UNDERSTANDING TOXIC SUBSTANCES

An Introduction to Chemical Hazards in the Workplace

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Adapted from a booklet developed by the California Hazard Evaluation and Information Service (HESIS) – Occupational Health Branch, a joint service of the California Department of Health Services and the Dept. of Industrial Relations, Division of Occupational Safety and Health (Cal-OSHA). Original authors were Jon Rosenberg, MD, Mark Nicas, MS, MPH and Yo Yomashiro – University of California, Davis

Introduction

Hazardous substances are used in many workplaces today. Working people are discovering that they need to know more about the health effects of chemicals, which they use or may be exposed to on the job. Textbooks, fact sheets, and material safety data sheets (MSDSs) provide important information, but they are often written in hard-to-understand technical language. To help you better understand technical information about hazardous workplace chemicals, this booklet explains how chemicals can affect the body, what to look for when reading health information, the different types of exposure limits for chemicals in the workplace, tips on how to know if you are exposed, what you can do to reduce exposure, and where to go for additional information.

What makes a chemical toxic?

The toxicity of a substance is its ability to cause harmful effects. These effects can strike a single cell, a group of cells, an organ system, or the entire body. A toxic effect may be visible damage, or a decrease in performance or function measurable only by a test. All chemicals can cause harm. When only a very large amount of the chemical can cause damage, the chemical is considered to be practically non-toxic. When a tiny amount is harmful, the chemical is considered to be highly toxic.

The toxicity of a substance depends on three factors: its chemical structure, the extent to which the substance is absorbed by the body, and the body's ability to detoxify the substance (change it into less toxic substances) and eliminate it from the body.

Are "toxic" and "hazardous" the same?

No. The toxicity of a substance is the potential of that substance to cause harm, and is only one factor in determining whether a hazard exists. The hazard of a chemical is the practical likelihood that the chemical will cause harm. A chemical is determined to be a hazard depending on the following factors:

toxicity: how much of the substance is required to cause harm,

route of exposure: how the substance enters your body,

dose: how much enters your body,

duration: the length of time you are exposed,

reaction and interaction: other substances you are exposed to at the same time, and,

sensitivity: how your body reacts to the substance compared to other people.

Some chemicals are hazardous because of the risk of fire or explosion. These are important dangers, but are considered to be safety rather than toxic hazards. The factors of a toxic hazard are more fully explained below.

Why are some chemicals more harmful than others?

The most important factor in toxicity is the chemical structure of a substance-what it is made of, what atoms and molecules it contains and how they are arranged. Substances with similar structures often cause similar health problems. However, slight differences in chemical structure can lead to large differences in the type of health effect produced. For example, silica in one form (amorphous) has little effect on health, and is allowed to be present in the workplace at relatively high levels. After it is heated, however, it turns into another form of silica (crystalline) that causes serious lung damage at levels 200 times lower than amorphous silica.

Routes of exposure

How can chemicals enter the body?

Exposure normally occurs through inhalation, skin or eye contact, and ingestion.

Inhalation The most common type of exposure occurs when you breathe a substance into the lungs. The lungs consist of branching airways (called bronchi) with clusters of tiny air sacs (called alveoli) at the ends of the airways. The alveoli absorb oxygen and other chemicals into the bloodstream.

Some chemicals are irritants and cause nose or throat irritation. They may also cause discomfort, coughing, or chest pain when they are inhaled and come into contact with the bronchi (chemical bronchitis). Other chemicals may be inhaled without causing such warning symptoms, but they still can be dangerous.

Sometimes a chemical is present in the air as small particles (dust or mist). Some of these particles, depending on their size, may be deposited in the bronchi and/or alveoli. Many of them may be coughed out, but others may stay in the lungs and may cause lung damage. Some particles may dissolve and be absorbed into the blood stream, and have effects elsewhere in the body.

Skin Contact The skin is a protective barrier that helps keep foreign chemicals out of the body. However, some chemicals can easily pass through the skin and enter the bloodstream. If the skin is cut or cracked, chemicals can penetrate through the skin more easily. Also, some caustic substances, like strong acids and alkalis, can chemically burn the skin. Others can irritate the skin. Many chemicals, particularly organic solvents, dissolve the oils in the skin, leaving it dry, cracked, and susceptible to infection and absorption of other chemicals.

