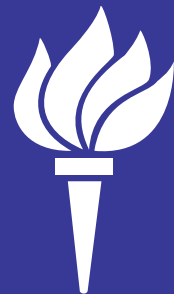


New York University

Laboratory Safety Handbook



EMERGENCY PHONE NUMBERS

NYU WASHINGTON SQUARE

- **Environmental Services** 8-1450
.....
- **Security/Public Safety** 8-2222
.....
- **Health Center** 3-1111
.....
- **Poison Control** (9) 212 764-7667
.....

The use of hazardous chemicals in laboratories is recognized by several authorities as being a potential health and safety hazard for the laboratory staff. It is for this reason that the Occupational Safety and Health Administration (OSHA) passed the Occupational Exposure to Hazardous Chemicals in Laboratories Standard (29 CFR 1910.1450). Furthermore, New York University is committed to fostering a work environment where the staff is well informed about the hazards of their work environment, and knows how to carry out their duties in a manner that protects both their health and safety.

THE OSHA LABORATORY STANDARD

The Laboratory Standard is a flexible performance standard that requires that employers who hire laboratory workers must do the following:

- Develop a written policy that describes how laboratory workers are protected from hazardous chemicals in the workplace.
- Maintain an inventory of hazardous chemicals and material safety data sheets.
- Provide health and safety information and training for laboratory workers.
- Provide medical consultation for employees suspected of being over exposed.
- Appoint a responsible person to oversee the program.

NYU CHEMICAL HYGIENE PROGRAM

A copy of the current Chemical Hygiene Plan is located on our website at <http://www.nyu.edu/environmental.services/policies>. Basic information regarding responsibilities is summarized below:

Environmental Services is responsible for the following elements of the program:

- Maintaining an inventory of hazardous chemicals and providing material safety data sheets (MSDS) to laboratories upon request. For more information on MSDSs and helpful links, go to our website at www.edu/environmental.services/msds
- Conducting the required health and safety training programs
- Performing testing of fume hoods
- Conducting exposure evaluations and monitoring when necessary

- Providing emergency spill training and response
- Implementing the respiratory protection program
- Maintaining necessary records
- Providing employees with copies of MSDS, the Chemical Hygiene Program, and the OSHA Standard upon request (Contact Environmental Services at 998-1450).
- Setting up medical consultation through the University Health Center.

Laboratory Managers are responsible for the following:

- Ensuring employees attend the training sessions
- Designating areas for extremely hazardous chemical operations
- Informing the Chemical Hygiene Officer of the use of extremely hazardous substances in the laboratory
- Ensuring employees follow standard operating procedures
- Informing employees of air monitoring results
- Informing Environmental Services of employee's changes in exposures

Employees are responsible for:

- Following all standard operating procedures
- Attending the safety training sessions
- Reporting any hazards or incidents to the laboratory supervisor

LABORATORY SAFETY HANDBOOK

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The hazard of a chemical is the risk, probability, or practical likelihood that the substance will cause harm under a specified condition. 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. A chemical is determined to be a hazard depending on the following factors:

- **Toxicity:** the amount of the substance required to cause harm
- **Route of exposure:** how the substance enters your body
- **Duration:** the length of time you are exposed
- **Frequency:** how many times you are exposed
- **Dose:** how much enters your body
- **Reaction and interaction:** the possibility that certain chemicals may combine with other chemicals to create a greater hazard, and
- **Sensitivity:** how your body reacts to the substance, compared to other people.

TOXICITY

Toxic effects are produced by a chemical if it reaches an appropriate site in the body at a concentration and for a length of time sufficient to produce a toxic response. The toxicity of a substance depends on three factors: its chemical and physical structure, the extent to which the substance is absorbed by the body, and the body's ability to detoxify and remove the substance. However, slight differences in chemical structure can lead to large differences in the type of health effect produced. For example, benzene, at one time commonly used in laboratories, has been shown to cause leukemia, a cancer of the blood. Toluene, which is structurally similar to benzene, is not a carcinogen and can be used as a substitute for this chemical.

The body has several systems, most importantly the liver, kidneys, and lungs, that can excrete and detoxify chemicals. The kidney, which receives a large volume of blood from the body, is a very efficient organ for the elimination of toxic chemicals by excreting potentially harmful substances into the

urine. The lungs may also serve to remove toxic chemicals, particularly highly volatile liquids. The liver serves as the primary organ that detoxifies or biotransforms substances into a less harmful substance. However, sometimes the product can be biotransformed into a substance more toxic than the original. For example, methanol can be converted to formaldehyde, a more toxic chemical.

It should also be noted that if the rate of exposure to a chemical exceeds the rate at which it can be eliminated, some of the chemical will accumulate and be stored in the body. Accumulation does not continue indefinitely. There is a point at which the amount in the body reaches a maximum and remains at that level as long as the rate of exposure remains the same. This point will be different for each chemical. Some chemicals, such as ammonia and formaldehyde, are efficiently excreted and do not accumulate at all. Other chemicals are stored in the body for longer periods. For instance, lead is stored in the bone, calcium is stored in the liver and kidneys, and polychlorinated biphenyls (PCBs) are stored in the fat. There are a few substances, such as asbestos fibers, that, once deposited, remain in the body forever. A concurrent illness that affects an organ, such as hepatitis (inflammation of the liver) and nephritis (inflammation of the kidney), can also decrease the functional ability of these organs to eliminate chemicals from the body.

ROUTES OF EXPOSURE

How a substance gets into the body is often determined by its form or physical properties. A toxic material may take on several different forms, each having its own route of entry into the body and each posing different hazards. It is important to know what form or forms a substance is in when the potential for exposure exists. Toxicologists classify substances into the following different forms: dusts, gases and vapors, liquids, solids, fumes and mists. Each of these forms has different physical properties and will enter the body through a preferred route.

Exposure normally occurs through inhalation, skin or eye contact, and ingestion. These are often referred to as the "routes of exposure."

Inhalation

Inhalation is the major route of entry for gases, vapors, mists, fumes, and respirable dusts. The lungs consist of branching airways (called bronchi) with clusters of tiny air sacs (called alveoli) at the ends of the airways. It is through these alveoli that the exchange of oxygen and carbon dioxide, to and from the bloodstream takes place.

Water-soluble gases, such as ammonia and chlorine, dissolve in the upper respiratory tract and may immediately irritate the nose or throat. They may also cause discomfort, coughing, or chest pain when they are inhaled (chemical bronchitis). Other gases may be inhaled without causing such warning symptoms (i.e., cyanide, ozone, phosgene), but they still can be dangerous because they travel deeper into the lung and to other systemic sites. Gases, vapors, and mists that are fat soluble can enter into the bloodstream and migrate to fat stores in the body.

Sometimes a chemical is present in the air as small particles (fume, dust, or mist). Some of these particles, depending on their size, may be deposited deep in the respiratory track, in the bronchi, and/or alveoli. Many of them may be coughed out or removed by mucocilliary action, but others may remain in the lungs and may cause permanent lung damage. Some particles may dissolve and be absorbed into the bloodstream or lymphatic system and cause effects elsewhere in the body.

Skin

The skin is a very efficient protective barrier that was long thought to keep many foreign chemicals out of the body. However, a surprising number of chemicals easily pass through the skin and enter the bloodstream. Generally, substances soluble in both water and fat go through the skin easily, fat soluble the most, and water soluble the least. Solvents, particularly the organic solvents commonly used in laboratories, dissolve the oil in the cutaneous layer and are able to enter the bloodstream rapidly.

If the skin is cut or cracked, chemicals can penetrate through the skin more easily. Also, some corrosive substances, like strong acids and alkalis, can chemically burn or irritate the skin. Once the skin is damaged, it becomes highly susceptible to further absorption of chemicals.

Following are some examples of toxic chemicals that are readily absorbed through the skin:

- acrylamide
- 2-butoxyethanol and (other glycol ethers)
- n-butyl alcohol
- cyclohexanone
- methyl butyl ketone
- cyclohexanol
- dichloroethyl ether
- dimethylformamide
- dinitrobenzene
- 1,1-dimethylhydrazine
- hydrazine
- mercury (inorganic and organic)
- methyl bromide
- methyl hydrazine
- methyl iodide
- r-nitroaniline (and other anilines)
- nitrobenzene
- nitroglycerin
- pentachlorophenol
- phenol
- picric acid
- thallium (soluble)
- tin (organic)
- toluidine

Eye Contact

Many chemicals used in laboratories may burn or irritate the eye. Occasionally they may be absorbed through the conjunctiva in the eye and enter the bloodstream. The eyes are extremely sensitive to chemicals, so any eye contact with chemicals or vapors should be taken as a serious incident.

Ingestion

The least common source of exposure in the laboratory is ingesting chemicals. However, chemicals can be inadvertently ingested if they contaminate your hands or clothing; accidentally contaminate food, drinks or cigarettes; or if a worker attempts to pipette by mouth, a forbidden practice. Fortunately, gastric and pancreatic juices minimize the toxic effects of chemicals which enter the body through this route. For many chemicals, absorption from the digestive system into the blood stream may be inefficient as well.

Puncture

If chemicals are present on the tip of a sharp object which punctures any part of the body these chemicals can now enter the blood stream and present harm. Extreme care should be taken when working with these objects particularly if infectious agents are present.

DOSE

Another factor which determines whether a chemical is toxic is the dose or how much of a chemical enters your body. As the father of toxicology, Paracelsus (1493-1541) said "All substances are poisons. The right dose differentiates a poison and a remedy." Some chemicals will produce death in trace amounts, some are harmless following even excessive exposure. In general, however, the higher the level of the toxic exposure, the greater the effect this exposure will have on your body. This connection between amount and effect is called the dose-response relationship.

For example, organic solvents used in laboratories, such as hexane, xylene and toluene all affect the brain to some extent, but to different degrees at different doses. The effects of these solvents are similar to those which 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, nausea or a headache. With an even larger dose you may become drunk, pass out or even stop breathing.

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 will produce a noticeable effect. Although the results of low level exposures are not clearly understood, if the concentration of a chemical in the air is kept well below the threshold level, harmful effects probably will not occur. The threshold level is different for every chemical, and for every individual. Some individuals are hypersensitive, that is they are very sensitive to small doses of chemicals that may not affect another person and some individuals are hyposensitive where they require much higher levels of exposure than the average person. Chemicals that cause cancer have a linear relationship with respect to dose and response. For a given dose of a carcinogen there is a known effect and the threshold concept does not exist.

DURATION

The longer you are exposed to a chemical, the more likely you are to be affected by it. At very low levels you may not experience any effects no matter how long you are exposed and at higher concentrations you may not be affected following a short-term exposure. 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.

FREQUENCY

When a person is repeatedly exposed to a chemical throughout the day or on different days, the effect this chemical will have on that person is increased. Although the times of exposure may be short and not continuous, if the exposure is present daily, the hazards associated with that exposure may be as severe as a long-term continuous exposure.

REACTION AND INTERACTION

The final factor determining whether a chemical is a hazard is its reaction and interaction with other chemicals. Most laboratory chemists are exposed to many chemicals on the job. Some combinations of chemicals can react to produce new substances that are more toxic than either of the parent compounds. The Material Safety Data Sheet for a chemical will list a chemical's well-known hazardous reactions and the substances that should not be combined with it.

An interaction occurs when exposure to more than one substance results in a health effect different from the effects of either one alone. There are several kinds of interactive effects. 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 example, carbon tetrachloride and ethanol (drinking alcohol) are both toxic to the liver. A metabolite of methylene chloride, a commonly used lab chemical, is carbon monoxide (CO). Cigarette smokers who inhale CO attain higher levels of carboxyhemoglobin in the blood. Exposure to methylene chloride also increases carboxyhemoglobin levels, and may increase risk of myocardial infarction (heart attack), especially among persons with preexisting heart disease. Another example of chemical interaction is that of consumed alcohol with concurrent exposure to organic solvents such as toluene. Many organic solvents can depress the central nervous system, potentiating the effects of the alcohol.

Potentialiation, another type of interaction, occurs when an effect of one substance is increased by exposure to a second substance that 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.

Additive effects are the third type of interaction chemicals may have. This effect is the least dangerous because the chemicals have the same effect when present together as if they were given separately.

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

SENSITIVITY

Another factor that determines whether a chemical is hazardous is sensitivity. People vary widely in their sensitivity to the effects of a chemical, depending on such factors as age, sex, inherited traits, diet, pregnancy, state of health, and use of medication, drugs, or alcohol. Depending on these factors, some people will experience the toxic effects of a chemical at a lower or higher dose than other people.

