

DATA SHEET: SOLVENTS

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Solvents are used in most paints (including many so-called water-based paints), varnishes, inks, and their thinners, in aerosol spray products, leather and textile dyes, permanent marking pens, glues and adhesives, some photographic chemicals, and much more.

WHAT ARE SOLVENTS?

The term “solvents” refers to liquid organic chemicals used to dissolve solid materials. Solvents can be made from natural sources such as turpentine and the citrus solvents, but most are derived from petroleum or other synthetic sources. Solvents are used widely because they dissolve materials like resins and plastics, and because they evaporate quickly and cleanly.

HOW DO SOLVENTS AFFECT US?

There are no “safe” solvents. All solvents, natural or synthetic, are toxic. Contact either with liquid solvents or inhalation of the vapors they emit into the air are hazardous.

In general, solvents can irritate and damage the skin, eyes, and respiratory tract, cause a narcotic effect on the nervous system, and damage internal organs such as the liver and kidneys. These kinds of damage can be acute (from single heavy exposures) or chronic (from repeated low dose exposures over months or years). In addition, some solvents are especially hazardous to specific organs or can cause specific diseases such as cancer.

SKIN CONTACT. All solvents can dissolve the skin’s protective barrier of oils, drying and chapping the skin and causing a kind of dermatitis. In addition, some solvents can cause severe burns and irritation of the skin. Natural solvents such as turpentine and limonene are known to cause skin allergies. Other solvents may cause no symptoms, but may penetrate the skin, enter the bloodstream, travel through the body and damage other organs.

THE EYES AND RESPIRATORY TRACT. All solvent vapors can irritate and damage the sensitive membranes of the eyes, nose, and throat. Inhaled deeply, solvent vapors also can damage lungs. The airborne concentration at which irritation occurs varies from solvent to solvent. Often workers are unaware of solvents’ effects at low concentrations. Their only symptoms may be increased frequency of colds and respiratory infections. Years of such exposure could lead to chronic lung diseases such as chronic bronchitis.

At higher concentrations symptoms are more severe and may include nose bleeds, running eyes, and sore throat. Inhaling very high concentrations or aspirating liquid solvents may lead to severe

disorders including chemical pneumonia and death. Liquid solvents splashed in the eyes can cause eye damage.

THE NERVOUS SYSTEM. All solvents can affect the brain or central nervous system (CNS) causing “narcosis.” Immediate symptoms of CNS effects may include dizziness, irritability, headaches, fatigue, and nausea. At progressively higher doses, the symptoms may proceed from drunkenness to unconsciousness and death. Years of chronic exposure to solvents can cause permanent CNS damage resulting in memory loss, apathy, depression, insomnia, and other psychological problems which are hard to distinguish from problems caused by everyday living.

Solvents also may damage the peripheral nervous system (PNS) which is the system of nerves leading from the spinal cord to the arms and legs. The symptoms caused by this PNS damage are numbness and tingling in the extremities, weakness, and paralysis. Some solvents such as n-hexane (found in some rubber cements and many spray products) can cause a combination of CNS and PNS effects resulting in a disease with symptoms similar to multiple sclerosis.

DAMAGE TO INTERNAL ORGANS. There is considerable variation in the kinds and degrees of damage different solvents can do to internal organs. Many solvents can damage the liver and kidney as these organs attempt to detoxify and eliminate the solvents from the body. One solvent, carbon tetrachloride, has such a devastating effect on the liver, especially in combination with alcohol ingestion, that many deaths have resulted from its use. Many solvents also can alter heart rhythm, even causing heart attacks or sudden cardiac arrest at high doses. This may be the mechanism which has killed many “glue sniffers.”

Some solvents also are known to cause cancer in humans or animals. Benzene can cause leukemia. Carbon tetrachloride can cause liver cancer. Many experts suspect that all chlorinated solvents (those with “chloro” or “chloride” in their names) may be carcinogens.