Eye Contact Some chemicals may burn or irritate the eye. Occasionally they may be absorbed through the eye and enter the bloodstream. The eyes are easily harmed by chemicals, so any eye contact with chemicals should be taken as a serious incident.

Ingestion The least common source of exposure in the workplace is swallowing chemicals. Chemicals can be ingested if they are left on hands, clothing or beard, or accidentally contaminate food, drinks or cigarettes. Chemicals present in the workplace as dust, for example, metal dusts such as lead or cadmium, are easily ingested.

What makes a chemical toxic?

Dose: How much is too much?

In general, the greater the amount of a substance that enters your body, the greater is the effect on your body. This connection between amount and effect is called the "dose-response relationship".

For example, organic solvents such as toluene, acetone, and trichloroethylene all affect the brain in the same way, but to different degrees at different doses. The effects of these solvents are similar to those that result from drinking alcoholic beverages. At a low dose, you may feel nothing or a mild, sometimes pleasant ("high") sensation. A larger dose may cause dizziness or headache. With an even larger dose you may become drunk, pass out, or even stop breathing.

When you inhale a toxic chemical, the dose you receive depends on four factors: (1) the level (concentration) of chemical in the air; (2) how hard (fast and deep) you are breathing, which depends on your degree of physical exertion; (3) how much of the chemical that is inhaled stays in your lungs and is absorbed into your bloodstream; and (4) how long the exposure lasts.

It is safest to keep exposure to any toxic substance as low as possible. Since some chemicals are much more toxic than others, it is necessary to keep exposure to some substances lower than others. The threshold level is the lowest concentration that might produce a harmful effect. It is different for every chemical. The threshold for one chemical may differ from person to person (see "Sensitivity"). If the concentration of a chemical in the air is kept well below the threshold level, harmful effects probably will not occur. Levels above the threshold are "too much." However, this means only that there is a possibility that health effects might occur, not that such effects definitely will occur (see "What are exposure limits?").

Duration: How long is too long?

The longer you are exposed to a chemical, the more likely you are to be affected by it. The dose is still important-at very low levels you may not experience any effects no matter how long you are exposed. At higher concentrations you may not be affected following a short-term exposure, but repeated exposure over time may cause harm.

Chemical exposure which continues over a long period of time is often particularly hazardous because some chemicals can accumulate in the body or because the damage does not have a chance to be repaired. The combination of dose and duration is called the rate of exposure.

The body has several systems, most importantly the liver, kidneys and lungs, that change chemicals to a less toxic form (detoxify) and eliminate them. If your rate of exposure to a chemical exceeds the rate at which you can eliminate it, some of the chemical will accumulate in your body. For example, if you work with a chemical for eight hours each day, you have the rest of the day (16 hours) to eliminate it from your body before you are exposed again the next day. If your body can't eliminate all the chemical in 16 hours and you continue to be exposed, the amount in the body will accumulate each day you are exposed. Illness that affects the organs for detoxification and elimination, such as hepatitis (inflammation of the liver), can also decrease their ability to eliminate chemicals from the body.

Accumulation does not continue indefinitely. There is a point where the amount in the body reaches a maximum and remains the same as long as your exposure remains the same. This point will be different for each chemical. Some chemicals, such as ammonia and formaldehyde, leave the body quickly and do not accumulate at all. Other chemicals are stored in the body for long periods. For instance, lead is stored in the bone, calcium is stored in the liver and kidneys, and polychlorinated biphenyls (PCBs) are stored in body fat. There are a few substances, such as asbestos fibers, that, once deposited, remain in the body forever.

Latency: How long does it take for a toxic effect to occur?

The effects of toxic substances may appear immediately or soon after exposure, or they may take many years to appear. Acute exposure is a single exposure or a few exposures. Acute effects are those which occur following acute exposures. Acute effects can occur immediately, or be delayed and occur days or weeks after exposure. Chronic exposure is repeated exposure that occurs over months and years. Chronic effects are those which occur following chronic exposures, and so are always delayed.

