

Tin damages the nervous system, causing shaking and tremors.

If you are at risk of exposure:

Use *Silver Shield* or latex inner gloves, and nitrile or neoprene outer gloves with long cuffs (see pages 262 to 265).

Use a respirator that can filter **metal** dust and fumes (see pages 266 to 270).

Noble gases

Noble gases are very stable chemicals that do not react easily with other chemicals and are not flammable. Many noble gases are normally found in the air. This means you breathe in small amounts of noble gases every day.

Noble gases are used in electronics. They are used in light bulbs for computer screens, televisions, and projectors. They are mixed with halogens (chlorine and fluorine) to make ultraviolet lasers that are used to make integrated circuits. The gases come in either compressed gas or liquid and gas form. You might work with noble gases in gas form, but a leak from a container can be liquid or gas.

These gases are not very toxic but they can be harmful in large amounts. Noble gases are asphyxiants. Asphyxiant gases replace oxygen in the air so there is less of it to breathe. Without oxygen you can die. Before entering a room with large amounts of noble gas, make sure that there is enough oxygen in the room or have a respirator mask with its own air supply.

The charts include only some of the noble gases that exist. See pages 178 to 184 and page 464 for how to find information about other noble gases. See the Index of chemical names on page 467 to find alternative names for noble gases.

Prevent or reduce exposure:

- Use ventilation systems that extract fumes and replace or dilute dirty air with clean air (see chapter 17: Ventilation).
- Wear gloves. Wear correct respirators that fit you. All protective clothing should be clean, available each day, put on before work, and never taken home with you (see chapter 18: Personal protective equipment).
- Have an emergency plan that includes first aid treatment and protective equipment for spills, splashes, and accidental exposures. Keep necessary emergency supplies at the work site well stocked and accessible to workers.
- Work areas where noble gases are used, stored, and mixed need to be controlled for heat and monitored for concentration of fumes and vapors.

Noble gases

Krypton (Kr) – CAS No. 7439-90-9

Neon (Ne)– CAS No. 7440-01-9

Xenon (Xe) – CAS No. 7440-63-3

What are they?

Noble gases are colorless gases that have no smell or taste. However, all noble gases (with the exception of **radon**) produce a bright colorful light when electric current is passed through a gas-filled space such as a tube. They are used to create light.

Do you work with them?

Noble gases are used to fill lamp bulbs in projectors and tubes in the electronics industry. They help light up electronic screens such as plasma televisions and plasma computer monitors. A gas mixture is placed between two glass sheets, one of which is the front screen. When the device is turned on, electricity passes through, interacts with the gas, and creates a visible picture on the screen. **Noble gases** are also found in ultraviolet lasers that are used to make circuit boards.

When they come in contact with your body

Skin: They may cause discomfort to your skin. In gas form they are not toxic to the skin, but if a liquid form touches you, it will burn quickly, but the skin will feel cold and numb. Treat it quickly as a chemical burn. See First Aid on page 175.

Eyes: They may cause discomfort to your eyes. In gas form, they are not toxic to the eyes, but a liquid form can cause severe eye burns. See First Aid on page 175.

Nose/lungs: The fumes can cause dizziness, headache, weakness, confusion, and suffocation. **Noble gases** take the place of oxygen in the room. Without enough oxygen, you can lose consciousness and die very quickly. Make sure there is enough oxygen before entering a room with noble gases present. See First Aid on page 174.

Mouth/belly: This is not a common way of coming into contact with **noble gases**.

When you are exposed over time:

Noble gases are not known to have dangerous long-term health effects.

If you are at risk of exposure:

Use cold-insulating gloves, an apron, and eye/face protection when handling cylinders in which gases are stored (see chapter 18: Personal protective equipment).

Use a supplied-air respirator (see pages 268 to 270).

Phthalates

Phthalates are oily, thick, colorless liquid chemicals. They are called "plasticizers" and added to plastic shoe soles, rubber material, and electronic cables to make them more bendable and soft.

Plastics such as polyvinyl chloride (PVC, see page 512) contain phthalates.

Phthalates get in your body and interfere with hormones. They harm the person in contact with them, but they also harm the person's future children. Daughters of people who come in contact with phthlates have an increased chance of developing breast cancer. Your future children, both sons and daughters, may develop fertility problems if you are exposed to phthalates.