REPRODUCTIVE HAZARDS AND BIRTH DEFECTS. The reproductive effects of solvents are not well researched. Those studies which do exist show there is reason for concern. For example, Scandinavian studies show higher rates of miscarriages, birth defects, and other reproductive problems among workers exposed to even relatively low levels of solvents. Two types of solvents in particular have been shown to atrophy animals’ testicles and cause birth defects. These are 1) glycol ethers or cellosolves (found in many photographic chemicals, liquid water-based cleaning products, some inks and water based paints, and aerosol sprays) and 2) glycidyl ethers (found in epoxy resin products).

Studies of one of the least toxic solvents--grain alcohol--show that babies born to drinking mothers may be of low birth weight and have varying degrees of mental retardation including “fetal alcohol syndrome.” This syndrome also has been seen in babies born to “glue sniffing” mothers.

In addition, the first study showing a connection between solvents and birth defects in humans was published in the *Journal of the American Medical Association* in March, 1999. The researchers studied Canadian women exposed to organic solvents who were employed as factory workers, laboratory technicians, artists or graphic designers, printing industry workers, chemists, painters, office workers, car cleaners, veterinary technicians, funeral home employees, carpenters and social workers. The authors claim the study indicates that “... women exposed occupationally to organic solvents had a 13-fold risk of major malformations as well as increased risk for miscarriages in previous pregnancies.”

A second study published in the *Archives of Pediatrics and Adolescent Medicine* (October, 2004) evaluated the “normal” children of 32 women who used solvents in various jobs such as graphic designers, hair stylists, an art conservator, and photo lab workers. The solvent exposures were not excessive and lasted between 1 and 40 hours per week for between 8 and 40 weeks during their pregnancies. The children of these women were compared with children of women who did not work with solvents who were of the same ages, IQs, incomes, and life styles. All the children were tested between 3 and 9 years of age and those of the solvent-exposed mothers were found to have poorer language, memory and attention skills, more hyperactivity and impulsivity.

EXPLOSION AND FIRE HAZARDS. Two properties which affect a solvent’s capacity to cause fires and explosions are evaporation rate and flashpoint. In general, the higher a solvent’s evaporation rate (see definition in Table) the faster it evaporates and the more readily it can create explosive or flammable air/vapor mixtures. Flash points are the lowest temperature at which vapors are created above a solvent’s surface in sufficient amounts to ignite in the presence of a spark or flame. The lower the solvent’s flashpoint, the more flammable it is. Materials whose flashpoints are at room temperature or lower are particularly dangerous.

The chlorinated hydrocarbons (see Chemical Classes, below) are usually not flammable and have no flash points. However, some of these react explosively on contact with certain metals and heating or burning them creates highly toxic decomposition products including phosgene gas. Hazardous amounts of these toxic gases can be created even by working with chlorinated solvents in a room where a pilot light is burning. **All, solvents, flammable or not, should be isolated from sources of heat, sparks, flame, and static electricity.**

CHEMICAL CLASSES OF SOLVENTS. All solvents fall into various classes of chemicals. A class is a group of chemicals with similar molecular structures and chemical properties. Important classes of solvents are aliphatic, aromatic, and chlorinated hydrocarbons, alcohols, esters, and ketones. The Table shows various solvents and their properties by class.

RULES FOR CHOOSING SAFER SOLVENTS

1. Compare Threshold Limit Values. Choose solvents with high threshold limit values whenever possible. (See complete definition in the USA data sheet on Threshold Limit Values.)
2. Compare evaporation rates. Choose solvents with low evaporations rates whenever possible. In fact, some very toxic solvents which evaporate very slowly may not be as hazardous to use as less toxic ones that evaporates very quickly.
3. Compare flash points. Choose solvents with high flashpoints whenever possible. Chlorinated solvents with no flash points, however, should not be considered safe. (See Explosion and Fire Hazards section above.)
4. Compare toxic effects. Although all solvents are toxic, some may be especially dangerous to you. For example, if you have heart problems, it makes sense to avoid solvents known for their toxic effects on the heart.
5. Compare within classes. Often solvents in the same chemical class can be substituted for each other and chemicals in the same class usually dissolve the same materials and work similarly.