Some individuals may also become allergic to a chemical. This type of reaction occurs after initial exposure or exposures to a chemical causes an immune-mediated allergy to develop. An allergic response to a chemical can develop even at a very low dose. Substances that are known to cause allergies are called allergens, or sensitizers. A list of some important skin sensitizers can be found in Appendix III.

For example, formaldehyde vapors are extremely irritating. Everyone will experience irritation of the eyes, nose, and throat at some level of exposure. In a few cases, sensitization to formaldehyde occurs, resulting in asthmatic attacks, which return immediately upon subsequent exposure. Only a few people will develop this allergy, and most people will not become sensitized to formaldehyde no matter how much they are exposed.

TYPES OF TOXIC EFFECTS

Acute and Chronic Effects

The effects of toxic substances may appear immediately or soon after exposure, or they may take many years to appear.

Acute exposure is a short-term exposure or a few short exposures, usually occurring within the same 24 hour period. **Acute effects** are those that occur following acute exposure.

Chronic exposure can be a low-level continuous exposure or a short-term repeated exposure that occurs over months and years. **Chronic effects** are those that occur following chronic exposures, and so are always delayed.

A toxic chemical may cause acute effects, chronic effects or both. For many chemicals the toxic effects following an acute exposure may be quite different from those following long-term exposures. For

example, inhalation of certain solvents may result in acute effects such as headaches and dizziness that go away at the end of the day. Over months, chronic effects, such as liver and kidney damage, may develop.

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 first exposure to a cancer-causing chemical.

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

LOCAL AND SYSTEMIC EFFECTS

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 after entering the body and being distributed may also cause damage to one or more distant organs. Effects that are produced this way are called systemic effects. Most chemicals produce systemic effects at one or two target organs, rather than at sites throughout the body. The internal organs most commonly affected are the liver, 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, some solvents (glycol ethers) can pass through the skin and cause serious internal damage without producing any observable effects on the skin.

CANCER CAUSING CHEMICALS

Not all chemicals cause cancer. Cancer is the uncontrolled growth and spread of abnormal cells in the body. Only a relatively small number of the many thousands of chemicals in use today are known to 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 adequate evidence for about 50 chemicals to be considered carcinogenic in humans. About 200 other chemicals are known to cause cancer in laboratory animals and are therefore likely to be human carcinogens (see tables "Known and Probable Carcinogens" and "Potential Carcinogens" in Appendix III).

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 develop cancer, chemicals are tested for carcinogenicity using laboratory animals. Chemicals that cause cancer in animals are considered to have the potential to cause cancer in humans, even if the degree of risk is uncertain.

Chemical storage areas in the research laboratory setting include central stockrooms, storerooms, laboratory work areas, storage cabinets, and refrigerators and freezers. Each laboratory will comply with the following requirements and guidelines concerning:

- General requirements
- Segregation of incompatible chemicals
- Chemical storage categories and recommendations for some specific hazard chemical classes

GENERAL REQUIREMENTS

- Every chemical will have an identifiable storage place and must be returned to that location after use. A storage scheme must be developed in each chemical storage area to ensure the segregation of incompatibles. An effort must be made to isolate particularly flammable, reactive, and toxic materials. Because of the risk of placing incompatible materials side-by-side, a storage scheme based solely on alphabetizing is prohibited.
- The storage of working containers on bench tops will be minimized to prevent the accidental spilling of chemicals and to reduce the risk of fire.
- Compatible chemicals should be grouped by container size to make it easier to retrieve chemicals and to reduce the possibility of bottle breakage. Large containers should be stored on lower shelves. Chemicals will not be stored on the floor.
- Chemical storage in hoods should be kept to a minimum. Storing containers inside the hood interferes with airflow, reduces the work space, and increases the risk of a spill, fire, or explosion.
- Labels must be maintained on all stored materials and new labels affixed to secondary containers.
- Stored chemicals should be stored in amber bottles and not exposed to direct sunlight or heat.
- Storage trays should be used to minimize the spread of a spill.
- Laboratory refrigerators must never be used for food.
- All chemical containers left out of storage areas will be checked at the end of each workday. Unneeded items will be returned to chemical areas or stockrooms.
- All chemical containers in the following groups will be dated when they are initially opened:
 - ♦ Picrics
 - ♦ Peroxides
 - ♦ Chemicals that react violently, polymerize, or become hazardous after polymerization.
 - ♦ Perchlorates
 - ♦ Other materials known to deteriorate, or become unstable or reactive over time
 - ♦ Peroxidizable materials (aldehydes, ethers and compounds containing benzylic hydrogen atoms, e.g., cumene isopropyl benzene and most alkene, vinyl, and vinylidene compounds)
- Expiration dates will be assigned to these chemicals. When provided, the manufacturers' expiration date should be displayed.
- All laboratory personnel, upon notice of retirement, termination, transfer, or graduation, in conjunction with the laboratory supervisor and Chemical Hygiene Officer, will arrange for the removal or safe storage of all hazardous materials remaining in their work area.
- Appropriate spill-control, cleanup, and emergency equipment must be available wherever chemicals are stored.

SEGREGATION OF INCOMPATIBLE CHEMICALS

Chemicals must be segregated to prevent mixing of incompatible chemical vapors or liquids in the event that containers break or leak. Chemicals must not be arranged alphabetically or haphazardly in stockrooms or in laboratory work areas. It is acceptable to store solid chemicals alphabetically if hazard classes are segregated. Particular attention must be paid to isolating flammables, air-reactives, peroxidizables, and toxic chemicals.

CHEMICAL STORAGE CATEGORIES AND RECOMMENDATIONS

Compressed Gases

- The names of compressed gases must be prominently posted.
- Storage of flammable gases in laboratories is not permitted, except when being used. No more than twice the procedure's requirements will be present in the laboratory.
- Flammable gas cylinders should be stored in a separate area from other types of compressed gases.
- Cylinders of incompatible gases must be segregated by distance.
- Cylinders must be grouped by the type of gas (e.g. toxic, corrosive, etc.)
- Empty cylinders should be separated from non-empty cylinders and labeled "empty."
- All compressed gases must be stored away from direct or localized heat (including radiators, steam pipes, or boilers) in well-ventilated and dry areas and away from areas where heavy items may strike them (e.g., near elevators or service corridors).
- All compressed gases, including empty cylinders, must be secured in an upright position with chains, straps or special stands of adequate strength and must be capped when stored or moved.
- A hand truck must be available for transporting gas cylinders to and from storage areas.
- All gas cylinders must be hydrostatically tested within ten years.

Special attention must be paid to the following chemicals because of their potential instability.

Inorganic: Nitrates, nitrites, and azides

Perchlorates

Perchloric acid

Peroxides

Phosphorous

Phosphorous pentoxide

Organic: Ether

Azides

INCOMPATIBLE CHEMICAL GROUPS

#	Chemical group.....Do not store with group numbers
1	Inorganic acids2-8, 10, 11, 13, 14,16-19, 21-23
2	Organic acids.....1, 3, 4, 7, 14, 16, 17-19, 22
3	Caustics1, 2, 6, 7, 8, 13-18, 20, 22, 23
4	Amines, alkanolamines1, 2, 5, 7, 8, 13-18, 23
5	Halogenated compounds1, 3, 4, 11, 14, 17
6	Alcohols, glycols, glycol ethers1, 7, 14, 16, 20, 23
7	Aldehydes.....1-4, 6, 8, 15-17, 19, 20, 23
8	Ketones1, 3, 4, 7, 19, 20
9	Saturated hydrocarbons.....20
10	Aromatic hydrocarbons.....1, 20
11	Olefins1,5,20
12	Petroleum oils.....20
13	Esters.....1, 3, 4, 19, 20
14	Monomers, polymerizable esters1-6, 15, 16, 19-21,23
15	Phenols3, 4, 7, 14, 16, 19, 20
16	Alkylene oxides1-4, 6, 7, 14, 15, 17-19, 23
17	Cyanohydrins1-5, 7, 16, 19, 23
18	Nitriles1-4, 16, 23
19	Ammonia1, 2, 7, 8, 13-17, 20, 23
20	Halogens3, 6-15, 19, 21, 22
21	Ethers1, 14, 20
22	Elemental phosphorus1-3, 20
23	Acid anhydrides.....1, 3, 4, 6, 7, 14, 16-19

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Flammable Liquids

- No more than 15-gallons of flammable liquid may be stored in the laboratory.
- Flammable materials should be stored in cabinets that meet OSHA and National Fire Protection Association standards.
- Never store flammable liquids on the floor or other areas that create a spill hazard.
- Do not store flammable materials in a refrigerator unless it is explosion proof.
- An emergency spill kit for flammable liquids should be available nearby.

Oxidizers

- Oxidizers must be stored away from incompatible materials such as:
 - ◆ Flammables and combustible materials
 - ◆ Greases
 - ◆ Paper trash bins
 - ◆ Finely divided metals
 - ◆ Organic liquids
- Nitric acid, sulfuric acid, and perchloric acid should be stored separately from organic acids in rooms, cabinets, or break-resistant containers and placed in acidic-resistant trays.
- Strong oxidizing agents should be stored and used in glass or other inert containers. Corks and rubber stoppers should not be used. High energy oxidizers should be segregated.

Peroxides and Chemicals That Tend to Form Peroxides

- These must be stored in airtight containers in a dark, cool, and dry place.
- To minimize the rate of decomposition, peroxides and peroxidizable materials should be stored at the lowest possible temperature consistent with their solubility and freezing point. Liquid peroxide or solutions should not be stored at or below temperature the peroxide freezes or precipitates

at, because peroxides in these forms are extremely sensitive to shock and heat.

Toxics

- Extremely toxic substances must be stored in unbreakable chemically resistant secondary containers.
- These chemicals include corrosives, dehydrating agents, carcinogens, allergic sensitizers, and reproductive hazards. They also include chemicals known to affect the nervous system, the liver, the kidneys, or the respiratory system.
- Adequate ventilation must be provided in storage areas especially for toxics that have a high vapor pressure.
- All dispensing of these materials must be conducted in a fume hood.

Flammable materials, oxidizers, peroxides and other shock-sensitive compounds are listed in Appendix III.

LABORATORY HAZARD EVALUATION

An assessment of protocols and experiments should be conducted prior to initiating a new experiment or procedure. The laboratory supervisor must request a review of protocols by Environmental Services.

Laboratory personnel will be familiar with their own and previous evaluations prior to beginning work and will use appropriate ventilation, protective equipment, and procedures to minimize exposure.

Substitution as a primary method of control

Following a hazard evaluation, laboratory personnel should always consider substituting less hazardous and toxic substances. Only chemicals for which appropriate exposure controls are present may be used.

Reevaluation prior to modification of procedures

Laboratory employees should obtain approval from their supervisor and reevaluate the potential hazards of laboratory chemicals before proceeding with a new laboratory task, whenever one or more of the following applies:

- There will be unknown results.
- There is a significant change in procedure or test likely to alter the hazard. A significant change is defined as a 10% or greater increase or decrease in the amount of one or more chemicals used, a substitution or deletion of any of the chemicals in a procedure, or a change in the conditions under which the procedure is conducted.
- Equipment normally used is not available, such as fume hoods or other local ventilation.

REPORTING LABORATORY INCIDENTS AND UNSAFE CONDITIONS

Report all laboratory incidents, no matter how minor, to the laboratory supervisor. Unusual or unexplainable chemical incidents should be discussed with others in the department, to caution others as to the risk of the procedure.

Unsafe conditions that must be reported include:

- Non-functioning hoods in areas where hazardous

chemicals are being used

- Unsafe storage conditions
- Blocked emergency exits
- Improperly charged fire extinguishers
- Eyewash stations or safety showers that do not work
- Absence of personal protective equipment (e.g., goggles, gloves)

PERSONAL HYGIENE

- Never store food or beverages in storage areas, refrigerators, glassware, or use utensils that are also used for laboratory operations.
- Do not eat, drink, smoke, chew gum, or apply cosmetics in laboratories where chemicals or other hazardous materials (e.g., radioactive or bio-hazardous materials) are present.
- Never use your mouth to draw fluid through a pipette. Always use a pipette bulb or other mechanical pipette device.
- Wash areas of exposed skin well before leaving the laboratory.