The charts include only some of the phthalates that exist. See pages 178 to 184 and page 464 for how to find information about other phthalates. See the Index of chemical names on page 467 to find alternative names for phthalates.

Prevent or reduce exposure:

- The most harmful route of exposure is through your mouth. Wash your hands very carefully before eating, drinking, and smoking to prevent any ingestion of phthalate particles.
- Phthalates do not evaporate as easily as some other liquid chemicals. But you should still have ventilation systems that extract fumes and dilute the air (see chapter 17: Ventilation).
- Do not mix or pour phthalates by hand.
- Wear gloves and other protective equipment when handling phthalates (see chapter 18: Personal protective equipment).
- Have an emergency plan that includes first aid treatment and protective equipment for spills, splashes, and accidental exposures. Keep necessary emergency supplies at the worksite, well stocked, and accessible to workers.

Phthalates

Butyl benzyl phthalate (BBP) – CAS No. 85-68-7	
Di(2-ethylhexyl)phthalate – CAS No. 117-81-7	
Dibutyl phthalate (DBP) – CAS No. 84-74-2	
Diethyl phthalate (DEP)– CAS No. 84-66-2	
Dimethyl phthalate (DMP) – CAS No. 131-11-3	
Dioctyl phthalate (DOP) – CAS No. 117-84-0	

What are they?

Phthalates are colorless, oily, thick liquids. Some may have a very slight sweet smell. Others have no smell at all.

Do you work with them?

Phthalates are used in the shoe industry to make soles softer and more flexible. **Dioctyl phthalate** is used to make rubber. **Phthalates** are added to glues and, in electronics, the plastic used to cover wires.

When they come in contact with your body

Skin: They can irritate and burn your skin. See First Aid on page 175.

Eyes: They can irritate your eyes. See First Aid on page 175.

Nose/lungs: They can irritate your nose, throat, and lungs, causing coughing, wheezing, and shortness of breath. You may also become dizzy and lightheaded. See First Aid on page 174.

Mouth/belly: If they get into your mouth and belly, they can cause nausea, vomiting, and diarrhea. See First Aid on page 176 and seek medical help.

When you are exposed over time:

All phthalates may harm your kidneys and liver, and can damage the nervous system causing weakness and numbness in the hands and feet.

Butyl benzyl phthalate, **dibutyl phthalate**, **di(2-ethylhexyl)phthalate**, and **dimethyl phthalate** may reduce fertility in men and women and may damage the baby in the womb. **Dioctyl phthalate** may damage the baby in the womb.

Butyl benzyl phthalate and **dibutyl phthalate** may cause cancer. **Di(2-ethylhexyl) phthalate** can cause cancer.

(continued)

Phthalates *(continued)*

If you are at risk of exposure:

Use elbow-length, butyl rubber, nitrile rubber or polyvinyl alcohol gloves and eye/face protection (see chapter 18: Personal protective equipment).

Use a respirator with a full face mask and air filter (see pages 266 to 270.

Safer substitutes:

Some alternative chemicals are **citrate esters**, **adipates** and **phosphates**. But many chemicals in these groups can also cause harm. **Dioctyl terephthalate** is a safer, phthalate-free alternative although its name might make you think it contains **phthalates**.

Polymers

Polymers are made of many chemicals called "monomers" that are linked together. A polymer is like a chain of paperclips. Each paperclip represents one monomer. Different polymers are made of different monomers and are linked in different ways. Things made from polymers can be rubbery like shoe soles, sticky like glue, or hard like plastic.

Polymers are often used in electronics, shoes, and textiles.

Polymers are not as toxic as the monomers that link together to make them. But a polymer can break down into individual toxic monomers that can harm you. Also, before a polymer becomes a hard plastic, strong rubber, or sticky glue, a worker may use many harmful chemicals to mold and cure the polymer into the desired shape or form.

The name of the polymer often contains the names of the monomers linked together to make it. The chart includes only a few of the many polymers that exist. See pages 178 to 184 and page 464 for how to find information about other polymers. See the Index of chemical names on page 467 to find alternative names for polymers.