A toxic chemical may cause acute effects, chronic effects or both. For example, if you inhale solvents on the job, you may experience acute effects such as headaches and dizziness which go away at the end of the day. Over months, you may begin to develop chronic effects such as liver and kidney damage.

The delay between the beginning of exposure and the appearance of disease caused by that exposure is called the “latency period”. Some chronic effects caused by chemicals, such as cancer, have very long latency periods. Cancer has been known to develop as long as 40 years after a worker's first exposure to a cancer-causing chemical.

The length of the latency period for chronic effects makes it difficult to establish the cause-and-effect relationship between the exposure and the illness. Since chronic diseases develop gradually, you may have the disease for some time before it is detected. It is, therefore, important for you and your physician to know what chronic effects might be caused by the substances you use on the job.

What are the differences between acute and chronic effects?

Acute	**Chronic**
Occurs immediately or soon after exposure (short latency).	Occurs over time or long after exposure (long latency)
Often involves a high exposure (large dose) over a short period.	Often involves low exposures (small doses) over a long period.
Often reversible after exposure stops.	Many effects are not reversible.
Can be minor or severe. For example, a small amount of ammonia can cause throat or eye irritation; larger amounts can be serious or even fatal.	Chronic effects are still unknown for many chemicals. For example, most chemicals have not been tested for cancer or reproductive effects.
Relationship between chemical exposure and symptoms is generally, although not always, obvious.	It may be difficult to establish the relationship between chemical exposure and illness because of the long time delay or latency period.
Knowledge often based on human exposure.	Knowledge often based on animal studies.

Reaction and interaction: What if you're exposed to more than one chemical?

Depending upon the job you have, you may be exposed to more than one chemical. If you are, you need to be aware of possible reactions and interactions between them. A reaction occurs when chemicals combine with each other to produce a new substance. The new substance may have properties different from those of the original substances, and it could be more hazardous. For example, when household bleach and lye (such as a drain cleaner) are mixed together, highly dangerous chlorine gas and hydrochloric acid are formed. The Material Safety Data Sheet (MSDS) for a chemical will often list its potential hazardous reactions and the substances which should not be mixed with it. An employer is required by law to have an MSDS for each hazardous substance in the workplace, and make them available for employees on request.

An interaction occurs when exposure to more than one substance results in a health effect different from the effects of either one alone. One kind of interaction is called synergism, a process in which two or more chemicals produce an effect that is greater than the sum of their individual effects. For instance, carbon tetrachloride and ethanol (drinking alcohol) are both toxic to the liver. If you are overexposed to carbon tetrachloride and drink alcohol excessively, the damage to your liver may be much greater than the effects of the two chemicals added together.

Another example of synergism is the increased risk of developing lung cancer caused by exposures to both cigarette smoking and asbestos. By either smoking one pack of cigarettes per day or being heavily exposed to asbestos, you may increase your risk of lung cancer to six times higher than someone who does neither. But if you smoke a pack a day and are heavily exposed to asbestos, your risk may be 90 times higher than someone who does neither.

Another interaction is potentiation, which occurs when an effect of one substance is increased by exposure to a second substance which would not cause that effect by itself. For example, although acetone does not damage the liver by itself, it can increase carbon tetrachloride's ability to damage the liver.

Unfortunately, few chemicals have been tested to determine if interactions with other chemicals occur.

Sensitivity: Are some people more affected than others?

Yes. People vary widely in their sensitivity to the effects of a chemical. Many things determine how an individual will react to a chemical. These include age, sex, inherited traits, diet, pregnancy, state of health and use of medication, drugs or alcohol. Depending on these characteristics, some people will experience the toxic effects of a chemical at a lower (or higher) dose than other people.

People may also become allergic to a chemical. These people have a different type of response than those who are not allergic. This response frequently occurs at a very low dose. Not all chemicals can cause allergic reactions. Substances that are known to cause allergies are called allergens, or sensitizers.