Appropriate Personal Apparel

- Confine long hair and loose clothing. Wear shoes at all times in the laboratory but do not wear sandals, perforated shoes or sneakers.
- Always wear long-sleeved and long-legged clothing. While performing laboratory work, never wear short-sleeved T-shirts, short skirts, or shorts. Jewelry should not be worn that interferes with gloves and other protective clothing or that could come into contact with electrical sources or react with chemicals.

PROPER EQUIPMENT USE

- Use equipment only for its intended purpose.
- Inspect equipment or lab apparatus for damage before use. Never use damaged equipment such as cracked glassware or equipment with frayed electrical wiring.

- Shield or wrap Dewar flasks and other evacuated glassware to contain chemicals and glass fragments should explosion occur.

Personal Protective Equipment and Fume Hoods

- Inspect all protective equipment (glasses, goggles, gloves) before use for damage. Do not use damaged protective equipment. To replace equipment, contact the laboratory supervisor.
- All personnel, students, and any visitors in locations where chemicals are stored or handled must wear safety glasses with side shields or goggles at all times.
- Check fume hoods before use to ensure adequate functioning. See the following section on controlling hazards for ways to monitor your hood's effectiveness. If there is a problem, contact Environmental Services immediately.
- Wear appropriate gloves when there is potential for skin contact with toxic chemicals. When ordering gloves, laboratory personnel will consult chemical permeation and resistance charts.
- Use additional personal protective equipment when necessary. See the following section on controlling hazards for criteria used when choosing equipment.
- Select appropriate equipment based on an evaluation of chemical and procedural hazards.

TRANSPORT OF CHEMICALS

The following guidelines will be used when transporting all chemicals within facilities, from building to building, and on public streets.

- Hand-carried chemicals should be placed in an outside container or acid carrying bucket to protect against breakage.
- Wheeled carts used to transport chemicals should be stable and move smoothly over uneven surfaces without tipping or stopping suddenly, and should have lipped surfaces that would contain the chemicals if the containers break.
- Laboratory employees transporting chemicals must wear safety glasses with side shields or splash goggles and a lab coat or apron in case containers break or chemicals are splashed.

- Use freight elevators when available. Passenger elevators should be used only during low-use time periods and only by those who are handling the chemicals.
- Compressed gas cylinders must be transported with hand trucks only with the cylinder strapped in place. Cylinders should NEVER be rolled or dragged. Keep the cylinder capped until it is used.

HOUSEKEEPING

- All work areas, including work benches and floors must be kept clean, dry, and uncluttered.
- Access to emergency equipment, utility controls, showers, eyewash stations, and laboratory exits must never be blocked.

TOXIC DISCHARGES AND WASTE DISPOSAL

- Deposit chemical waste in their appropriate, labeled receptacles and follow all other disposal procedures described in Safety Policy #101, Hazardous Waste Disposal, located on the ES website.
- Be particularly careful not to release hazardous substances into designated "cold" or "warm" rooms, since these facilities have recirculated atmospheres.
- Minimize the release of toxic vapors into the laboratory by using venting apparatus such as vacuum pumps and distillation columns into local exhaust devices. When especially toxic or corrosive vapors are involved, they should pass through scrubbers prior to being discharged from the local exhaust system.

WORKING ALONE

- Employees should avoid working alone when conducting research and experiments involving hazardous substances and procedures.
- Research Laboratories: Personnel working alone should contact security to make them aware of their presence in the facility. Security should be required to make periodic checks of all laboratories. These personnel should plan a route of escape in case of an emergency.

NYU will ensure that:

- **General ventilation systems, fume hoods and other protective equipment are functional and meet the requirements for procedures performed.**
- **Personal protective equipment is appropriate, available and used.**
- **Emergency safety facilities and equipment are sufficient and accessible.**

GENERAL VENTILATION

The general ventilation system in laboratories must be well maintained.

- Storage areas used for flammables must have 6 air changes per hour. Intake vents for the system will be far enough removed from the system's exit port to prevent cross-contamination.
- A slightly negative pressure should be maintained in laboratories to ensure airflow into the laboratory from uncontaminated areas. These recommendations will be taken into account in all future designs and redesigns of ventilation systems for laboratory use.
- General ventilation will not be relied on to protect employees from toxic exposures. Fume hoods and other local exhaust system devices must be used for these purposes. Specific circumstances under which fume hoods must be used are indicated below.

FUME HOODS

Fume hoods minimize exposure to toxic and hazardous materials by isolating activities from the general laboratory environment and by capturing chemical vapors, fumes, and mists at their source, preventing them from entering the general laboratory environment. Their use is encouraged whenever possible and mandated for certain substances and procedures, as outlined below.

Performance Requirements

- Laboratory fume hoods will be vented so that a minimum average face velocity of 80 feet per minute (fpm) is achieved, and a maximum of 150 fpm is not exceeded, with the sash open approximately 18 inches. A maintenance and inspection program for laboratory fume hoods shall be implemented.
- Ventilation ducts should lead to a point where laboratory contaminants can be released safely into the atmosphere. Duct work must be arranged so that exhaust from one duct cannot be forced out through any other hood served by the common duct. This is achieved by locating the blower as far from the hood as possible to avoid pressurizing the duct work and by installing the duct connections on the proper curvature or angle.

When Fume Hoods Will be Used

- The toxicity of the substance used should be considered. Hoods should always be used when the chemical is a known or suspected carcinogen, reproductive hazard, sensitizer, or acutely toxic chemical.
- The quantity should be considered. Hoods should always be used when handling large quantities of hazardous chemicals (over 500 milliliters of liquid or over 30 grams of a solid)
- Flammable and reactive substances should be handled in a fume hood.
- Running new reactions that may be unpredictable or old reactions that have been unreliable should be conducted in a hood.

Required Work Practices with Fume Hoods

- All laboratory employees must check the functioning of fume hoods before use and employ work practices that optimize the protection afforded by fume hoods. Methods for evaluating fume hood performance will be a subject covered in employee training, and will generally include:

- ◆ Continuous monitoring devices
 - ◆ Smoke tube tests
 - ◆ Velometers
 - ◆ Chem wipes on the bottom edge of each sash
- All improperly functioning fume hoods should be reported to the laboratory supervisor, then contact Environmental Services.
 - Chemicals or equipment kept in hoods must not block vents.
 - Hoods must not be used to dispose of or store hazardous chemicals.
 - Hoods should be closed when not in use. Keep the sash down as far as possible during use to improve the overall performance of the hood. If chemicals remain in the hood after use, they should be placed in the rear of the hood and the fan must be left on.
 - Reduce turbulence near and in the hood by closing nearby doors and windows when possible, opening and closing the sash slowly and smoothly, and by avoiding rapid movements inside the hood.
 - Connect electrical equipment to outlets outside the hood when possible. This way, in the event of an emergency one can disconnect equipment without creating a spark inside the hood.
 - Wash the hood work platform as often as necessary to maintain a clean, dry surface.

Fume Hoods in which Perchloric Acid, Strong Oxidizing Agents, or Highly Reactive Chemicals Are Used

Fume hoods for handling or heating perchloric acid, strong oxidizing agents, or other highly reactive chemicals must be served by an independent duct. Crystals can form inside the duct work due to condensation, which can lead to explosions when performing maintenance work on the ventilation system. If you are unsure of whether this is the case when using these materials, Do Not Go Forward with Your Work. Contact the Chemical Hygiene Officer, or his designee, immediately at 998-1450.

Situations in which Laboratory Work Should Not Proceed

- When fume hoods are not operating properly, they should not be used.
- Where there is reason to believe that laboratory employees would be unnecessarily exposed to toxic chemicals due to the failure of a hood to function properly, then activities should cease and an alternative solution found.

PERSONAL PROTECTIVE EQUIPMENT & CLOTHING FOR ROUTINE USE

Protective clothing and equipment will be selected based on the types of chemicals handled, the degree of protection required, and the areas of the body that may become contaminated. All clothing and equipment must meet standards set by the American National Standards Institute. All respiratory protective equipment must be chosen in conjunction with the Chemical Hygiene Officer to ensure compliance with legal requirements concerning the use and distribution of these devices. Every effort will be made to evaluate the effectiveness of equipment and make improvements where possible. The Chemical Hygiene Officer, or his designee, should be consulted for suggestions.

Special consideration must be given to purchasing appropriate personal protective equipment and other safety equipment when extremely hazardous substances are involved. Choice of this equipment under these circumstances must be reviewed by the Chemical Hygiene Officer, or his designee, in advance of purchase.

Eye Protection

All laboratory employees must wear protective eyewear when working with potentially harmful chemicals.

- All eyewear must meet the American National Standards Institute's (ANSI) "Practice for Occupational and Educational Eye and Face Protection," Z87.1 - 1989. Prior to use, personnel will verify that the equipment has been approved for the particular procedure (e.g., protective equipment may be ANSI certified for chemical splashes but not for explosions). ANSI standards require minimum lens

thickness of 3 millimeters, impact resistance, passage of a flammability test, and lens-retaining frames.

Gloves

- Gloves must be worn whenever there is a chance for hand contact with chemicals, such as during the transfer of chemicals from one container to another or during the transfer of chemical wastes.
- Gloves must be worn if chemicals in use are corrosive, easily absorbed through the skin or are acute or chronic toxins.
- Lab personnel must inspect gloves prior to each use and will consult the glove permeation and resistance charts (available from the manufacturer) to make sure that the glove is made of the proper material for the chemicals being used. Glove materials vary in the way they resist being degraded and permeated.

Clothing

- Protective and appropriate clothing is required when a potential exists for chemical or biohazard splashes, fire, extreme heat or cold, excessive moisture, or radiation.
- Lab supervisors and directors are responsible for setting requirements for their use.
- Protective clothing that should be readily available to laboratory personnel include:
 - ♦ Lab coats
 - ♦ Boots or shoe covers
 - ♦ Gauntlets/Lab aprons
 - ♦ Jump suits/coveralls
- Laboratory personnel will consider the following characteristics in protective clothing selection and purchase:
 - ♦ ability to resist fire, heat and the chemicals used
 - ♦ impermeability, when needed

- ♦ comfort, permitting easy execution of tasks when worn
- ♦ ease of cleaning (unless disposable)
- ♦ ability to be removed during an emergency or chemical splash (e.g., has snap fasteners rather than buttons)

Safety Shields

- Safety shields must be used on or near equipment when there is potential for explosion or splash hazards. Fixed shields will be used whenever possible.
- Portable shields may be used when the hazard is limited to small splashes, heat or fire. Where combustion is possible, the shield must be made of non-flammable or slow burning material.

Respirators

- Only authorized personnel who have been trained, received medical clearance, and have been properly fit tested are allowed to use respiratory protection.
- Respirators generally are not a substitute for engineering controls during routine operations.
- See the Safety Policy #109 for further information on respiratory protection, located on ES website.

A. WHAT CONSTITUTES A BIOHAZARD?

Any microorganism that can cause disease in humans or animals is considered a biohazard. This includes pathogenic prokaryotic and eukaryotic microbes, viruses and subviral agents. It also includes microorganisms that could produce latent (silent or non clinical) infections, and materials that could harbor biohazards (such as human blood, body fluids, tissues and cells).

Recombinant organisms that are produced through genetic manipulation are considered biohazards if they have any potential for survival in the environment or in living things, or pose a health risk for humans, animals or other living things

B. WHAT IS BIOSAFETY?

Biosafety is a set of specialized practices for the safe handling and disposal of biohazards. It includes the safe management of recombinant DNA (rDNA) activities.

C. WHAT ARE BIOSAFETY LEVELS?

Biohazards can be classified based on the severity of the hazard. The Centers for Disease Control and Prevention (CDC) and the National Institutes of Health (NIH) have done this in their publication *Biosafety in Microbiological and Biomedical Laboratories* (BMBL). BMBL describes four biosafety levels (BSLs), which consist of combinations of laboratory practices and techniques, safety equipment and laboratory facilities. Excerpts from BMBL are available from the Environmental Services Department.

1. **Biosafety Level 1** is for organisms not known to cause disease in healthy adults.
2. **Biosafety Level 2** is for agents of moderate risk to humans. Representative organisms include the influenza virus, human herpes viruses, *Staphylococcus aureus*, *Plasmodium cynomologi*, *Trypanosoma cruzi* and *Leishmania spp.* BSL2 is also used for work with human blood, body fluids, tissues and cells. At BSL2, the primary hazards are accidental percutaneous or mucous membrane exposures, or ingestion of infectious materials. Extreme care must

be taken with contaminated needles or sharp instruments. Any procedure with the potential for producing aerosols or splashing should be conducted using primary containment equipment, such as a biosafety cabinet or safety centrifuge cups. Other barriers, such as splash shields, gloves and lab coats should be used as appropriate.