RULES FOR SOLVENT USE

1. Try to find replacements for solvent-containing products. New and improved water-based products are being developed. Keep abreast of developments in new materials.
2. Use the least toxic solvent possible. Use the Table to select the safest solvent in each class. Consult Material Safety Data Sheets on the products you use and choose those containing the least toxic solvents.
3. Insist on compliance with OSHA hazard communication laws at your workplace. This law requires: a complete inventory of all solvents and solvent-containing products; complete labeling all containers, even ones into which solvent products have been transferred; a file of Material Safety Data Sheets on all solvents kept where it is available during all working hours; and formal training of all potentially exposed persons.
4. Avoid breathing vapors. Use solvents in areas where local exhaust ventilation is available. Dilution ventilation should only be used when very small amounts of solvents or solvent-containing products are used. (See USA data sheet on Ventilation for Theaters and Shops.) Use self-closing waste cans for solvent-soaked rags, keep containers closed when not in use, and design work practices to reduce solvent evaporation. Keep a respirator with organic cartridges or an emergency air-supplying respirator at hand in case of spills or ventilation failure.
5. Avoid skin contact. Wear gloves for heavy solvent exposure and use barrier creams for incidental light exposures. Obtain a manufacturer's glove chart to determine which type of plastic or rubber glove will resist the solvents you use. Wash off splashes immediately with water and mild soap. Never clean hands with solvents or solvent-containing hand-cleaners. If solvents in amounts larger than a pint are used at one time, or if large spills are possible, have an emergency shower installed.
6. Protect eyes from solvents. Wear chemical splash goggles that meet ANSI standard Z87.1 whenever there is a chance a splash may occur. Install an eye wash fountain or other approved source of clean water which provides at least fifteen minutes flow. Prominently post emergency procedures (usually near telephone) for obtaining emergency medical advice and treatment if necessary.
7. Protect against fire, explosion, and decomposition hazards. Follow all local and federal codes for use, handling, ventilation, and storage. Never smoke or permit heat, flames, or sparks near solvents. Install sprinkler system, fire extinguishers approved for solvent fires, or other proper fire-suppression system. Store amounts larger than a gallon in approved flammable storage cabinets (this recommendation exceeds requirements). Do not use heat and/or ultraviolet light sources near chlorinated hydrocarbons. Ground containers from which solvents are dispensed. Local exhaust ventilation fans for solvent vapors must be explosion-proof.
8. Be prepared for spills. Check all applicable local and federal regulations regarding release of solvent liquids and vapors. If spills of large amounts are likely, use chemical solvent absorbers sold by most major chemical supply houses. Special traps to keep solvent spills out of sewers may be required by law. Release of large amounts of liquid or vapor of certain solvents must be reported to environmental protection authorities.
9. Use and dispose of solvents in accordance with local or federal regulations. These vary around the country depending on the type of sewage treatment systems, air quality problems and other factors that determine how solvents may be used and discarded. You may need to call a local department of environmental protection, publicly-owned water treatment facility or other governmental agency to find out the rules in your area.

TABLE - COMMON SOLVENTS AND THEIR HAZARDS (see pages 6-10 below)

COLUMN 1 SOLVENT CLASS designates the chemical group into which solvents fall. Under each class heading are listed individual solvents and their common synonyms.

COLUMN 2 Threshold Limit Value-Time Weighted Averages are the 2009 ACGIH (American Conference of Governmental Industrial Hygienists) eight-hour, time-weighted Threshold Limit Values (TLV-TWA) will be in parts per million (ppm) unless otherwise noted. A notice of intended change (NIC) indicates the new value has been proposed by ACGIH. When no TLV-TWA exists, the TLV-STEL (15 minute standard) or the TLV-Ceiling limit will be used. If ACGIH has not set a standard or if there is a more protective standard, these may be listed such as the OSHA permissible exposure limit (PEL), a Workplace Environmental Exposure Limit (WEEL) from the American Industrial Hygiene Association, or a German Republic standard (MAK). (SEE data sheet on TLVs.)