For example, formaldehyde gas is very irritating. Everyone will experience irritation of the eyes, nose, and throat, with tears in the eyes and a sore throat, at some level of exposure. All people will experience irritation if exposed to high enough levels. A person may be more sensitive to formaldehyde and have irritation at low levels of exposure. Formaldehyde also occasionally causes allergic reactions, such as allergic dermatitis, or hives. A few people may be allergic to formaldehyde and develop hives at very low levels, although most people will not get hives no matter how much they are exposed to formaldehyde.

How can toxic substances harm the body?

When a toxic substance causes damage at the point where it first contacts the body, that damage is called a local effect. The most common points at which substances first contact the body are the skin, eyes, nose, throat and lungs. Toxic substances can also enter the body and travel in the bloodstream to internal organs. Effects that are produced this way are called systemic. The internal organs most commonly affected are the liver, kidneys, heart, nervous system (including the brain) and reproductive system.

A toxic chemical may cause local effects, systemic effects, or both. For example, if ammonia gas is inhaled, it quickly irritates the lining of the respiratory tract (nose, throat and lungs). Almost no ammonia passes from the lungs into the blood. Since damage is caused only at the point of initial contact, ammonia is said to exert a local effect. An epoxy resin is an example of a substance with local effects on the skin. On the other hand, if liquid phenol contacts the skin, it irritates the skin at the point of contact (a local effect) and can also be absorbed through the skin, and may damage the liver and kidneys (systemic effects).

Sometimes, as with phenols, the local effects caused by a chemical provide a warning that exposure is occurring. You are then warned that the chemical may be entering your body and producing systemic effects which you can't yet see or feel. Some chemicals, however, do not provide any warning at all, and so they are particularly hazardous. For example, glycol ethers (Cellosolve solvents) can pass through the skin and cause serious internal damage without producing any observable effect on the skin.

Do all toxic chemicals cause cancer?

No. Cancer, the uncontrolled growth and spread of abnormal cells in the body, is caused by some chemicals but not others. It is not true that "everything causes cancer" when taken in large enough doses. In fact, most substances do not cause cancer, no matter how high the dose. Only a relatively small number of the many thousands of chemicals in use today cause cancer.

Chemicals that can cause cancer are called carcinogens and the ability to cause cancer is called carcinogenicity. Evidence for carcinogenicity comes from either human or animal studies. There is enough evidence for about 30 chemicals to be called carcinogenic in humans. About 200 other chemicals are known to cause cancer in laboratory animals and are, therefore, likely to be human carcinogens.

Determining the causes of cancer in humans is difficult. There is usually a long latency period (10 to 40 years) between the start of exposure to a carcinogen and the appearance of cancer. Thus, a substance must be used for many years before enough people will be exposed to it long enough for researchers to see a pattern of increased cancer cases. It is often difficult to determine if an increase in cancer in humans is due to exposure to a particular substance, since exposure may have occurred many years before, and people are exposed to many different substances.

Since the study of cancer in humans is difficult and requires that people be exposed to carcinogenic chemicals and possibly get cancer, chemicals are tested for carcinogenicity using laboratory animals. If animals were exposed to the low levels typical of most human exposure, many hundreds of animals would be required for only a few to get cancer. To avoid this expense, animal cancer tests use large doses of chemicals in order to be able to detect an increase in cancer in a reasonable number of animals, such as 25-50. However, animal tests are still expensive, take about three years to perform, and are often inconclusive. When an animal cancer test is positive, the risk to a small number of rats at high doses must be used to try to predict the risk to humans at much lower doses. Chemicals that cause cancer in animals are considered likely to cause cancer in humans, even if the degree of risk is uncertain.

The issue of whether there is a safe dose for a carcinogen is controversial. Some scientists believe that any exposure, no matter how small, carries some risk. However, at very low exposures, the risk, if any, may be so small that it can be considered the same as no risk at all. Most carcinogens appear to require either exposure over a number of years or very high doses before the risk of developing cancer from exposure to them becomes of serious concern.

Do all toxic chemicals cause mutations?

Toxic chemicals can also cause genetic damage. The genetic material of a cell consists of genes, which exist in chromosomes. Genes and chromosomes contain the information that tells the cell how to function and how to reproduce (form new cells).