3. **Biosafety Level 3** is used for agents with a potential for respiratory transmission, and agents which may cause serious or potentially lethal infection. Representative microorganisms include *Mycobacterium tuberculosis*, St Louis encephalitis virus and *Coxiella burnetii*. The primary hazards include auto-inoculation, ingestion and exposure to infectious aerosols. All laboratory manipulations should be performed in a biosafety cabinet or using other enclosed equipment. In addition, access to BSL3 laboratories must be controlled, and the ventilation system must be designed to minimize the release of infectious aerosols.
4. **Biosafety Level 4** is for work with dangerous and exotic agents which pose a high individual risk of life-threatening disease, which may be transmitted via the inhalation route and for which there is no available vaccine or therapy. No work is conducted on BSL4 organisms at New York University, and no facilities currently exist here for BSL4 work.

D. WHAT ARE THE ELEMENTS OF THE BIOSAFETY LEVELS?

1. **Techniques and Work Practices:** The most important element of safe work with biohazards is strict adherence to good microbiological practices and techniques (see Section on Microbiological Practices). The principal investigator in charge of the laboratory is responsible for communicating the potential hazards and for providing or arranging for the appropriate training of personnel in the lab. For specific details on work practices at each biosafety level, refer to BMBL.
2. **Safety Equipment:** Safety equipment includes containment equipment as well as personal protective equipment (PPE).

The biological safety cabinet is the principal con-

tainment device used to provide protection from aerosols or splashes generated by procedures such as vortex mixing, uncapping stoppered tubes, sonication, homogenizing, use of French press, opening centrifuge tubes and heat sealing. Safety centrifuge cups are another example of containment equipment, as they are designed to prevent aerosols from being released during centrifugation.

PPE may include, but is not limited to, gloves, lab coats, gowns, shoe covers, boots, respirators, face shields, safety glasses and goggles. In some situations, such as some animal studies, the use of containment equipment may be impractical. In those cases, the choice of appropriate PPE is important in order to protect personnel from exposure to infectious agents.

3. **Biosafety Cabinets:** There are several types of biosafety cabinets. A detailed discussion is included in Appendix A of BMBL. As a general rule, a Type 2 biosafety cabinet is required for work at or above BSL2. The Environmental Services Department retains a contractor to test and certify all biosafety cabinets at the University at least once a year.
4. **Facility Design:** Properly designed labs and animal facilities can provide protection for persons working inside and outside of the laboratory, as well as persons and animals in the community surrounding the University. Some important elements of basic facility design include separation of the laboratory or animal room from public access and the availability of a sink for handwashing. If the risk of airborne transmission is great, additional design features, such as specialized ventilation systems, filtering of exhaust air, airlock entrances and controlled access zones may be necessary.

E. HOW DO YOU SELECT THE BIOSAFETY LEVELS FOR A SPECIFIC AGENT?

BMBL contains Agent Summary Statements, which provide guidance for selection of biosafety levels. While the list is not all-inclusive, it contains information for many microorganisms that are proven laboratory hazards, have high potential for laboratory associated infections, or for which the consequences

of infection are serious. The Environmental Services Department can assist with recommendations for microorganisms that are not covered in BMBL.

F. WHAT ABOUT THE OSHA BLOODBORNE PATHOGENS STANDARD?

In 1988, the Occupational Safety and Health Administration (OSHA) issued the Bloodborne Pathogens Standard. The standard mandates that each employer develop an Exposure Control Program to protect employees from exposure to human blood, tissue and body fluids. NYU's Exposure Control Program is located on our web site at <http://www.nyu.edu/environmental.services/policies>. The precautions described in this program are essentially the same as BSL2

G. WHAT ARE THE BASIC PRINCIPLES OF BIOSAFETY?

1. Know and understand the biology and infectious potential of the biohazards you handle.
2. Handle all potentially infectious materials as if the biohazard is present.
3. Use the principles of good microbiological practices (see next section) when handling any biohazard.
4. Plan in advance for safe handling of accidents.
5. Use disinfectants with proven efficacy against the specific biohazard you are handling.
6. Work at the appropriate BSL for the biohazard you are handling.
7. Accept full responsibility for your work.
8. Complete any necessary training before you work with biohazards
9. Remain vigilant and monitor all biosafety practices.
10. Report all accidents to your supervisor and the University Health Center.

11. Dispose of biohazards properly.

H. WHAT ARE THE BASIC PRINCIPLES OF GOOD MICROBIOLOGICAL PRACTICE?

1. Never pipette by mouth.
2. Avoid hand-to-mouth or hand-to-eye contact in the laboratory .
3. Never eat, drink, take medicine or apply cosmetics in the laboratory.
4. Always wear protective equipment (lab coat, gloves, eye protection) appropriate for the task.
5. Change gloves frequently.
6. Remove gloves and lab coat and wash hands before leaving the laboratory.
7. Wash hands thoroughly after handling microorganisms, cell cultures, human blood or tissues and before leaving the laboratory.
8. Handle all pathogens or materials containing pathogens in biosafety cabinets if the potential for aerosolization exists.
9. Store all biohazards securely in clearly labeled, sealed containers.
10. Never recap a used needle or otherwise manipulate it by hand.
11. Dispose of needles and other sharps in Sharps Containers.
12. Label all biohazards with the Universal Biohazard Symbol.
13. Know the location of appropriate spill kits or other decontamination equipment.
14. Clean work surfaces with proven disinfectant after work with biohazards and at end of work shift.

I. HOW DO YOU HANDLE CELL CULTURES?

When cell cultures are known to contain an etiologic

agent or an oncogenic virus, the cell line can be classified at the same level as that recommended for the agent. Unfortunately, many cell lines have not been classified, and most cell lines have not been thoroughly tested for the presence of viruses. Several vertebrate species carry complete copies of viral genomes in their DNA, even though whole virus is not released from the cell. Scientists handling mammalian cells may be handling viruses unwittingly. The possibility exists that human material with no known infection may contain HIV, HBV, tuberculosis or other pathogens.

1. Sub-primate cell lines and continuous cell cultures which do not harbor a primate virus, and are not contaminated with bacteria, mycoplasma, or fungi can be handled at BSL1. The following precautions should be taken.
 - a) Work surfaces are decontaminated before and after each procedure
 - b) Mechanical pipetting devices are used for all procedures: mouth pipetting is prohibited.
 - c) Eating, smoking, or application of cosmetics are not permitted in the lab.
 - d) Laboratory coats are worn in the lab, and are removed before leaving the lab.
 - e) Hands are washed before and after handling cells.
 - f) Cells can be manipulated on an open bench top.
2. The following cell lines or tissues should be handled following BSL2 containment and practices, whether or not they have been shown to harbor a pathogenic agent:
 - a) all non-continuous cell lines derived directly from human clinical materials;
 - b) all human clinical material (e.g., samples of human tissues and fluids obtained after surgical resection or autopsy);

- c) all non-human primate tissue;
 - d) all cell lines producing infectious viral particles;
 - e) all mycoplasma-containing cell lines; and
 - f) many human or non-human primate cells derived from lymphoid tissue, tumor tissue, or cells transformed by primate oncogenic viruses.
3. In addition to the guidelines listed for BSL1 containment, the following precautions should be followed for BSL2 cell lines.
- a) A biological safety cabinet is used for all cell manipulations which may create aerosols, whether or not the procedure requires sterility.
 - b) Reusable contaminated materials are placed into a container with bleach or other suitable disinfectant or are autoclaved prior to being washed.
 - c) Disposable contaminated materials are discarded directly into autoclave bags or red bags.
 - d) Disposable gloves are worn.
4. According to American Type Culture Collection (ATCC), no cell line has been shown to harbor an etiologic agent or an oncogenic virus requiring the precautions necessary for Biosafety Level 3 or 4.

J. DISINFECTION AND DECONTAMINATION

1. Definitions

- a) A sterilizer or sterilant is intended to destroy all microorganisms (viruses, bacteria, fungi, and bacterial or fungal spores) on inanimate surfaces.
- b) A disinfectant is intended to destroy or irreversibly inactivate specific viruses, bacteria, or pathogenic fungi (but not necessarily spores) on inanimate surfaces.
- c) A hospital disinfectant is effective against *Staphylococcus aureus*, *Salmonella choleraesuis*, and *Pseudomonas aeruginosa*. It may

also be effective against such organisms as *Mycobacterium tuberculosis*, pathogenic fungi, or certain specifically named viruses. All commercially available hospital disinfectants contain a claim of effectiveness for specific agents in their labeling.

- d) An antiseptic is a chemical germicide formulated to be used on skin or tissue.

2. **Decontamination** refers to a procedure that eliminates or reduces microbial contamination to a safe level with respect to the transmission of infection. Sterilization and disinfection procedures are often used for decontamination.

The best general-purpose disinfectant solution is household bleach (5.25% sodium hypochlorite) diluted 1:10 in water. There are many commercially available disinfectants. They should be selected carefully based on their known activity against the agents used in the particular laboratory.

K. SELECT AGENTS

The Department of Health and Human Services and the US Department of Agriculture have listed certain biological agents and toxins which are considered to pose a threat to public health and could possibly be used as bioterrorism agents. These biological agents and toxins, more often referred to as "Select Agents", are heavily regulated and any possession or research use of such materials must be registered with the DHHS or USDA.

For a detailed list of Select Agents please refer to our website:

<http://www.nyu.edu/environmental.services/biosafety>

SUGGESTED SHELF STORAGE PATTERN - INORGANIC

SULFUR, PHOSPHORUS ARSENIC,
PHOSPHORUS PENTOXIDE

ARSENATES, CYANIDES, CYANATES
(Store away from any water)

HALIDES, SULFATES, SULFITES,
THIOSULFATES, PHOSPHATES,
HALOGENS, ACETATES

SULFIDES, SELENIDES, PHOSPHIDES,
CARBIDES, NITRIDES

AMIDES, NITRATES (not AMMONIUM
NITRATE) NITRITES, AZIDES
(Store ammonium nitrate away from all
other substances-**ISOLATE IT!**)

BORATES, CHROMATES,
MANGANATES, PERMANGANATES

METALS & HYDRIDES
(Store away from any water. Store
flammable solids in flammables cabinet)

CHLORATES, PERCHLORATES,
CHLORITES, PERCHLORIC ACID,
PEROXIDES, HYPOCHLORITES,
HYDROGEN PEROXIDE

HYDROXIDES, OXIDES, SILICATES,
CARBONATES, CARBON

MISCELLANEOUS

ACIDS CABINET
ACIDS except NITRIC

Store Nitric Acid away from other
acids unless your acid cabinet
provides a separate compartment
for Nitric Acid

If possible, avoid
using the floor

SUGGESTED SHELF STORAGE PATTERN - ORGANIC

ALCOHOLS, GLYCOLS, AMINES,
AMIDES, IMINES, INIDES
(Store flammables in a dedicated cabinet)

PHENOL, CRESOLS

HYDROCARBONS, ESTERS, ALDEHYDES
(Store flammables in a dedicated cabinet)

PEROXIDES, AZIDES,
HYDROPEROXIDES

ETHERS, KETONES, KETENES,
HALOGENATED HYDROCARBONS,
ETHYLENE OXIDE
(Store flammables in a dedicated cabinet)

ACIDS, ANHYDRIDES,
PERACIDS

ETHERS, KETONES, KETENES,
HALOGENATED HYDROCARBONS,
ETHYLENE OXIDE
(Store flammables in a dedicated cabinet)

(Store certain organic acids
in acid cabinet)

EPOXY COMPOUNDS,
ISOCYANATES

MISCELLANEOUS

SULFIDES, POLYSULFIDES, ETC

MISCELLANEOUS

POISONS CABINET
SEVERE POISONS

FLAMMABLES CABINET
ALCOHOLS, GLYCOLS, ETC
ETHERS, KETONES, ETC
FLAMMABLES

If possible, avoid
using the floor

Material Safety Data Sheet

Section 1. Product and Company Identification

Product Name Formaldehyde solution min. 37% stabilized with about 10% Menthol BP,FU,USP
 Product Code 1.04002
 Manufacturer EMD Chemicals Inc. P.O. Box 70, 480 Democrat Road, Gibbstown, NJ 08027

Prior to January 1, 2003 EMD Chemicals Inc. was EM Industries, Inc. or EM Science, Division of EM Industries, Inc.