Prevent or reduce exposure:

- Use ventilation systems that extract fumes and replace or dilute dirty air with clean air (see chapter 17: Ventilation).
- Enclose operations whenever possible.
- Do not mix or pour polymers by hand.
- Use gloves when handling polymers. Wear correct respirators that fit you. All protective clothing should be clean, available each day, put on before work, and never taken home with you (see chapter 18: Personal protective equipment).
- Have an emergency plan that includes first aid treatment and protective equipment for spills, splashes, and exposures. Keep necessary emergency supplies at the work site well stocked and accessible to workers.
- Work areas where polymers are used, stored, and mixed need to be controlled for heat and monitored for concentration of fumes and vapors. The work areas should also have alarms, fire extinguishers, and a fire emergency plan (see chapter 11: Fire).

Polymers

Ethylene vinyl acetate (EVA) – CAS No. 24937-78-8

Phenol formaldehyde (PF) resin – CAS No. 9003-35-4

Polyurethane (PU) – CAS No. 9009-54-5

⊘ **Polyvinyl chloride (PVC) – CAS No. 9002-86-2**

What are they?

Polymers come in both liquids and solids. **Ethylene vinyl acetate** comes as white powder that smells like wax, while its monomer, **Vinyl acetate**, is a clear liquid with a strong, sweet smell. **Phenol formaldehyde resin** is a liquid with a slight pleasant smell. **Polyurethane** comes as liquid or solid, while its monomer, **Urethane**, is a white flour-like powder or sand-like crystal. **Polyvinyl chloride** comes as white powder or pellets, while its monomer, **Vinyl chloride**, is a colorless gas with a sweet smell, but it is used as a liquid under pressure.

Do you work with them?

Polymers are used to make rubber in shoe soles. They are used to make plastics and textiles. **Phenol formaldehyde** is a resin used in photoresist in electronics and in textiles to prevent wrinkles. **Polymers** are also used in glues.

When they come in contact with your body

Skin: They irritate your skin. You may develop a skin rash, redness, dryness, and blisters. Your skin might start peeling, itching, and cracking. See First Aid on page 175.

Eyes: They irritate your eyes. See First Aid on page 175.

Nose/lungs: The vapors and dusts irritate your nose, throat, and lungs, causing congestion, coughing, sneezing, and shortness of breath. They can cause dizziness, confusion, and headaches. See First Aid on page 174.

Mouth/belly: If they get into your mouth and belly, they can cause nausea, stomach pain, vomiting, and diarrhea. See First Aid on page 176 and seek medical attention.

When you are exposed over time:

Polymers are not as toxic to people as the monomers they contain. But when cut, heated, or manipulated, polymers and their byproducts can release dangerous dust and vapors.

Vinyl acetate in **EVA** may affect the heart, nervous system, and liver. It may reduce fertility in men. It may cause cancer.

(continued)

Polymers *(continued)*

Phenol formaldehyde resin releases **formaldehyde**, which can damage your lungs, cause bronchitis and asthma, and may damage a baby inside the womb and reduce fertility in women. See **Formaldehyde** on page 496.

Urethane in **Polyurethane** can damage kidneys, liver, brain, and bone marrow. It may cause cancer. It may damage and cause cancer in a baby inside the womb.

Vinyl chloride in **PVC** can damage the liver, nervous system, and lungs. It may damage a baby inside the womb, reduce fertility in men, and cause miscarriages. It can cause liver, brain, lung, and other cancers. In electronics, workers using **PVC** are often exposed to **lead** and **cadmium** (see pages 503 to 505), and **phthalates** (see pages 508 to 510).

If you are at risk of exposure:

Use ethylene vinyl alcohol gloves and eye/face protection (see chapter 18: Personal protective equipment). Do not heat or work with large amounts of **polymers** at once.

Use a respirator, especially when there is a lot of dust or vapor, when working with large surfaces, or when heating **polymers**. See Respirators on pages 266 to 270.

Safer substitutes:

Alternatives to **phenol formaldehyde resin** are **glyoxal resin** and **polymeric carboxylic acid**. A safer alternative to **PVC** is **polyethylene**. An alternative is not to use **polymers** at all and to use metal or glass instead.

Radiation

Radiation is a form of energy that travels as invisible waves through air away from the radiation source. Radiation used in electronics includes radiofrequency (RF) radiation, ultraviolet (UV) light, and x-rays. A lot of radiation comes from the sun or elements in the earth around us. This type of radiation is called natural radiation. Other radiation is man-made, such as that used in manufacturing.