Some chemicals may change or damage the genes or chromosomes. This kind of change, or damage in a cell is called a mutation. Anything that causes a mutation is called a mutagen. Mutations may affect the way the cell functions or reproduces. The mutations can also be passed on to new cells that are formed from the damaged cell. This can lead to groups of cells that do not function or reproduce the same way the original cell did before the mutation occurred.

Some kinds of mutation result in cancer. Most chemicals that cause cancer also cause mutations. However, not all chemicals that cause mutations cause cancer.

Tests for the ability of a chemical to cause a mutation take little time and are relatively easy to perform. If testing shows a chemical to be a mutagen, additional testing must be done to determine whether or not the chemical also causes cancer.

Can future generations be affected?

Exposure to chemical substances may affect your children or your ability to have children. Toxic reproductive effects include the inability to conceive children (infertility or sterility), lowered sex drive, menstrual disturbances, spontaneous abortions (miscarriages), stillbirths, and defects in children that are apparent at birth or later in the child's development.

Teratogens are chemicals, which cause malformations or birth defects by directly damaging tissues in the fetus developing in the mother's womb. Other chemicals that harm the fetus are called fetotoxins. If a chemical causes health problems in the pregnant woman herself, the fetus may also be affected. Certain chemicals can damage the male reproductive system, resulting in sterility, infertility, or abnormal sperm.

There is not enough information on the reproductive toxicity of most chemicals. Most chemicals have not been tested for reproductive effects in animals. It is difficult to predict risk in humans using animal data. There may be "safe" levels of exposure to chemicals that affect the reproductive system. However, trying to determine a "safe" level is very difficult, if not impossible. It is even more difficult to study reproductive effects in humans than it is to study cancer. At this time, only a few industrial chemicals are known to cause birth defects or other reproductive effects in humans.

What are the different forms of toxic materials?

Toxic materials can take the form of solids, liquids, gases, vapors, dusts, fumes, fibers and mists. How a substance gets into the body and what damage it causes depends on the form or the physical properties of the substance.

A toxic material may take different forms under varying conditions and each form may present a different type of hazard. For example, lead solder in solid form is not hazardous because it is not likely to enter the body. Soldering, however, turns the lead into a liquid, which may spill or come into contact with skin. When the spilled liquid becomes solid again, it may be in the form of small particles (dust) that may be inhaled or ingested and absorbed. If lead is heated to a very high temperature such as when it is welded, a fume may be created; a fume consists of very small particles that are extremely hazardous as they are easily inhaled and absorbed. It is thus important to know what form or forms a given substance takes in the workplace. A description of each of the forms follows.

Solid. A solid is a material that retains its form, like stone. Most solids are generally not hazardous since they are not likely to be absorbed into the body, unless present as small particles such as dust.

Liquid. A liquid is a material that flows freely, like water. Many hazardous substances are in liquid form at normal temperatures. Some liquids can damage the skin. Some pass through the skin and enter the body and may or may not cause skin damage. Liquids may also evaporate (give off vapors), forming gases which can be inhaled.

Gas. A gas consists of individual chemical molecules dispersed in air, like oxygen, at normal temperature and pressure. Some gases are flammable, explosive, and/or toxic. The presence of a gas may be difficult to detect if it has no color or odor, and does not cause immediate irritation. Such gases, like carbon monoxide, may still be very hazardous.

Vapor. A vapor is the gas form of a substance that is primarily a liquid at normal pressure and temperature. Most organic solvents evaporate and produce vapors. Vapors can be inhaled into the lungs, and in some cases may irritate the eyes, skin or respiratory tract. Some are flammable, explosive and/or toxic. The term vapor pressure or evaporation rate is used to indicate the tendency for different liquids to evaporate.

Dust. A dust consists of small solid particles in the air. Dusts may be created when solids are pulverized or ground, or when powder (settled dust) becomes airborne. Dusts may be hazardous because they can be inhaled into the respiratory tract. Larger particles of dust are usually trapped in the nose and windpipe (trachea) where they can be expelled, but smaller particles (respirable dust) can reach and may damage the lungs. Some, like lead dust, may then enter the bloodstream through the lungs. Some organic dusts, such as grain dust, may explode when they reach high concentrations in the air.