Effective Date 4/29/2003

For More Information Call
 856-423-6300 Technical Service, Monday-Friday: 8:00 AM - 5:00 PM

In Case of Emergency Call
 800-424-9300 CHEMTREC (USA), 613-996-6666 CANUTEC (Canada), 24 Hours/Day: 7 Days/Week

Synonym Formalin solution
 Material Uses Laboratory Reagent
 Chemical Family Alcohol solution

Section 2. Composition and Information on Ingredients

Component	CAS #	% by Weight
FORMALDEHYDE	50-00-0	25-50
METHANOL	67-56-1	3-20
Water	7732-18-5	30

Section 3. Hazards Identification

Physical State and Appearance Liquid.

Emergency Overview DANGER !POISON !

FLAMMABLE LIQUID AND VAPOR.

VAPOR MAY CAUSE FLASH FIRE.

MAY BE FATAL IF INHALED, ABSORBED THROUGH SKIN OR SWALLOWED.

CAUSES EYE AND SKIN BURNS.

MAY CAUSE ALLERGIC SKIN REACTION.

CANCER HAZARD

CONTAINS MATERIAL WHICH CAN CAUSE CANCER

CONTAINS MATERIAL WHICH CAUSES DAMAGE TO THE FOLLOWING ORGANS: MUCOUS MEMBRANES, GASTROINTESTINAL TRACT, RESPIRATORY TRACT, SKIN, CENTRAL NERVOUS SYSTEM, EYE, LENS OR CORNEA.

WARNING: This product contains a chemical(s) known to the State of California to cause cancer.

Routes of Entry Dermal contact. Eye contact. Inhalation. Ingestion.

Potential Acute Health Effects

Eyes Hazardous in case of eye contact (corrosive). Causes eye burns.

Skin Extremely hazardous in case of skin contact (permeator). May be fatal if absorbed. Hazardous in case of skin contact (corrosive). Skin contact produces burns. May be hazardous in case of skin contact (sensitizer).

Inhalation Extremely hazardous in case of inhalation. May be fatal if inhaled.

Ingestion Extremely hazardous in case of ingestion. May be fatal if swallowed.

Potential Chronic Health Effects

Carcinogenic Effects Classified + (Proven.) by OSHA [FORMALDEHYDE]. Classified 3 (Possible for human.) by European Union [FORMALDEHYDE].

Classified A2 (Suspected for human.) by ACGIH, 2A (Probable for human.) by IARC [FORMALDEHYDE].

Additional information See Toxicological Information (section 11)

Medical Conditions Aggravated by Overexposure: Repeated exposure to a highly toxic material may produce general deterioration of health by an accumulation in one or many human organs.

Section 4. First Aid Measures

Eye Contact Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention immediately.

Skin Contact In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Cover the irritated skin with an emollient. Cold water may be used. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Inhalation If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Ingestion If swallowed, do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person.

Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention immediately.

Section 5. Fire Fighting Measures

Flammability of the Product Product will burn.

Auto-ignition Temperature 300°C (572°F)

Flash Points Closed cup: 56°C (132.8°F).
Flammable Limits The greatest known range is LOWER: 7% UPPER: 73% (FORMALDEHYDE)
Products of Combustion These products are carbon oxides (CO, CO2).
Fire Hazards in Presence of Various Substances Highly flammable in presence of open flames, sparks and static discharge, of shocks, of heat.
Flammable in presence of oxidizing materials.
Explosion Hazards in Presence of Various Substances Risks of explosion of the product in presence of static discharge:
Highly flammable in presence of open flames, sparks and static discharge.
Explosive in presence of open flames, sparks and static discharge.
Risks of explosion of the product in presence of mechanical impact:
Highly flammable in presence of shocks.
Explosive in presence of shocks.
Fire Fighting Media
and Instructions SMALL FIRE: Use DRY chemical powder.
LARGE FIRE: Use alcohol foam, water spray or fog. Cool containing vessels with water jet in order to prevent pressure build-up, autoignition or explosion.
Protective Clothing (Fire) Be sure to use an approved/certified respirator or equivalent.
Special Remarks on Fire Hazards Dangerous fire and explosion risk. Container explosion may occur under fire conditions or when heated. Vapor may travel considerable distance to source of ignition and flash back. (METHANOL)
Special Remarks on Explosion Hazards Flammable gas and vapor.

Section 6. Accidental Release Measures

Small Spill and Leak Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container. If necessary: Neutralize the residue with a dilute solution of sodium carbonate.
Large Spill and Leak Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Cover with DRY earth, DRY sand or other non-combustible material followed with plastic sheet to minimize spreading or contact with rain. Do not get water inside container. Do not touch spilled material. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Neutralize the residue with a dilute solution of sodium carbonate. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.
Spill Kit Information The following EM SCIENCE SpillSolv (TM) absorbent is recommended for this product:
SX1340 Formaldehyde Treatment Kit

Section 7. Handling and Storage

Handling Keep away from heat, sparks and flame. Keep container closed. Use only with adequate ventilation. To avoid fire or explosion, dissipate static electricity during transfer by grounding and bonding containers and equipment before transferring material. Use explosion-proof electrical (ventilating, lighting and material handling) equipment.
Storage Store in a segregated and approved area. Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Avoid all possible sources of ignition (spark or flame).

Section 8. Exposure Controls/Personal Protection

Engineering Controls Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective occupational exposure limits. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection

Eyes Splash goggles.

Body Lab coat.

Respiratory Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate.

Hands Gloves.

Feet Not applicable.

Protective Clothing (Pictograms)

Personal Protection in Case of a Large Spill Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self-contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Product Name Exposure Limits

FORMALDEHYDE EH40-MEL (United Kingdom (UK), 1997).

STEL: 2.5 mg/m³

STEL: 2 ppm

TWA: 2.5 mg/m³

TWA: 2 ppm

ACGIH (United States, 2000).

CEIL: 0.37 mg/m³

CEIL: 0.3 ppm

NIOSH REL (United States, 1994).

CEIL: 0.1 ppm Period: 15 minute(s).

TWA: 0.01 ppm Period: 10 hour(s).

OSHA Final Rule (United States, 1989).

STEL: 2 ppm

TWA: 0.75 ppm

OSHA Transitional Rule (United States, 1993).

STEL: 2 ppm

TWA: 0.75 ppm

METHANOL ACGIH (United States, 1994). Skin

TWA: 262 mg/m³

STEL: 328 mg/m³

OSHA (United States, 1989). Skin

TWA: 260 mg/m³

STEL: 325 mg/m³

ACGIH (United States, 1994). Skin
STEL: 328 mg/m³
STEL: 250 ppm
TWA: 262 mg/m³
TWA: 200 ppm
NIOSH REL (United States, 1994). Skin
STEL: 325 mg/m³
STEL: 250 ppm
TWA: 260 mg/m³ Period: 10 hour(s).
TWA: 200 ppm Period: 10 hour(s).
OSHA Final Rule (United States, 1989). Skin
STEL: 325 mg/m³
STEL: 250 ppm
TWA: 260 mg/m³
TWA: 200 ppm
Water Not available.

Section 9. Physical and Chemical Properties

Odor Pungent.
Color Colorless.
Physical State and Appearance Liquid.
Molecular Weight Not applicable.
Molecular Formula Not applicable.
pH 2.8 to 4 [Acidic.]
Boiling/Condensation Point The lowest known value is 64.55°C (148.2°F) (METHANOL). Weighted average: 93.4°C (200.1°F)
Melting/Freezing Point May start to solidify at -0.1°C (31.8°F) based on data for: Water. Weighted average: -57.91°C (-72.2°F)
Specific Gravity 1.09 (Water = 1)
Vapor Pressure The highest known value is 12.9 kPa (97 mmHg) (@ 20°C) (METHANOL).
Vapor Density The highest known value is 1.11 (Air = 1) (METHANOL). Weighted average: 1.06 (Air = 1)
Volatility 99.9% (v/v). (METHANOL.)
Odor Threshold The lowest known value is 0.05 ppm (FORMALDEHYDE) Weighted average: 23.51 ppm
Evaporation Rate The highest known value is 5.91 (METHANOL) Weighted average: 1.9 compared to (n-BUTYL ACETATE=1)
VOC 70 (%)
LogKow Not available.
Solubility Soluble in water.

Section 10. Stability and Reactivity

Stability and Reactivity The product is stable.
Conditions of Instability Avoid Heat
Incompatibility with Various Substances Reactive with oxidizing agents, metals, acids, alkalis.
Rem/Incompatibility Avoid all possible sources of ignition (spark or flame). Incompatible with halogens, hydrogen peroxide, chlorinated hydrocarbons, fluorine, nitric acid, oxidizing agents and sulfuric acid.
Hazardous Decomposition Products Not available.
Hazardous Polymerization Will not occur.

Section 11. Toxicological Information

RTECS Number:
Formaldehyde LP8925000
Methanol PC1400000
Water ZC0110000
Toxicity Acute oral toxicity (LD50): 42 mg/kg [Mouse]. (FORMALDEHYDE).
Acute dermal toxicity (LD50): 15800 mg/kg [Rabbit]. (METHANOL).
Acute toxicity of the vapor (LC50): 64000 ppm 4 hour(s) [Rat]. (METHANOL).
Chronic Effects on Humans CARCINOGENIC EFFECTS: Classified + (Proven.) by OSHA [FORMALDEHYDE]. Classified 3 (Possible for human.) by European Union [FORMALDEHYDE]. Classified A2 (Suspected for human.) by ACGIH, 2A (Probable for human.) by IARC [FORMALDEHYDE].
Acute Effects on Humans Hazardous in case of eye contact (corrosive). Causes eye burns. Extremely hazardous in case of skin contact (permeator).
May be fatal if absorbed. Hazardous in case of skin contact (corrosive). Skin contact produces burns. May be hazardous in case of skin contact (sensitizer).
Extremely hazardous in case of inhalation. May be fatal if inhaled. Extremely hazardous in case of ingestion. May be fatal if swallowed.
Synergetic Products (Toxicologically) Not available.
Irritancy Draize Test: Not available.
Sensitization Hazardous in case of skin contact (sensitizer).
Carcinogenic Effects Classified + (Proven.) by OSHA [FORMALDEHYDE]. Classified 3 (Possible for human.) by European Union [FORMALDEHYDE].
Classified A2 (Suspected for human.) by ACGIH, 2A (Probable for human.) by IARC [FORMALDEHYDE].
Toxicity to Reproductive System Not available.
Teratogenic Effects Not available.
Mutagenic Effects Not available.

Section 12. Ecological Information

Ecotoxicity Not available.
BOD5 and COD Not available.
Toxicity of the Products of Biodegradation The products of degradation are less toxic than the product itself.

Section 13. Disposal Considerations

EPA Waste Number U122 U154

Treatment Incineration, fuels blending or recycle. Contact your local permitted waste disposal site (TSD) for permissible treatment sites.

+ Section 14. Transport Information

DOT Classification Proper Shipping Name: FORMALDEHYDE, SOLUTIONS

Hazard Class: 8

UN number: UN2209

Packing Group: III

RQ: Not applicable.

TDG Classification Not available.

IMO/IMDG Classification Not available.

ICAO/IATA Classification Not available.

Section 15. Regulatory Information

U.S. Federal Regulations TSCA 8(b) inventory: FORMALDEHYDE ; METHANOL; Water

SARA 302/304/311/312 extremely hazardous substances: FORMALDEHYDE

SARA 302/304 emergency planning and notification: FORMALDEHYDE

SARA 302/304/311/312 hazardous chemicals: FORMALDEHYDE ; METHANOL

SARA 311/312 MSDS distribution - chemical inventory - hazard identification: FORMALDEHYDE : Fire Hazard, Immediate (Acute) Health Hazard, Delayed (Chronic) Health Hazard; METHANOL: Fire Hazard, Immediate (Acute) Health Hazard, Delayed (Chronic) Health Hazard

SARA 313 toxic chemical notification and release reporting: FORMALDEHYDE 37.5%; METHANOL 11.5%

Clean Water Act (CWA) 307: No products were found.

Clean Water Act (CWA) 311: FORMALDEHYDE

Clean air act (CAA) 112 accidental release prevention: FORMALDEHYDE

Clean air act (CAA) 112 regulated flammable substances: No products were found.

Clean air act (CAA) 112 regulated toxic substances: FORMALDEHYDE

WHMIS (Canada) CLASS B-3: Combustible liquid with a flash point between 37.8°C (100°F) and 93.3°C (200°F).