Some types of radiation are more dangerous than others. The higher the amount of energy, the more dangerous the radiation. X-rays are more dangerous than UV light, but UV light is more dangerous than RF radiation.

You can be exposed to a large amount of radiation all at once or to smaller amounts over a long period of time. Whole-body exposure to radiation is more damaging than if only a small part of your body comes in contact with radiation.

Prevent or reduce exposure:

- Distance, time and shielding are the main ways to reduce radiation exposure. Placing yourself far away from the radiation source, spending less time near the source, and shielding yourself behind a radiation-proof barrier will help control exposure to harmful radiation.
- Enclose machines with a radiation-proof shield.
- Avoid contact with machines. Use a remote control to operate them.
- Avoid looking directly at a radiation source.
- Wear protective equipment and clothing (see chapter 18: Personal protective equipment).
- Always turn off a machine that could give off radiation when it is not in use. Turn off, tag out, and lock out the machine for repairs.
- Warning signs and radiation level monitors should be posted around work areas. Workers in the area should wear radiation monitoring badges.

Radiation

Radiofrequency (RF) radiation	
Ultraviolet (UV) light	
X-ray	 

What are they?

Radiation is an invisible form of energy. You need special equipment to detect and measure radiation. If you are close to an **RF radiation** heater and feel that your skin is getting warmer and your body temperature increases, you are being exposed to harmful **RF radiation**. But even if you don't feel warm, radiation can go through your skin and cause harm.

Do you work with them?

Radiation is mostly found in the electronics industry. **RF radiation** is used in heaters for dry etching and for dopant deposits on wafers. **X-rays** are produced from dopant deposits on wafers. **UV light** is used during the photolithography process in chip production. In the shoe industry, **RF radiation** is used to heat or melt rubber and glue, and in the garment industry to dry textile webs.

When they come in contact with your body

Skin: They severely burn your skin. **UV light** causes reddening and darkening of the skin.

Eyes: They severely burn your eyes. **UV light** causes photokeratitis and conjunctivitis. Signs of photokeratitis are pain, watery eyes, and blurred vision. It feels like you have sand in your eyes. Signs of conjunctivitis are watery eyes and discomfort. High levels of **RF radiation** and **UV light** causes eye cataracts. Signs of cataracts are clouded and blurred vision, sensitivity to light, difficulty seeing at night, and fading of colors. If exposed to large amounts of **RF radiation** and **UV light**, you may become blind.

Nose/lungs: Inhaling the dust of a material exposed to radiation damages your respiratory tract and causes harm over time.

Mouth/belly: Ingesting the dust of a material exposed to radiation may damage your digestive tract and cause more harm over time.

When you are exposed over time:

All radiation can harm your organs and damage your immune system.

RF radiation may harm your nervous system and affect your reflexes and heart rate. It can cause miscarriages, affect the menstrual cycle, and decrease breastmilk in nursing women. It may reduce fertility in men. It can harm a baby in the womb.

UV light can cause skin cancer.

X-rays can cause all types of cancer. **X-rays** can reduce fertility in men and women. They are also very damaging to the baby in the womb.

(continued)

Radiation *(continued)*

If you are at risk of exposure:

Use radiation-proof suits, gloves, and goggles. When working with **UV lights** use nitrile gloves and wear a long-sleeved shirt . For **RF radiation**, electrically insulating gloves can protect against **RF** burns. For **X-ray radiation**, use lead-lined gloves.

Wear a radiation monitoring badge.

Solvents

Solvents come in liquid form and are used as cleaners, added to glues to make them stronger or quicker to dry, and are part of many mixes of chemicals in shoe, garment, and electronics industries.

Most solvents quickly burn and explode when exposed to heat. They also release more vapors and fumes when heated.

There are many "families" of solvents. Solvents that are similar share many qualities, and are often used in the same processes. In some families, there are several chemicals that are more dangerous than other chemicals in the same family. Some entire families of solvents are dangerous to people's health, for example, aromatic hydrocarbons (see page 522) and chlorinated hydrocarbons (see page 524). The best way to protect workers who use solvents is to ban the most dangerous solvents and find less dangerous substitute solvents.

The charts include only some of the solvents that exist. See pages 178 to 184 and page 464 for how to find information about other solvents. See the Index of chemical names on page 467 to find alternative names for solvents.