Fume. A fume consists of very small, fine solid particles in the air which form when solid chemicals (often metals) are heated to very high temperatures, evaporate to vapor, and finally become solid again. The welding or brazing of metal, for example, produces metal fumes. Fumes are hazardous because they are easily inhaled. Many metal fumes can cause an illness called metal fume fever, consisting of fever, chills and aches like the "flu." Inhalation of other metal fumes, such as lead, can cause poisoning without causing metal fume fever.

Fiber. A fiber is a solid particle whose length is at least three times its width. The degree of hazard depends upon the size of the fiber. Smaller fibers such as asbestos, can lodge in the lungs and cause serious harm. Larger fibers are trapped in the respiratory tract; and are expelled without reaching the lung.

Mist. A mist consists of liquid particles of various sizes, which are produced by agitation or spraying of liquids. Mists can be hazardous when they are inhaled or sprayed on the skin. The spraying of pesticides and the machining of metals using metal working fluids are two situations where mists are commonly produced.

What are exposure limits?

Exposure limits are established by health and safety authorities to control exposure to hazardous substances. In Washington State, “Permissible Exposure Limits (PELs)” are set forth in WISHA regulations. By law, Washington employers who use these regulated chemicals must control employee exposures to be below the PELs for these substances. Permissible exposure limits usually represent the maximum amount (concentration) of a chemical that can be present in the air without presenting a health hazard. However, permissible exposure limits may not always be completely protective, for the following reasons:

1. Although exposure limits are usually based on the best available information, this information, particularly for chronic (long-term) health effects, may be incomplete. Often we learn about chronic health effects only after workers have been exposed to a chemical for many years, and then as new information is learned, the exposure limits are changed.

2. Exposure limits are set to protect most workers. However, there may be a few workers who will be affected by a chemical at levels below these limits (see

"Sensitivity"). Employees performing extremely heavy physical exertion breathe in more air and more of a chemical, and so may absorb an excessive amount.

3. Exposure limits do not take into account chemical interactions. When two or more chemicals in the workplace have the same health effects, industrial hygienists use a mathematical formula to adjust the exposure limits for those substances in that workplace. This formula applies to chemicals that have additive effects, but not to those with synergistic or potentiating effects (see "Reaction and Interaction").

4. Exposure limits usually apply to the concentration of a chemical in the air, and are established to limit exposure by inhalation. Limiting the concentration in air may not prevent excessive exposure through skin contact or ingestion. Chemicals that may produce health effects as a result of absorption through the skin have an "S" designation next to their numerical value in the PEL table. Workers exposed to these chemicals must be provided with protective clothing to wear when overexposure through the skin is possible. Some chemicals, like lead and cadmium in dust form, may be ingested through contamination of hands, hair, clothes, food and cigarettes.

In Washington, Permissible Exposure Limits (PELs) are enforced by the Department of Labor & Industries – WISHA Division. PELs have been set for about 600 chemicals. An employer can be cited and/or fined if employee exposure levels exceed the PELs listed in the Respiratory Hazards Rule – WAC 296-841.

There are three types of WISHA PELs:

1. The 8-Hour Time Weighted Average (TWA) is the average employee exposure over an 8-hour period, based on industrial hygiene monitoring. The measured level may sometimes go above the TWA value, as long as the 8-hour average stays below. All chemicals with PELs have a TWA value.

2. The Ceiling Limit is the maximum allowable level. It must never be exceeded, even for an instant. Only a few chemicals have a Ceiling limit.

3. The Short Term Exposure Limit(STEL)is a value that can be exceeded only for a specified short period of time (between 5-15 minutes). When there is an STELfor a substance, exposure still must never exceed the Ceiling Limit, and the 8-hour average still must remain below the TWA. Most chemicals with PELs have a STEL value.

How can exposure be measured and monitored?

When toxic chemicals are present in the workplace, your exposure can be determined by measuring the concentration of a given chemical in the air and the duration of exposure. This measurement is called air or environmental monitoring or sampling and is usually done by industrial hygienists, using various types of instruments. The air is collected from your breathing zone (the air around your nose and mouth) so that the concentrations measured will accurately reflect the concentration you are inhaling. The exposure levels calculated from this monitoring can then be compared to the Permissible Exposure Limit (PEL) for that chemical.