Class D-1A: Material causing immediate and serious toxic effects (VERY TOXIC).

Class D-2A: Material causing other toxic effects (VERY TOXIC).

Class D-2B: Material causing other toxic effects (TOXIC).

CLASS E: Corrosive liquid.

CEPA DSL: FORMALDEHYDE ; METHANOL; Water

This product has been classified in accordance with the hazard criteria of the Controlled Product Regulations and the MSDS contains all required information.

International Regulations

EINECS FORMALDEHYDE 200-001-8

METHANOL 200-659-6

Water 231-791-2

DSCL (EEC) R23/24/25- Toxic by inhalation, in contact with skin and if swallowed.

R34- Causes burns.

R39/23/24/25- Toxic: danger of very serious irreversible effects through inhalation, in contact with skin and if swallowed.

R40- Possible risks of irreversible effects.

R43- May cause sensitization by skin contact.

International Lists Australia (NICNAS): FORMALDEHYDE ; METHANOL; Water

Japan (MITI): FORMALDEHYDE ; METHANOL; Water

Japan (MOL): FORMALDEHYDE

Korea (TCCL): FORMALDEHYDE ; METHANOL; Water

Philippines (RA6969): FORMALDEHYDE ; METHANOL; Water

China: No products were found.

State Regulations Pennsylvania RTK: FORMALDEHYDE : (special hazard, environmental hazard, generic environmental hazard); METHANOL: (environmental hazard, generic environmental hazard)

Massachusetts RTK: FORMALDEHYDE ; METHANOL

New Jersey: Formaldehyde solution min. 37% stabilized with about 10% methanol BP,FU,USP

California prop. 65: This product contains the following ingredients for which the State of California has found to cause cancer, birth defects or other reproductive harm, which would require a warning under the statute: FORMALDEHYDE

California prop. 65 (no significant risk level): FORMALDEHYDE

California prop. 65: This product contains the following ingredients for which the State of California has found to cause cancer which would require a warning under the statute: FORMALDEHYDE

Section 16. Other Information

National Fire Protection Association (U.S.A.) 2

Health 3

Fire Hazard 0

Reactivity

Specific Hazard

Changed Since Last Revision +

Notice to Reader

The statements contained herein are based upon technical data that EMD Chemicals Inc. believes to be reliable, are offered for information purposes only and as a guide to the appropriate precautionary and emergency handling of the material by a properly trained person having the necessary technical skills. Users should consider these data only as a supplement to other information gathered by them and must make independent determinations of suitability and completeness of information from all sources to assure proper use, storage and disposal of these materials and the safety and health of employees and customers and the protection of the environment. EMD CHEMICALS INC. MAKES NO REPRESENTATION OR WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE, WITH RESPECT TO THE INFORMATION HEREIN OR THE PRODUCT TO WHICH THE INFORMATION REFERS.

1. SUBSTANCES KNOWN TO BE A HUMAN CARCINOGEN*

Aflatoxins	Cadmium and Cadmium Compounds	Estrogens, Steroidal	Soots
Alcoholic Beverage Consumption	Chlorambucil	Ethylene Oxide	Strong Inorganic Acid Mists
Aminobiphenyl	(2-Chloroethyl)-3-(4-methylcyclohexyl)- 1-nitrosoarene (MeCCNU)	Melphalan	Containing Sulfuric Acid
Analgesic mixtures containing phenacetin	Chromium Hexavalent Compounds	Methoxsalen with ultraviolet a therapy (puva)	Exposure to Sunlamps or Sunbeds
Arsenic and Certain Arsenic Compounds	Coal Tars	Mineral Oils (Untreated and Mildly Treated)	2,3,7,8-Tetrachlorodibenzo- <i>p</i> -dioxin (TCDD); "Dioxin"
Asbestos	Coal Tar Emissions	Mustard gas	"Thiotepa"
Azathioprine	Cyclophosphamide A (Ciclosporin)	2-Naphthylamine	Thorium dioxide
Benzene	Diethylstilbestrol	Nickel Compounds	Vinyl chloride
Benzidine	Dyes Metabolized to Benzidine	Radon	Ultraviolet Radiation, Broad Spectrum UV
Beryllium and Beryllium Compounds	Environmental Tobacco Smoke	Silica, Crystalline (Respirable Size)	Radiation
Butadiene	Erionite	Smokless Tobacco	Wood Dust
1,4-Butanediol dimethyl-sulfonate (myleran®)		Solar Radiation	

2. SUBSTANCES ANTICIPATED TO BE A HUMAN CARCINOGEN†*

Acetaldehyde	Dibenz[<i>a,h</i>]anthracene	Hexamethyl-phosphoramide	N-nitrososarcosine
2-Acetylaminofluorene	7H-Dibenzo[<i>c,g</i>]carbazole	Hydrazine and hydrazine sulfate	Norethisterone
Acrylamide	Dibenzo[<i>a,e</i>]pyrene	Hydrazobenzene	Ochratoxin A
Acrylonitrile	Dibenzo[<i>a,h</i>]pyrene	Indeno[1,2,3- <i>cd</i>]pyrene	4,4'-Oxydianiline
Adriamycin® (Doxorubicin Hydrochloride)	Dibenzo[<i>a,i</i>]pyrene	Iron dextran complex	Oxymetholone
2-Aminoanthraquinone	Dibenzo[<i>a,j</i>]pyrene	Isoprene	Phenacetin
<i>o</i> -Aminoazotoluene	1,2-dibromo-3-chloropropane	Kepone® (chlordecone)	Phenazopyridine Hydrochloride
1-Amino-2-methylanthraquinone	1,2-dibromoethane (ethylene dibromide)	Lead Acetate	Phenolphthalein
2-Amino-3-methylimidazo[4,5- <i>f</i>]quinoline(IQ)	2,3-Dibromo-1-propanol	Lead Phosphate	Phenoxybenzamine Hydrochloride
Amitrole	tris(2,3-Dibromopropyl) Phosphate	Lindane and other Hexachlorocyclohexane Isomers	Phenytol
<i>o</i> -Anisidine hydrochloride	1,4-dichlorobenzene	2-Methylaziridine (Propyleneimine)	Polybrominated biphenyls
Azacitidine (5-Azacytidine®, 5-AzaC)	3,3'-dichlorobenzidine and 3,3'-dichlorobenzidine 2hcls	5-Methylchrysene	Polychlorinated biphenyls
Benz[<i>a</i>]anthracene	Dichlorodiphenyltrichloroethane (DDT)	4,4'-Methylenebis(2-Chloroaniline)	Polycyclic aromatic hydrocarbons
Benzo[<i>b</i>]fluoranthene	1,2-Dichloroethane	4,4'-Methylenebis(N,N-dimethylbenzenamine)	Procarbazine hydrochloride
Benzo[<i>k</i>]fluoranthene	Dichloromethane (methylene chloride)	4,4'-Methylenedianiline and its dihydrochloride	Progesterone
Benzo[<i>a</i>]pyrene	1,3-Dichloropropene (technical grade)	Methyleugenol	1,3-Propane sultone
Benzotrifluoride	Diepoxybutane	Methyl Methanesulfonate	Beta-propiolactone
Bromodichloromethane	Diesel Exhaust Particulates	N-methyl- <i>n</i> -nitro- <i>n</i> -nitrosoguanidine	Propylthiouacil
2,2-bis-(Bromoethyl)-1,3-propanediol (Technical Grade)	Diethyl sulfate	Metronidazole	Reserpine
Butylated hydroxyanisole	Diglycidyl resorcinol ether	Michler's ketone	Saccharin
Carbon tetrachloride	3,3'-Dimethoxybenzidine and 3,3'-dimethoxybenzidine 2hcls.	Mirex	Safrole
Ceramic fibers (respirable size) [55]	4-Dimethylamino-azobenzene	Nickel (Metallic)	Selenium sulfide
Chloramphenicol	3,3'-Dimethylbenzidine	Nitrilotriacetic Acid	Streptozotocin
Chlorendic acid	Dimethylcarbamoyl chloride	<i>o</i> -Nitroanisole	Styrene-7,8-oxide
Chlorinated paraffins (c12, 60% chlorine)	1, 1-Dimethylhydrazine	6-Nitrochrysene	Sulfallate
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosoarene (ccnu)	Dimethyl sulfate	Nitrofen	Tetrafluoroethylene
Chloroform	Dimethylvinyl chloride	Nitrogen mustard hydrochloride	Tetrachloroethylene (perchloroethylene)
3-Chloro-2-methylpropene	1,6-Dinitropyrene	2-Nitropropane	Tetranitromethane
4-Chloro- <i>o</i> -phenylenediamine	1,8-Dinitropyrene	1-Nitropyrene	Thioacetamide
Chloroprene	1,4-Dioxane	4-Nitropyrene	Thiourea
<i>p</i> -Chloro- <i>o</i> -toluidine and <i>p</i> -Chloro- <i>o</i> -toluidine Hydrochloride	Disperse Blue 1	<i>N</i> -nitrosodi- <i>n</i> -butylamine	Toluene diisocyanate
Chlorotocin	Dyes Metabolized to 3,3'-Dimethoxybenzidine	<i>N</i> -nitrosodiethanolamine	<i>o</i> -Toluidine and <i>o</i> -toluidine hydrochloride
C.I. Basic red 9 monohydrochloride	Dyes Metabolized to 3,3'-Dimethylbenzidine	<i>N</i> -nitrosodiethylamine	Toxaphene
Cisplatin	Epichlorohydrin	<i>N</i> -nitrosodimethylamine	Trichloroethylene
<i>p</i> -Cresidine	Ethylene thiourea	<i>N</i> -nitrosodimethylamine	2,4,6-Trichlorophenol
Cupferron	di(2-Ethylhexy) Phthalate	<i>N</i> -nitrosodi- <i>n</i> -propylamine	1,2,3-Trichloropropane
Dacarbazine	Ethyl methanesulfonate	<i>N</i> -nitroso- <i>N</i> -ethylurea	Ultraviolet A Radiation
Danthron (1,8-Dihydroxyanthraquinone)	Formaldehyde (gas)	4-(<i>N</i> -nitrosomethylamino)-1-(3-pyridyl)-1-butanone	Ultraviolet B Radiation
2,4-Diaminoanisole sulfate	Furan	<i>N</i> -Nitroso- <i>N</i> -methylurea	Ultraviolet C Radiation
2,4-diaminotoluene	Glasswool (respirable size)	<i>N</i> -Nitrosomethylvinylamine	Urethane
Dibenz[<i>a,h</i>]acridine	Glycidol	<i>N</i> -Nitrosomorpholine	Vinyl Bromide
Dibenz[<i>a,i</i>]acridine	Hexachlorobenzene	<i>N</i> -Nitrosornicotine	Vinyl Fluoride
	Hexachlorocyclohexane Isomers	<i>N</i> -nitrosopiperidine	
	Hexachloroethane	<i>N</i> -nitrosopyrrolidine	

* National Toxicology Program, 10th Annual Report on Carcinogens, 2002

† Those substances "which may reasonably be anticipated to be carcinogens" are defined as those for which there is a limited evidence of carcinogenicity in humans or sufficient evidence of carcinogenicity in experimental animals.