COLUMN 3 ODOR THRESHOLD (OT) in parts per million (ppm). These are the levels at which most people tested can detect the odor. Keep in mind that this value represents a broad range of concentrations and you may not be able to detect the solvent at this level.

COLUMN 4 FLASH POINT (FP) in degrees Fahrenheit (F °). The FP is the lowest temperature at which a solvent gives off sufficient vapor to form an ignitable mixture with air near its surface. The lower the FP, the more flammable the solvent. Some petroleum solvents exhibit a range of FPs.

COLUMN 5 EVAPORATION RATE (ER). These will be listed as FAST, MEDIUM OR SLOW. This is the rate at which a material will vaporize (volatilize, evaporate) from the liquid or solid state when compared to another material. The two common liquids used for comparison are butyl acetate and ethyl ether.

WHEN BUTYL ACETATE = 1.0

> 3.0 = FAST

0.8 - 3.0 = MEDIUM

< 0.8 = SLOW

WHEN ETHYL ETHER = 1.0

< 3.0 = FAST

3.0 - 9.0 = MEDIUM

> 9.0 = SLOW

COLUMN 6 COMMENTS on particular effects of the solvent. All solvents can cause narcosis at high levels. The symptoms listed here are those for which the TLVs were set or other special hazards. Abbreviations include central nervous system (CNS) damage, peripheral nervous system (PNS) damage, upper respiratory tract (URT) damage, skin damage, narcosis, etc.

COLUMNS: 1 SOLVENT CLASS name, synonym	2 TLV-TWA ppm	3 OT ppm	4 FP F°	5 ER	6 COMMENTS: Major Hazards in addition to General Hazards noted in the Data Sheet.
ALCOHOLS					ONE OF THE SAFER CLASSES.
Ethyl Alcohol, ethanol grain and denatured alcohol,	1000 (STEL)	84	55	MED	Least Toxic. Denatured means contains small amounts of various unpalatable/toxic additives.
Isopropyl Alcohol, 2-propanol, rubbing alcohol	200	22	53	MED	Eye, URT, CNS effects. Cancer effects unknown.
Methyl Alcohol, methanol, wood alcohol	200	100	52	FAST	Headaches, eye damage. Skin absorbs. High doses can cause blindness.
N-Propyl Alcohol, n-propanol	100	5.3	59	MED	Eye, URT irritation. Not evaluated for cancer effects.
Isoamyl Alcohol, 3-methyl-1-butanol, fuel oil	100	0.03- 0.07	109	SLOW	Eye, URT irritation.
N-Butyl Alcohol, n-butanol	20	1.2	95	SLOW	Eye, URT irritation. Lacrimator.
ALIPHATIC HYDROCARBONS					MOST ARE MIXTURES DERIVED FROM PETROLEUM.
Kerosene, jet fuels	200 mg/m ³ *	Unk.	100- 150	VERY SLOW	Low toxicity. Skin, URT irritation, CNS damage. Skin absorbs.
Heptane, n- & iso-heptanes, heptanes (mix of isomers)	400	40- 547	25	FAST	One of least toxic substitutes for n-hexane. CNS impairment, URT irritation, skin absorbs
Mineral Oil, pure	5 mg/m ³ *	None	High	VERY LOW	The TLV is only for large inhalable particle. No standard exists for respirable mist. Imperfectly refined mineral oil is a carcinogen.
VM & P Naphtha, Gamsol®, others	300	1-40	20-40	MED	This TLV was withdrawn in 2008 leaving artists with no simple substitute for turpentine.
Stodard solvent, other similar petroleum fractions	100	1-30	>100	SLOW	May contain significant amounts of aromatics. Eye, skin, kidney CNS damage; nausea.
N-Hexane, normal hexane, commercial hexanes contain 55% n-hexane	50	65- 250	-7	FAST	Do not use. Potent CNS & peripheral nerve toxin causing multiple sclerosis-like disease. Eye irritant. Skin absorbs. Substitute heptane.
Hexane isomers	500	—	—	FAST	Low toxicity.
Gasoline	300	0.3	-45	FAST	Do not use. Extremely flammable. May contain skin-absorbing benzene, toxic additives.