Environmental monitoring is the most accurate way to determine your exposure to most chemicals. However, for chemicals that are absorbed by routes other than inhalation, such as through the skin and by ingestion, air monitoring may underestimate the amount of chemical you absorb. For these and some other chemicals, the levels of the chemical (or its breakdown products) in the body can sometimes be measured in the blood, urine or exhaled air. Such testing is called biological monitoring, and the results may give an estimate of the actual dose absorbed into the body. For one substance, lead, biological monitoring is required by law when air monitoring results are above a certain level. The American Conference of Governmental Industrial Hygienists (ACGIH) has recommended the exposure limits for biological monitoring for a small number of chemicals. These are called Biological Exposure Indices (BEIs) and are published together with TLVs.

Practical clues to exposure

Odor.

If you smell a chemical, you are inhaling it. However, some chemicals can be smelled at levels well below those that are harmful, so that detecting an odor does not mean that you are inhaling harmful amounts. On the other hand, if you cannot smell a chemical, it may still be present. Some chemicals cannot be smelled even at levels that are harmful.

The odor threshold is the lowest level of a chemical that can be smelled by most people. If a chemical's odor threshold is lower than the amount that is hazardous, the chemical is said to have good warning properties. One example is ammonia. Most people can smell it at 5 ppm, below the PEL of 25 ppm. It is important to remember that for most chemicals, the odor thresholds vary widely from person to person. In addition, some chemicals, like hydrogen sulfide, cause you to rapidly lose your ability to smell them (called olfactory fatigue). With these cautions in mind, knowing a chemical's odor threshold may serve as rough guide to your exposure level.

Don't depend on odor to warn you. Remember that your sense of smell may be better or worse than average, that some very hazardous chemicals have no odor (carbon monoxide), some chemicals of low toxicity have very strong odors (mercaptans added to natural gas), and others produce olfactory fatigue.

Taste.

If you inhale or ingest a chemical, it may leave a taste in your mouth. Some chemicals have a particular taste, which may be mentioned in an MSDS.

Particles in Nose or Throat.

If you cough up mucous (sputum or phlegm) with particles in it, or blow your nose and see particles on your handkerchief, then you have inhaled some chemical in particle form. Unfortunately, most particles which are inhaled into the lungs are too small to see.

Settled Dust or Mist.

If chemical dust or mist is in the air, it will eventually settle on work surfaces or on your skin, hair and clothing. If settled dust or mist is visible, it is possible you inhaled some of this chemical while it was in the air.

Immediate Symptoms.

If you or your co-workers experience symptoms known to be caused by a chemical during or shortly after its use, you may have been overexposed. Symptoms might include tears in your eyes; a burning sensation of skin, nose, or throat; a cough; dizziness or a headache.

Can you be tested for health effects of exposure?

Sometimes. Medical surveillance is a program of medical examinations and tests designed to detect early warning signs of harmful exposure. A medical surveillance program may discover small changes in health before severe damage occurs. Testing for health effects is called medical monitoring. The type of testing needed in a surveillance program depends upon the particular chemical involved. Unfortunately, medical monitoring tests that accurately measure early health effects are available only for a small number of chemicals. A complete occupational surveillance program should consist of industrial hygiene monitoring, medical monitoring, and biological monitoring when appropriate. Tests for health effects when you are already sick are not part of medical surveillance, and must be selected by your physician on a case by case basis.

When there is possible employee exposure to certain chemicals, such as asbestos and lead, employers are required by WISHA regulations to establish medical surveillance programs. Employees have the right under WISHA regulations to see and copy their own medical records and records of exposure to toxic substances. Employers must keep these records for at least 30 years after the end of employment of workers.

How can exposures be reduced?

Knowledge

Everyone who works with toxic substances should know the names, toxicity and other hazards of the substances they use. Employers are required by law to provide this information, along with training in how to use toxic substances safely. A worker may obtain information about a chemical's composition, physical characteristics, and toxicity from the Material Safety Data Sheet (MSDS). WISHA regulations, require manufacturers to supply an MSDS for -products that contain certain toxic substances. Employers obtain the MSDS when they purchase the product and must make the MSDS available to employees. Unfortunately, the precise chemical composition is often proprietary (trade secret) information, and the toxicity information on an MSDS may be incomplete and unreliable.