Prevent or reduce exposure:

- Use ventilation systems that extract fumes and replace or dilute dirty air with clean air (see chapter 17: Ventilation).
- Enclose operations whenever possible.
- Do not mix or pour solvents by hand.
- Use gloves when workers are handling solvents directly (cleaning). Wear correct respirators that fit you. All protective clothing should be clean, available each day, put on before work, and never taken home with you (see chapter 18: Personal protective equipment).
- Have an emergency plan that includes first aid treatment and protective equipment for spills, splashes, and accidental exposures. Keep necessary emergency supplies at the work site well stocked and accessible to workers.
- Work areas where solvents are used, stored, and mixed need to be controlled for heat and monitored for concentration of fumes and vapors. The work areas should also have alarms, fire extinguishers, and a fire emergency plan (see chapter 11: Fire).

Alcohol solvents

Ethyl alcohol (ethanol) – CAS No. 64-17-5

Isopropyl alcohol (IPA) – CAS No. 67-63-0

Methyl alcohol (methanol) – CAS No. 67-56-1

What are they?

Alcohol solvents are colorless liquids. **Ethanol** smells a little like wine. **IPA** smells musty. **Methanol** has a slightly sweet odor.

Do you work with them?

Alcohol solvents are used as cleaners. They are used to make rubber for shoes, to spot clean fabric, to electroplate, and in printed circuit boards. **IPA** and **methanol** are the most common.

When they come in contact with your body

Skin: They irritate your skin. After continued or repeated exposure to **alcohols**, you may develop a skin rash, redness, and dryness. Your skin might start peeling, itching, and cracking. See First Aid on page 175.

Eyes: They irritate, burn, and can cause permanent damage to the eyes. **Methanol** will blur your vision and can cause blindness. See First Aid on page 175.

Nose/lungs: The fumes can irritate your nose and throat, causing coughing and wheezing. Breathing the vapors can make you feel weak, dizzy, lightheaded, short of breath, and even pass out. **IPA** can slow down your pulse and lower your blood pressure, and at high levels it can cause hallucinations. See First Aid on page 174.

Mouth/belly: They can lead to loss of appetite, nausea, vomiting, and diarrhea. Larger amounts could cause loss of consciousness. See First Aid on page 176 and seek medical attention.

When you are exposed over time:

All alcohols can harm your liver, kidneys, and nervous system. **Alcohols** can enter into a mother's milk and pass to a baby through breastfeeding.

Ethanol can cause miscarriages, birth defects, and other problems. It may cause cancer of the liver, esophagus, breast, prostate, and colorectum.

Isopropyl alcohol may damage a baby in the womb.

Methanol may damage a baby in the womb.

(continued)

Alcohol solvents *(continued)*

If you are at risk of exposure:

Use butyl gloves. Polyvinyl alcohol (PVA) gloves will not protect you from **alcohol solvents**. If you're working with **alcohols** as liquids, use indirect-vent, impact- and splash-resistant goggles (see chapter 18: Personal protective equipment).

If there is no ventilation installed, or if you are doing maintenance work and you do not know the level of **alcohol** in the air, use a respirator that can filter **solvents**.

Aliphatic hydrocarbon solvents (petroleum distillates)

2,2-Dimethylbutane (neohexane) - CAS No. 75-83-2		
2-Methylpentane - CAS No. 107-83-5		
Cyclohexane - CAS No. 110-82-7		
Heptane - CAS No. 142-82-5		
Hexane - CAS No. 110-54-3		

What are they?

Aliphatic hydrocarbon solvents are colorless liquids. **Hexane** and **heptane** have a mild, gasoline-like smell. **Cyclohexane** has a strong, sweet smell.

Do you work with them?

Aliphatic hydrocarbon solvents are used in glues for shoes and as cleaners in electronics. They are used in surface coatings and adhesives. **Cyclohexane** is used to make nylon.

When they come in contact with your body

Skin: They can irritate and burn your skin. If they get on your skin repeatedly, your skin will become dry, cracked, and red and you might develop a rash. See First Aid on page 175.

Eyes: They can irritate the eyes. See First Aid on page 175.

Nose/lungs: Inhalation of these solvents can lead to irritation of the nose and throat. Breathing the vapors can cause you to feel weak, dizzy, lightheaded, and short of breath, and even pass out. See First Aid on page 174.