* milligrams per cubic meter

COLUMNS: 1	2	3	4	5	6
SOLVENT CLASS name, synonym	TLV-TWA ppm	OT ppm	FP F°	ER	COMMENTS: Major Hazards in addition to General Hazards noted in the Data Sheet.

AMIDES/AMINES

MANY ARE SENSITIZING. TOXIC AT LOW LEVELS

Dimethyl formamide (DMF)	10	0.5-100	136	SLOW	Try to avoid. Skin absorbs. Liver damage.
Ethanolamine	3	2.6	185	VERY SLOW	Severe skin, eye irritant. Narcosis, liver & kidney damage reported at high levels.
Diethanolamine	0.2 ppm	0.27	342	VERY SLOW	Liver & kidney damage, eye damage on contact. Skin absorbs.
Triethanolamine	5 mg/m ³ *	Unk.	385	**	Hazards similar to ethanolamine. Avoid. An animal carcinogen.

* milligrams per cubic meter

** hygroscopic: absorbs water and evaporates very slowly.

AROMATIC HYDROCARBONS

A HAZARDOUS CLASS, AVOID IF POSSIBLE.

Ethyl Benzene, ethyl benzol, Phenylethane	100	0.1-0.6	59	SLOW	URT irritation, CNS impairment, eye irritant. ACGIH may reduce TLV to 50 ppm
Xylenes xylol, dimethyl benzenes	100	0.08-40	20	SLOW	URT & eye irritation, CNS impairment. Stomach pain reported with m-xylene.
Toluene, toluol, methyl benzene, phenyl methane	20	2.9	40	MED	CNS impairment. Visual impairment; Female reproductive system damage, pregnancy loss. Try to avoid.
Styrene, vinyl benzene, phenyl ethylene	20	0.02-0.47	90	SLOW	CNS impairment, URT irritation, peripheral neuropathy. Suspect carcinogen. Try to avoid.
Diethylbenzenes: 1,3-DEB, 1,4-DEB	5 (WEEL)	2.3	~130	SLOW	URT & eye irritant. CNS impairment.
Trimethylbenzenes: 1,2,3-TMB; 1,2,4-TMB; 1,3,5-TMB	25	2.4	~130	MED	CNS impairment, asthma, blood effects. Not well-studied.
Benzene, benzol	0.5	34-119	12	MED	Do not use. Causes leukemia. Skin absorbs.

COLUMNS: 1	2	3	4	5	6
SOLVENT CLASS name, synonym	TLV-TWA ppm	OT ppm	FP F°	ER	COMMENTS: Major Hazards in addition to General Hazards noted in the Data Sheet.

CHLORINATED HYDROCARBONS
MANY IN THIS CLASS CAUSE CANCER. AVOID.

1,1,1-trichloroethane, methyl chloroform	350	390	**	FAST	CNS impairment, liver & kidney damage. Causes irregular heart beat reported.
Methylene Chloride, dichloromethane	50	160	**	FAST	Avoid. Suspect cancer agent. Metabolizes to carbon monoxide in blood. CNS damage. Stresses the heart.
Trichloroethylene	10	82	**	MED	CNS damage. Suspect cancer agent. Irregular Heartbeat. Liver damage, headache.
Perchloroethylene, perc, tetrachloroethylene	25	47	**	MED	Suspect cancer agent. Irregular heartbeat, CNS damage, skin reddens after alcohol ingestion.
Chloroform	10	133- 276	**	FAST	Do not use. Suspect cancer agent.
Ethylene Dichloride, 1,2-dichloroethane	10	6- 185	56	MED	Strong intoxicant, causes liver damage, nausea, suspect cancer agent.
Carbon Tetrachloride <small>** these solvents do not have typical flash points. They dissociate with heat or ultraviolet radiation to form toxicgases such as phosgene.</small>	5	140- 584	**	FAST	Do not use. Cancer agent. Severe liver damage and/or death can result when combined with with alcohol. Skin absorbs.