Engineering controls

Limiting exposure at the source is the preferred way to protect workers. The types of engineering controls, in order of effectiveness, are:

Substitution is using a less hazardous substance. But before choosing a substitute, carefully consider its physical and health hazards. For example, mineral spirits (Stoddard Solvent) is less of a health hazard than perchloroethylene for dry cleaning, but is more of a fire hazard and an air pollutant.

Process or equipment enclosure is the isolation of the source of exposure, often through automation. This completely eliminates the routine exposure of workers. For example, handling of radioactive materials is often done by mechanical arms or robots.

Local exhaust ventilation is a hood or air intake at or over the source of exposure to capture or draw contaminated air from its source before it spreads into the room and into your breathing zone.

General or dilution ventilation is continual replacement and circulation of fresh air sufficient to keep concentrations of toxic substances diluted below hazardous levels. However, concentrations will be highest near the source, and overexposure may occur in this area. If the dilution air is not well mixed with the room air, pockets of high concentrations may exist.

Personal Protective Equipment

Personal protective equipment (respirators, gloves,, googles, aprons) should be used only when engineering controls are not possible or are not sufficient to reduce exposure.

Respiratory protective equipment consists of devices that cover the mouth and nose to prevent substances in the air from being inhaled. A respirator is effective only when used as part of a comprehensive program established by the employer, which includes measurement of concentrations of all hazardous substances, selection of the proper respirator, training the worker in its proper use, fitting of the respirator to the worker, maintenance, and replacement of parts when necessary.

Protective clothing includes gloves, aprons, goggles, boots, face shields, and any other materials worn as protection. It should be made of material designed to resist penetration by the particular chemical being used. Such material may be called impervious to that chemical. The manufacturer of the protective clothing usually can provide some information regarding the substances that are effectively blocked.

Barrier creams are special lotions used to coat the skin and prevent chemicals from reaching it. They may be helpful when the type of work prevents the use of gloves. However, barrier creams are not recommended as substitutes for gloves. Cosmetic skin creams and lotions (such as moisturizing lotion) are not barrier creams.

Checklist for researching toxic substances used on the job

In order to determine the health risks of substances you use or may be exposed to on the job, and to find out how to work with them safely, you need to obtain information from many sources including material safety data sheets (MSDSs), medical and monitoring records; and reference materials. The law requires employers to make much of this information available to employees. The following checklist will help you gather facts, which you can use along with the information in this pamphlet to get the answers you need.

What is the substance? What's in it? How toxic is it? Are health effects acute, chronic, or both?

Is there evidence based on research with animals or humans that the substance is a carcinogen? A mutagen? A teratogen or reproductive toxin?

How does this substance enter the body (routes of entry): inhalation, skin absorption, ingestion?

What is the legal exposure limit (PEL) or recommended safe exposure limit?

To how much of the substance are you being exposed? What is the concentration of the substance in the workplace air? How long are you exposed?

Are you exposed to other chemicals at the same time? Can they have a combined (additive or synergistic) effect?

Do you have any medical conditions or take any drugs that might interact with chemicals?

What controls are recommended to prevent overexposure?

Is any type of medical testing recommended?

Additional information

The following sources have additional information on the toxicity of specific chemicals.

National Institute of Occupational Safety & Health (NIOSH) – Reduce Contamination at Home - http://www.cdc.gov/niosh/thttext.html

NIOSH – Pocket Guide to Chemical Hazards - http://www.cdc.gov/niosh/npg/npg.html

American Conference of Governmental Industrial Hygienists (ACGIH) - http://www.acgih.org/home.htm

Agency for Toxic Substances & Disease Registry (ATSDR) – ToxFAQs - http://www.atsdr.cdc.gov/toxfaq.html

New Jersey Dept. of Health – Hazardous Substance Fact Sheets - http://www.state.nj.us/health/eoh/rtkweb/rtkhsfs.htm