Mouth/belly: They can lead to loss of appetite, nausea, vomiting, and diarrhea. See First Aid on page 176 and seek medical attention.

When you are exposed over time:

All **aliphatic hydrocarbons** can affect your brain, causing headaches and dizziness.

2,2-dimethylbutane can cause irregular heartbeat.

Cyclohexane may permanently damage the liver and kidney. It can cause headaches, convulsions, and other problems with the nervous system.

Heptane can cause damage to the nervous system, causing reduced coordination and personality changes, fatigue, and reduced memory and concentration.

(continued)

Aliphatic hydrocarbon solvents *(continued)*

Hexane can damage the nervous system, causing problems with coordination, memory and concentration, personality changes, and fatigue. It may damage the testes. High doses can be fatal.

If you are at risk of exposure:

Use nitrile or *Viton* gloves and eye/face protection (see chapter 18: Personal protective equipment).

Use a respirator that can filter organic **solvents** (see pages 266 to 270).

Safer substitutes:

Heptane is less toxic than **hexane.**

Aromatic hydrocarbon solvents

⊘ **Benzene – CAS No. 71-43-2**	
⊘ **Styrene – CAS No. 100-42-5**	
Toluene – CAS No. 108-88-3	
Xylene – CAS No. 1330-20-7	

What are they?

Aromatic hydrocarbon solvents are clear, colorless to light yellow liquids that have sweet odors.

Do you work with them?

Aromatic hydrocarbon solvents are found in garment, shoe, and electronics factories. **Toluene** is a common additive for glues in shoes, and **styrene** is found in resins that reinforce plastics in electronics.

When they come in contact with your body

Skin: They irritate your skin and lead to dermatitis, which results in skin rash, dryness, redness, and a burning feeling. **Benzene** can cause blisters. See First Aid on page 175.

Eyes: They irritate your eyes. **Benzene** can make you blind. See First Aid on page 175.

Nose/lungs: The fumes can irritate your nose and throat, causing coughing and wheezing. Breathing the vapors can cause headaches, drowsiness, dizziness, confusion, nausea, weakness, and loss of consciousness. **Benzene** can cause bronchitis, lung edema, and pneumonia. It can cause problems with the heart. Breathing a lot of **benzene** (20,000 ppm) can kill you in 10 to 15 minutes. **Toluene** affects the nervous system, causing difficulty thinking, slow reflexes, dilated pupils, anxiety, and weakness. See First Aid on page 174.

Mouth/belly: Benzene and **xylene** can cause nausea, vomiting, and abdominal pain. **Benzene** can cause rapid heart rate, difficulty breathing, chest tightness, and respiratory failure, all of which can be fatal. See First Aid on page 176 and seek medical attention.

When you are exposed over time:

All aromatic hydrocarbons can damage your liver, kidneys, brain, and the nervous system.

Benzene can cause problems with the blood and destroy blood cells. This can cause aplastic anemia. It may cause birth defects. It can cause leukemia (cancer of the blood).

Styrene may cause birth defects and other reproductive health problems. It may cause lung cancer.

Toluene may cause birth defects.

Xylene may cause birth defects. It may cause cancer. Higher exposures can cause coma.

(continued)

Aromatic hydrocarbon solvents *(continued)*

If you are at risk of exposure:

Use polyvinyl alcohol (PVA), *Silver Shield*, or *Viton* gloves. If you work with **aromatic hydrocarbons** as liquids, use indirect vent, impact- and splash-resistant goggles. If you are exposed to fumes, gas, or vapor forms of these **solvents**, use non-vented, impact-resistant goggles (see chapter 18: Personal protective equipment).

Use a respirator that can filter **solvents** (see pages 266 to 270.)

Safer substitutes:

Toluene has been used as a safer alternative to **benzene**. However, **toluene** is still toxic.

Chlorinated hydrocarbon solvents

⊘ **Carbon tetrachloride - CAS No. 56-23-5**	
Dichloropropane (DCP) - CAS No. 78-87-5	
Methyl chloroform - CAS No. 71-55-6	
Methylene chloride (DCM) - CAS No. 75-09-2	
Tetrachloroethylene (PERC) - CAS No. 127-18-4	
⊘ **Trichloroethylene (TCE) - CAS No. 79-01-6**	

What are they?

Chlorinated hydrocarbon solvents are colorless liquids that contain chlorine. They have a mild, sweet smell.