3. PROPERTIES OF FLAMMABLE SUBSTANCES

Substance	Flammable Limits, % by Volume in Air		Flash Point (Closed Cup), OC
	Lower	Upper	
Amines			
methyl amine, CH ₅ N	5.0	21	gas
ethyl amine, C ₂ H ₇ N	3.5	14	-18°C
trimethyl amine, C ₃ H ₉ N	2.0	12	gas
Alcohols			
methyl alcohol, CH ₄ O	6.0	37	12
ethyl alcohol, C ₂ H ₆ O	3.3	19	13
iso propyl alcohol, C ₃ H ₈ O	2.3	13	12
2-pentanol, C ₅ H ₁₂ O	1.2	9.0	39
Aldehydes and Ketones			
formaldehyde, CH ₂ O	7.0	73	gas
acetaldehyde, C ₂ H ₄ O	4.0	55	-38
furfural, C ₅ H ₄ O ₂	2.1		60
acetone, C ₃ H ₆ O	2.6	13	-20
methyl ethyl ketone, C ₄ H ₈ O	1.8	11	7
Esters			
methyl formate, C ₂ H ₄ O ₂	5.9	20	-19
methyl acetate, C ₃ H ₆ O ₂	3.2	16	-9
ethyl acetate, C ₄ H ₈ O ₂	2.2	11	4
n-butyl acetate, C ₆ H ₁₂ O ₂	1.4	7.6	27
p-diethyl phthalate, C ₁₂ H ₁₄ O ₂			117
Ethers			
dimethyl ether, C ₂ H ₆ O	3.4	18	gas
diethyl ether, C ₄ H ₁₀ O	1.9	48	45
ethylene oxide, C ₂ H ₄ O	3.0	80	<-18
dioxane, C ₄ H ₈ O ₂	2.0	22	12
Halides			
methyl chloride, CH ₃ Cl	8.1	17	gas
ethyl chloride, C ₂ H ₅ Cl	3.9	15	-50
methylene chloride, CH ₂ Cl ₂		practically nonflammable	
n-butyl chloride, C ₄ H ₉ Cl	1.8	10	7
methyl bromide, CH ₃ BR	10	16	practically nonflammable
ethyl bromide, C ₂ H ₅ BR	6.8	11	
Hydrocarbons			
methane, CH ₄	5.0	15	gas
ethane, C ₂ H ₆	3.0	13	gas
propane, C ₃ H ₈	2.3	9.4	gas
n-butane, C ₄ H ₁₀	1.9	8.5	gas
n-pentane, C ₅ H ₁₂	1.4	7.8	49
n-hexane, C ₆ H ₁₄	1.2	7.4	-30
n-heptane, C ₇ H ₁₆	1.1	6.7	41
n-octane, C ₈ H ₁₈	1.0	4.7	3
benzene, C ₆ H ₆	1.4	8.0	-17
toluene, C ₇ H ₈	1.3	7.0	4
o-xylene, C ₈ H ₁₀	1.0	6.0	32
Miscellaneous			
hydrogen, H ₂	4.0	74	gas
ammonia, NH ₃	16	25	gas
carbon monoxide, CO	12.5	74	gas
hydrogen sulfide, H ₂ S	4.3	46	gas
carbon disulfide, CS ₂	1.3	44	-30

Mode of Ignition of Flammable Vapors

It does not take much to ignite flammable vapors. Any flame will do. So will a spark, however tiny. A catalytic surface, such as a bit of platinum-black, may also serve. Most combustible vapors are denser than air, which has an effective molecular weight of 29. Therefore, they settle down onto to bench tops and floors, where they may accumulate and spread out horizontally and eventually reach an ignition source. Flammable vapors from massive sources such as spillage have also been known to descend into stairwells and elevator shafts and ignite on a lower story. If the path of vapor within the flammable range is continuous, the flame will propagate itself from the point of ignition back to its source.

Source: Green ME and Turk A (1978). Safety in Working with Chemicals. New York: MacMillan Publishing Company Co.

4. HIGHLY TOXIC SUBSTANCES

The substances listed below are highly toxic as defined by the Federal Hazardous Substances Act (FHSA). Very small amounts of these chemicals may cause immediate, acutely toxic reactions. All necessary precautions should be taken to limit exposure to these highly toxic chemicals and substitutes for such chemicals should be used whenever possible.

The FHSA uses the LD₅₀ and LC₅₀ as a measure of the acute toxicity of a substance. The FHSA defines a highly toxic substance as one where the LD₅₀ is 50 mg/kg or less when orally administered or where the LC₅₀ is 200 ppm or less when a gas or vapor is inhaled. The LD₅₀ is the dose of a substance that produces death in 50% of a group of laboratory animals. The LC₅₀ is the vapor concentration of a substance that produces death in 50% of animals. Although this measure of lethality can be influenced by a variety of factors, historically they have provided a measure of toxicity which can be used in estimating the comparative safety of substances. The LD₅₀ values in this table are determined for the most part following oral administration of the chemical to rats and are expressed in milligrams per kilogram (mg/kg). The LC₅₀ is expressed in parts per million (ppm). The lowest LD₅₀ or LC₅₀ reported in the literature is shown for each substance.

Source: Council of State Science Supervisors (1984). School Science Laboratories: A Guide to Some Hazardous Substances. Wash, DC: US Consumer Product Safety Commission and the National Institute for Occupational Safety and health.

SUBSTANCE	CAS NO.	LD ₅₀ (mg/kg) or LC (Dum)
Adrenaline	51434	50mg/kg
Barium Hydroxide	17194-00-2	5 to 50 mg/kg
Chlorine	7782-50-5	137 ppm
Colchicine	64-86-8	50 mg/kg
Mercury	7439-97-6	*
Mercury Chloride	7487-94-7	10 mg/kg
Mercuric Iodide	7774-29-0	40 mg/kg
Mercuric Nitrate	7783-34-8	**
Mercuric Oxide	21908-53-2	18 mg/kg
Mercuric Sulfate	1376644-4	24 mg/kg
Osmium Tetraoxide	20816-12-0	14 mg/kg
Phosphorus (White)	7723-14-0	4.8 mg/kg
Phosphorus Pentoxide	1314-56-3	9.7 ppm
Potassium Cyanide	151-5-8	***
Potassium Periodate	7790-21-8	48 mg/kg
Silver Cyanide	506-64-9	***
Sodium Cyanide	143-33-9	4 mg/kg

* Mercury presents a special type of hazard due to acute and chronic neurotoxicity of mercury vapors, the Occupational Safety and Health Administration has set the Acceptable Ceiling Concentration at 100 micrograms per cubic meter. The acceptable Ceiling Concentration is the level which can never be exceeded, even for an instant.

** Toxicity is expected to be similar to other mercuric salts.

*** Toxicity is expected to be similar to Sodium Cyanide.

5. CORROSIVES AND IRRITANTS

SUBSTANCE	CAS NO.	CORROSIVE	IRRITANT
Acetaldehyde	75-07-0		X
Acetic Acid	64-19-7	X	
Acetic Anhydride	108-24-7		X
Aluminum Chloride	7446-70-0	X	
Ammonia	1336-21 -6		X
Ammonium Dichromate	7789-09-5	X	
Ammonium Oxalate	1425849-2	X	
Antimony Pentachloride	7647-18-9 -	X	
Antimony Oxide	1309-64-4		X
Antimony Trichloride	10025-91 -9	X	
Bismuth Trichloride	7787-60-2	X	
Bromine	7726-95-6	X	
Calcium Carbide	75-20-7		X
Calcium Fluoride	7789-75-5		X
Calcium Oxide	1305-78-8	X	
Catechol (pyrocatechol)	120-80-9		X
Chlorine**	7782-50-5	X	
Cupric Bromide	7789-45-9	X	
Cupric Chloride	1344-67-8		X
Cupric Nitrate	10031 43-3		X
Cupric Sulfate	7758-98-7		X
p-Dichlorobenzene	106-46-7		X
Diethyl Phthalate	84-66-2		X
Ethyl Methacrylate	97-63-2		X
Ferric Chloride	7705-08-0		X
Hexachlorophen	7030-4		X
Hydrochloric Acid	7647-01-0	X	
Hydrofluoric Acid	7664-39-3	X	
Hydrogen Peroxide (30%)	7722-84-1		X
Hydrogen Sulfide	7783-06-4		X
Hydroquinone	123-31 -9	X	
Iodine (crystals)	7553-56-2		X
Lead Carbonate	598-63-0		X
Lithium	7439-93-2	X	
Methyl Ethyl Ketone	78-93-3		X

SUBSTANCE	CAS NO.	CORROSIVE	IRRITANT
Methyl Methacrylate	80-62-6		X
Methyl Salicylate	119-36-8		X
Naphthalene	91-20-3		X
Nitric Acid	7697-37-2	X	
Oxalic Acid	144-62-7	X	
Phosphorus (White)**	7723-14-0	X	
Phosphorus Pentoxide**	1314-56-3 -	X	
Phthalic Anhydride	85-44-9		X
Potassium Chromate	7789-00-6	X	
Potassium Cyanide**	151 -50-8	X	
Potassium Fluoride	7789-23-3	X	
Potassium Metal	7740-09-7	X	
Potassium Hydroxide	1310-58-3	X	
Potassium Permanganate	7722-64-7		X
Sodium Metal	7440-23-5	X	
Sodium Cyanide**	1 43-33-9	X	
Sodium Ferrocyanide	13601 -19-9	X	
Sodium Hydroxide	1310-73-2	X	
Sodium Sulfide	1313-84-4		X
Disodium Hexafluorosilicate (sodium Silicofluoride)	16893-85-9	X	
Stannic Chloride	7646-78-8	X	
Sulfuric Acid	7664-93-9	X	
Sulfuric Acid Fuming	8014-95-9		X
Titanium Trichloride	7705-07-9		X
Toluene	108-88-3		X
Trichlorotrifluoroethane	76-13-1		X
Turpentine	8006-64-2		X

**Highly toxic substances included here for their corrosive or irritant characteristics

Source: Council of State Science Supervisors (1984). School Science Laboratories: A Guide to Some Hazardous Substances. Wash, DC: US PSC and NIOSH.

6. SELECTED ALLERGIC CONTACT SENSITIZERS

METALS

- Nickel and nickel salts
- Chromium salts
- Cobalt salts
- Organomercurials

PLANT SENSITIZERS

- Toxicodendron genus: pentadecylcatechols and other catechols
- Primula obconica: - d-methylene - d-butyrolactone
- Compositae family: sesquiterpene lactones

RUBBER ADDITIVES

- Mercaptobenzthiazolce
- Thiuram sulfides
- p-Phenylenediamine and derivatives
- Diphenylguanidine
- Resorcinol monobenzoate

- Epoxy oligomer (M.W. 340)
- Methyl methacrylate and other acrylic monomers
- Pentaerythritol triacrylate and other multifunctional acrylates
- Hexamethylenediisocyanate
- p-Tertiary butyl phenol
- Ethylenediamine, hexamethylenetetramine, and other aliphatic amines
- Formaldehyde
- Neomycin
- Benzocaine
- Captan

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Causes of Contact Allergy.

Contact allergy may occur from a very large number of antigens; it seems possible that most substances may at least very rarely be antigens. However, there is a great range in antigenic potency, and a relatively small number of strong sensitizers have been identified experimentally or in humans. Strong allergens are often aromatic substances with molecular weights less than 500; they tend to be highly lipid soluble and quite reactive with protein, although exceptions occur.

7. AGENTS REPORTED TO AFFECT MALE REPRODUCTIVE CAPACITY*

Steroids

Natural and synthetic androgens (antiandrogens), estrogens (antiestrogens) and progestins

Antineoplastic Agents

Alkaloids - vinca alkaloids (vinblastine, vincristine)
Alkylating agents - esters of methanesulfonic acid (MMS, EMS, busulfan); ethylenimines (TEM, TEPA); hydrazines (procarbazine); nitrogen mustards (chlorambucil, cyclophosphamide); nitrosoureas (CCNU, CNU, MNU)
Antimetabolites - amino acid analogs [azaserine (DON)]; folic acid antagonists (methotrexate); nucleic acid analogs (azauridine, 5-bromodeoxyuridine, cytosine arabinoside, 5-fluorouracil, 6-mercaptopurine)
Antitumor antibiotics - actinomycin D, adriamycin, bleomycin, daunomycin, mitomycin C

Drugs That Modify the Central Nervous System

Alcohols
Anesthetic gases and vapors - enflurane, halothane, methoxyflurane, nitrous oxide
Antiparkinsonism drugs - levodopa
Appetite suppressants
Narcotic and nonnarcotic analgesics - opioids
Neuroleptics (antidepressants, antimanic, and antipsychotic agents) - phenothiazines, imipramine, and amitriptyline
Tranquilizers - phenothiazines, reserpine, monoamine oxidase inhibitors

Drugs That Modify the Autonomic Nervous System

Antiadrenergic drugs (for hypertensive and cardiac disorders) - alpha and beta-blocking agents, clonidine, methyl dopa, guanethidine, bretylium, reserpine

Other Therapeutic Agents

Alcoholism - tetraethylthiuram disulfide (antabuse)
Analgesics and antipyretics - phenacetin
Anticonvulsants - diphenylhydantoin (phenytoin)
Antiinfective agents - amphotericin B, hexachlorophene, hycanthone, nitrofurans derivatives (furacin, furadroxyl), sulfasalazine
Antischistosomal agents - niridazole, hycanthone
Antiparasitic drugs - quinine, quinacrine, chloroquine
Diuretics - aldactone, thiazides
Gout suppressants - colchicine
Histamines and histamine antagonists - chlorcyclizine, cimetidine
Oral hypoglycemic agents - chlorpropamide
Xanthine - caffeine, theobromine