Do you work with them?

Chlorinated hydrocarbon solvents are used as cleaners. They are used to make rubber for shoes, degreasers in electroplating, and as agents in wafer production and semiconductor cleaning.

When they come in contact with your body

Skin: They can irritate your skin. **Carbon tetrachloride** can burn your skin. **TCE** might make you allergic, and you will have a reaction even at low exposure levels. See First Aid on page 175.

Eyes: They can irritate and burn the eyes. **Carbon tetrachloride** can make you blind if it gets in your eyes. See First Aid on page 175.

Nose/lungs: The fumes can irritate your nose and throat. Breathing the fumes can cause you to feel weak, dizzy, lightheaded, short of breath, and to pass out. Often you will also have poor equilibrium, lack of coordination, mental confusion, and numb and tingling limbs. Inhaling **Dichloropropane** and **PERC** fumes can create a buildup of fluid in the lungs, called lung edema. See First Aid on page 174.

Mouth/belly: They can lead to loss of appetite, nausea, vomiting, and diarrhea. See First Aid on page 176 and seek medical attention.

When you are exposed over time:

All **chlorinated hydrocarbons** can damage the liver and kidneys.

Carbon tetrachloride can lead to coma. It may damage a baby in the womb and reduce fertility in men. It may cause cancer.

(continued)

Chlorinated hydrocarbons *(continued)*

Dichloropropane can cause liver cancer.

Methyl chloroform may cause miscarriages and birth defects. It also may cause liver and kidney cancer.

Methylene chloride may cause lung, liver, and breast cancer.

PERC may damage a baby in the womb, decrease fertility in men and women, and cause miscarriages. It can cause many types of cancer including liver, esophagus, bladder, lung, and leukemia (cancer of the blood).

TCE can lead to irregular heartbeat. It can cause birth defects and it can cause liver, kidney, and lung cancer.

If you are at risk of exposure:

Use gloves. If you are working with these chemicals in liquid form, use indirect-vent, impact- and splash resistant goggles. If you are exposed to fumes, gas, or vapors, use non-vented goggles (see chapter 18: Personal protective equipment).

Use a respirator that can filter **solvents** (see pages 266 to 270).

Safer substitutes:

Bromopropane has been used as a safer substitute for **TCE**. But it can cause cancer so it is not a real solution.

Ester solvents

Butyl acetate - CAS No. 123-86-4	
Ethyl acetate - CAS No. 141-78-6	
Isobutyl acetate - CAS No. 110-19-0	

What are they?

Ester solvents are colorless liquids with a pleasant, fragrant, fruity odor. **Butyl acetate** smells like bananas.

Do you work with them?

Ester solvents are used in garments, shoes, and electronics as glues, surface cleaners, and to make plastic materials.

When they come in contact with your body

Skin: They can irritate and burn your skin. If they get on your skin repeatedly, your skin will become dry, cracked, and red and you might develop a rash. See First Aid on page 175.

Eyes: They can irritate and burn the eyes. See First Aid on page 175.

Nose/lungs: The fumes can irritate your nose and throat. Breathing the vapors can cause you to feel weak, dizzy, lightheaded, short of breath, and to pass out. See First Aid on page 174.

Mouth/belly: They can lead to loss of appetite, nausea, vomiting, and diarrhea. See First Aid on page 176 and seek medical attention.

When you are exposed over time:

Butyl acetate may damage a baby in the womb. **Butyl acetate** can irritate your lungs and damage your nervous system. You may develop bronchitis along with coughing, phlegm, and shortness of breath.

Ethyl acetate may damage liver and kidneys. It may decrease fertility in men.

If you are at risk of exposure:

Use neoprene or butyl rubber gloves and eye/face protection (see chapter 18: Personal protective equipment)**.**

Use respirator that can filter organic **solvents** (see pages 266 to 270).

Glycol ether solvents

ETHYLENE-BASED GLYCOL ETHERS
These are more toxic and have "ethanol" or "ethylene" in the name.

Ethylene glycol butyl ether (EGBE) – CAS No. 111-76-2

Ethylene glycol ethyl ether (EGEE) – CAS No. 110-80-5

Ethylene glycol methyl ether (EGME) – CAS No. 109-86-4

PROPYLENE-BASED GLYCOL ETHERS
These are less toxic and have "propanol" or "propylene" in their name.