Metals and Trace Elements

Aluminum, arsenic, boranes, boron, cadmium, cobalt, lead, mercury, methylmercury, molybdenum, nickel, silver, uranium

Insecticides

Benzene hexachlorides - lindane

Carbamates - carbaryl

Chlorobenzene derivatives - chlorophenothane (DDT), methoxychlor

Indane derivatives - aldrin, chlordane, dieldrin

Phosphate esters (cholinesterase inhibitors) - dichlorvos (DDVP), hexamethyl-phosphoramide

Miscellaneous - chlordecone (kepone)

Herbicides

Chlorinated phenoxyacetic acids - 2,4-dichlorophenoxyacetic acid (2,4-D), 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), yalane

Quaternary Ammonium compounds - diquat, paraquat

Rodenticides

Metabolic inhibitors - fluoroacetate (fluoroacetamide)

Fungicides, Fumigants, and Sterilants

Apholate, captan, carbon disulfide, dibromochloropropane (DBCP), ethylene dibromide, ethyleneoxide, thiocarbamates (cineb, maneb), triphenyltin

Food Additives and contaminants

Aflatoxins, cyclamate, diethylstilbestrol (DES), dimethylnitrosamine, gossypol, metanil yellow, monosodium glutamate, nitrofurans derivatives

Industrial Chemicals

Chlorinated hydrocarbons - hexafluoroacetone, polybrominated biphenyls (PBBs) polychlorinated biphenyls (PCBs), 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)

Hydrazines - dithiocarbamoylhydrazine

Monomers - vinyl chloride, chloroprene

Polycyclic aromatic hydrocarbons (PAHs) - dimethylbenzanthracene (DMBA), benz(a)pyrene

Solvents - benzene, carbon disulfide, glycol ethers, hexane, thiophene, toluene, xylene

Miscellaneous - diethyl adipate, chloroprene, ethylene oxide cyclic tetramer

Consumer Products

Flame retardants - tris-2,3-dibromopropyl phosphate (TRIS)

Plasticizers - phthalate esters (DBP, DEHP)

Antispermatic Drugs (Investigational)

Derivatives of 1-benzylindazole-3-carboxylic acid, 1-pchlorobenzyl-LH indazol-3-carboxylic acid, chlorohydrins, chloro-sugars (6-chloroglucose), dichloroacetyldiamines derivatives (Win 13,099, 17,416, 18,446), dihydronaphthalenes (nafoxidine), dinitropyrroles (ORF-1616), gossypol, 5-thiogluucose, a-chlorohydrin, monothioglycerol

Miscellaneous

Personal habits - alcohol consumption, tobacco smoking

Agents of abuse - marijuana and other centrally acting drugs

Physical factors - heat, light, hypoxia

Radiation - alpha, beta, and gamma radiation; x-rays

Stable isotopes - deuterium oxide

* Both laboratory and clinical reports are included (Target Organ Toxicity Center Reproductive Toxicity Information File).

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8. AGENTS REPORTED TO AFFECT FEMALE REPRODUCTIVE CAPACITY*

Steroids

Natural and synthetic androgens (antiandrogens), estrogens (antiestrogens) and progestins
Antineoplastic Agents
Alkylating agents - cyclophosphamide, busulfan
Antimetabolites - folic acid antagonists (methotrexate)

Other Therapeutic Agents

Anesthetic gases and vapors - halothane, enflurane, methoxyflurane
Antiparkinsonism drugs - levodopa
Antiparasitic drugs - quinacrine
Appetite suppressants Narcotic and nonnarcotic analgesics - opioids
Neuroleptics (antidepressants, antimanic, antipsychotic agents) - phenothiazines, imipramine, and amitriptyline
Serotonin
Sympathomimetic amines - epinephrine, norepinephrine, amphetamines
Tranquilizers-phenothiazines, reserpine, monoamine oxidase inhibitors

Metals and Trace Elements

Arsenic, lead, lithium, mercury and methylmercury, molybdenum, nickel, selenium, thallium

Insecticides

benzene hexachlorides -lindane
Carbamates - carbaryl
Chlorobenzene derivatives chlorophenothane (DDT), methoxychlor
Indane derivatives - aldrin, chlordane, dieldrin
Phosphate esters (cholinesterase inhibitors) - parathion

Miscellaneous - chlordecone (kepone), merex, hexachlorobenzene, ethylene oxide

Herbicides

Chlorinated phenoxyacetic acids - 2,4-dichlorophenoxyacetic acid (2,4-D), 2,4,5-trichlorophenoxyacetic acid (2,4,5-T)

Food Additives and contaminants

Cyclohexylamine, diethylstilbestrol (DES), dimethylnitrosamine, monosodium glutamate, nitrofurans derivatives (AF2), nitrosamines, sodium nitrite

Industrial Chemicals and Processes

Building materials - formaldehyde
Chlorinated hydrocarbons - polychlorinated biphenyls (PCBs), chloroform, trichloroethylene
Paints and dyes - aniline
Plastic monomers - caprolactam, styrene, vinyl chloride
Polycyclic aromatic hydrocarbons (PAHs) - benzo(a)pyrene
Rubber manufacturing - chloroprene
Solvents - benzene, carbon disulfide, chloroform, ethanol, glycol ethers, hexane, toluene, trichloroethylene, xylene
Miscellaneous - cyanoketone, hydrazines

Consumer Products

Flame retardants - TRIS, polybrominated biphenyls (PBBs)
Plasticizers - phthalic acid esters (DEHP)

Miscellaneous

Personal habits - alcohol consumption, tobacco smoking
Agents of abuse - marijuana and other centrally acting drugs

* Both laboratory and clinical reports are included (Target Organ Toxicity Center Reproductive Toxicity Information File).

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9. AIR AND WATER REACTIVE CHEMICALS

Air Reactive: (Pyrophorics)

Grignard reagents
Metal alkyls and aryls, such as RLi, RNa, R Al, R Zn
Metal Carbonyls, such as Ni(CO)₄, Fe(CO)₅, CO₂(CO)₈
Alkali metals such as Na, K
Metal powders, such as Al, Co, Fe, Mg, Mn, Pd, Pt, Ti, Sn, Zn, Zr
Metal hydrides, such as NaH, LiAlH₄
Nonmetal hydrides, such as B₂H₆ and other boranes, PH₃, AsH₃
Nonmetal alkyl, such as R₃B, R₃P, R₃As
Phosphorus (white)

Water Reactive:

Alkali metals
Alkali metal hydrides
Alkali metal amides
Metal alkyls, such as lithium alkyls
Grignard reagents
Halides of nonmetals such as BCl₃, BE₃, PCl₃, PCl₅, SiCl₄, S₂Cl₂
Inorganic acid halides such as POCl₂, SOCl₂, SO₂Cl₂
Anhydrous metal halides such as AlCl₃, TiCl₄, ZrCl₄, SnCl₄
Phosphorus Pentoxide
Calcium Carbide
Organic acid halides and anhydrides of low molecular weight

10. COMMON PEROXIDE-FORMING CHEMICALS

LIST A

Severe Peroxide Hazard on Storage with Exposure to Air

Discard within 3 months

- Diisopropyl ether (isopropyl ether)
- Divinyl acetylene (DVAP)
- Potassium metal
- Potassium amide
- Sodium amide (sodamide)
- Vinylidene chloride (1, 1 - dichloroethylene^a)

LIST B

Peroxide Hazard on Concentration; Do Not Distill or Evaporate Without First Testing for the Presence of Peroxides

Discard or test for peroxides after 6 months

- Acetaldehyde diethyl acetal (acetal)
- Cumene (isopropyl benzene)
- Cyclohexene
- Cyclopentene
- Decalin (decahydronaphthalene)
- Diethylene glycol dimethyl ether (diglyme)
- Dioxane
- Diacetylene (butadiene)
- Dicyclopentadiene
- Diethyl ether (ether)
- Ethylene glycol dimethyl ether (glyme)
- Ethylene glycol ether acetates
- Ethylene glycol monoethers (cellosolves)
- Furan
- Methylacetylene
- Methyl cyclopentane
- Methyl isobutyl ketone
- Tetrahydrofuran (THF)
- Tetralin (tetrahydronaphthalene)
- Vinyl ethers^a

LIST C

Hazard of Rapid Polymerization Initiated by Internally Formed Peroxides^a

a. Normal Liquids; discard or test for peroxides after 6 months^b

- Chloroprene (2-chloro-1,3-buta-diene)^c
- Styrene
- Vinyl acetate
- Vinylpyridine

a. Normal Gases, discard after 12 months^d

- Butadiene^c
- Tetrafluoroethylene (TFE)^c
- Vinylacetylene (MVA)^c
- Vinyl chloride

^a Polymerizable monomers should be stored with a polymerization inhibitor from which the monomer can be separated by distillation just before use.

^b Although common acrylic monomers such as acrylonitrile, acrylic acid, ethyl acrylate, and methyl methacrylate can form peroxides, they have not been reported to develop hazardous levels in normal use and storage.

^c The hazard from peroxides in these compounds is substantially greater when they are stored in the liquid phase, and if so stored without an inhibitor they should be considered as in LIST A.

^d Although air will not enter a gas cylinder in which gases are stored under pressure, these gases are sometimes transferred from the original cylinder to another in the laboratory, and it is difficult to be sure that there is no residual air in the receiving cylinder. An inhibitor should be put into any such secondary cylinder before one of these gases is transferred into it; the supplier can suggest inhibitors to be used. The hazard posed by these gases is much greater if there is a liquid phase in such a secondary container, and even inhibited gases that have been put into a secondary container under conditions that create a liquid phase should be discarded within 12 months.

11. SHOCK-SENSITIVE COMPOUNDS

Acetylenic compounds, especially polyacetylenes, haloacetylenes, and heavy metal salts of acetylenes (copper, silver, and mercury salts are particularly sensitive)

Acyl nitrates

Alkyl nitrates, particularly polyol nitrates such as nitrocellulose and nitroglycerine

Alkyl and acyl nitrites

Alkyl perchlorates

Amminemetal oxosalts: metal compounds with coordinated ammonia, hydrazine, or similar nitrogenous donors and ionic perchlorate, nitrate, permanganate, or other oxidizing group

Azides, including metal, nonmetal, and organic azides

Chlorite salts of metals, such as AgClO_2 and $\text{Hg}(\text{ClO}_2)_2$

Diazo compounds such as CH_2N_2

Diazonium salts, when dry

Fulminates (silver fulminate, AgCNO , can form in the reaction mixture from the Tollens' test for aldehydes if it is allowed to stand for some time; this can be prevented by adding dilute nitric acid to the mixture as soon as the test has been completed)

Hydrogen peroxide becomes increasingly treacherous as the concentration rises above 30%, forming explosive mixtures with organic materials and decomposing violently in the presence of traces of transition metals

N-Halogen compounds such as difluoroamino compounds and halogen azides

N-Nitro compounds such as N-nitromethylamine, nitrourea, nitroguanidine, and nitric amide

Oxo salts of nitrogenous bases: perchlorates, dichromates, nitrates, iodates, chlorites, chlorates, and permanganates of ammonia, amines, hydroxylamine, guanidines, etc.

Perchlorates salts. Most metal, nonmetal, and amine perchlorates can be detonated and may undergo violent reaction in contact with combustible materials

Peroxides and hydroperoxides, organic

Peroxides (solid) that crystallize from or are left from evaporation of peroxidizable solvents

Peroxides, transition-metal salts

Picrates, especially salts of transition and heavy metals, such as M, Pb, Hg, Cu, and Zn; picric acid is explosive but is less sensitive to shock or friction than its metal salts and is relatively safe as a water-wet paste (see Chapter 7)

Polynitroalkyl compounds such as tetranitromethane and dinitroacetonitrile

Polynitroaromatic compounds, especially polynitro hydrocarbons, phenols, and amines

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12. HIGH ENERGY OXIDIZERS

Ammonium

perchlorate

Ammonium

pernaganate

Barium peroxide

Bromine

Calcium chlorate

Calcium hypochlorite

Chlorine trifluoride

Chromium anhydride

or chromic acid

Fluorine

Hydrogen peroxide

Magnesium

perchlorate

Nitrogen peroxide

Nitrogen trioxide

Perchloric acid

Potassium bromate

Potassium chlorate

Potassium perchlorate

Potassium peroxide

Propyl nitrate

Dibenzoyl peroxide

Sodium chlorate

Sodium chlorite



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