1-Methoxy 2-propanol – CAS No. 107-98-2

2-Methoxy 1-propanol – CAS No. 1589-47-5

What are they?

Glycol ether solvents are colorless liquids. They have a mild, pleasant smell or no smell at all.

Do you work with them?

Glycol ether solvents are used as cleaners, dyes, and coatings in shoe, garment and electronics factories. They are often ingredients of proprietary mixes.

When they come in contact with your body

Skin: They irritate and burn your skin. You may develop a skin rash, redness, and dryness. Your skin might start peeling, itching, and cracking. See First Aid on page 175.

Eyes: They irritate and burn your eyes. See First Aid on page 175.

Nose/lungs: Some **glycol ethers** evaporate quickly and can easily be inhaled. Their fumes can irritate your nose and throat, causing coughing, wheezing, and shortness of breath. Breathing the vapors can cause you to feel weak, dizzy, lightheaded, disoriented, and tired. See First Aid on page 174.

Mouth/belly: They can lead to loss of appetite, nausea, vomiting, and weight loss. See First Aid on page 176 and seek medical attention.

When you are exposed over time:

All **glycol ethers** can harm your liver, kidneys, and nervous system, causing trembling and weakness. **Glycol ethers** can enter mother's milk and pass to a baby through breastfeeding.

(continued)

Glycol ether solvents *(continued)*

Ethylene-based glycol ethers can cause anemia by damaging red blood cells and bone marrow. Some **ethylene-based glycol ethers** can decrease fertility in women and men and damage the baby in the womb.

Ethylene glycol butyl ether may cause liver cancer.

Ethylene glycol ethyl ether is slightly less toxic, but can also decrease fertility in women and men and harm the baby in the womb.

Ethylene glycol methyl ether can cause changes in personality, memory loss, and chronic headaches. Breathing large amounts may damage the spleen and produce bloody urine. It can decrease fertility in women and men, damage the testes, and is extremely toxic to the baby in the womb.

Propylene-based glycol ethers are less dangerous than **ethylene-based glycol ethers**.

2-methoxy, 1-propanol can damage the baby in the womb.

If you might come in contact with them:

Use butyl rubber gloves. If these are not available, use neoprene or nitrile gloves. Use eye/face protection (see chapter 18: Personal protective equipment).

Use a respirator that can filter **glycol ether** fumes (see pages 266 to 270).

Safer substitutes:

Glycol ethers such as **propyl ether, isopropyl ether,** and **phenyl ether** are less harmful to the reproductive organs and baby inside the womb. **Propylene-based glycol ethers** are safer than **ethylene-based glycol ethers.**

Ketone solvents

Acetone – CAS No. 67-64-1

Methyl butyl ketone (MBK) – CAS No. 591-78-6

Methyl ethyl ketone (MEK) – CAS No. 78-93-3

Methyl isobutyl ketone (MIBK) – CAS No. 108-10-1

What are they?

Ketone solvents are colorless liquids that have a pleasant, sweet or mint-like smell.

Do you work with them?

Ketone solvents are added to glues for shoes. They are used in surface coatings on electronics, as adhesives for PVC pipes, and as cleaners in shoes, garments, and electronics. **MIBK** is added to the rubber in shoes.

When they come in contact with your body

Skin: They can cause skin irritation. If they get on your skin repeatedly, your skin will become dry, cracked, and red and you might develop a rash. See First Aid on page 175.

Eyes: They can irritate and burn the eyes. See First Aid on page 175.

Nose/lungs: The fumes can irritate your nose and throat, causing coughing and wheezing. Breathing the vapors can cause you to feel weak, dizzy, lightheaded, short of breath, and to pass out. See First Aid on page 174.

Mouth/belly: They can lead to loss of appetite, nausea, vomiting, and diarrhea. See First Aid on page 176 and seek medical attention.

When you are exposed over time:

All **ketones** can damage the nervous system causing weakness and poor coordination in the hands and feet. They can damage the liver and kidneys.

MBK and **acetone** may reduce fertility in men. **Acetone** may cause miscarriages.

MEK may cause birth defects.

MIBK may cause cancer.

If you are at risk of exposure:

Use butyl rubber gloves and eye/face protection (see chapter 18: Personal protective equipment).

Use a respirator that can filter for organic **solvents** (see pages 266 to 270).