ESTERS/ACETATES
ONE OF LEAST TOXIC CLASSES.

Ethyl Acetate	400	3.9	24	FAST	Least toxic in class. URT & eye irritant.
Methyl Acetate	200	4.6	14	FAST	Headache. URT irrit. Ocular nerve damage.
Isoamyl Acetate, banana oil , 2-pentyl acetate	50	0.22	64	MED	Eye & URT irritant. Used for fit- testing.

ETHERS
**DO NOT USE. EXTREMELY FLAMMABLE. FORMS
EXPLOSIVE PEROXIDES WITH AIR.**

COLUMNS: 1	2	3	4	5	6
SOLVENT CLASS name, synonym	TLV-TWA ppm	OT ppm	FP F°	ER	COMMENTS: Major Hazards in addition to General Hazards noted in the Data Sheet.

GLYCOLS

VARY GREATLY IN TOXICITY.

Propylene Glycol, 1,2-propanediol	10 mg/m ^{3**} (German MAK-TWA)	Unk.	210	*	Least toxic glycol. May cause allergies. Use in cat/dog food causes blood damage.
Ethylene Glycol, 1,2-ethandiol	10 mg/m ^{3**} (German MAK-TWA)	0.1-40	232	*	URT & eye irritant. Neurological damage and blindness at high doses. Skin absorbs.
Diethylene Glycol	10 mg/m ³ (German MAK-TWA)	Unk.	255	*	Probably more toxic than Ethylene Glycol, but does not cause blindness. Skin absorbs.
Triethylene Glycol, Triglycol	1000 mg/m ³ (German MAK-TWA)	Unk.	350	*	MAK only applies to large (inhalable) mist particles. No standard for respirable size. Systemic effects noted in German MAK.

* hygroscopic: absorbs water and evaporates very slowly

** milligrams per cubic meter

GLYCOL ETHERS (CELLOSOLVES) & their Acetates

TRY TO AVOID, ESPECIALLY IF PLANNING A FAMILY.

2-butoxyethanol, butyl cellosolve, ethylene glycol monobutyl ether	20	0.1	141	SLOW	Eye & URT irritation. Affects kidneys, liver, reproductive. Skin absorbs.
2-ethoxyethanol, cellosolve, ethyl cellosolve, ethylene glycol monoethyl ether	5	2.7	110	SLOW	Reproductive hazard for men and women. Blood, liver, kidneys. Skin absorbs. Do not use.
2-methoxyethanol, methyl cellosolve ethylene glycol monomethyl ether	0.1	2.4	102	SLOW	Same as above. Skin absorbs. Do not use.
Di- and Tri-Ethylene and Propylene Glycol Ethers and their Acetates	—	—	—	—	This is a large class, many of which are not well-studied. Experts suspect many can harm reproductive systems.

COLUMNS: 1	2	3	4	5	6
SOLVENT CLASS name, synonym	TLV-TWA ppm	OT ppm	FP F°	ER	COMMENTS: Major Hazards in addition to General Hazards noted in the Data Sheet.
KETONES					TOXICITY VARIES WIDELY.
Acetone , 2-propanone, dimethyl ketone,	500	62	-4	FAST	Least toxic. URT & eye irritant. CNS impairment. Damages blood. Inadequate EPA cancer data.
Methyl Ethyl Ketone , MEK, 2-butanone	200	5.4	16	FAST	URT irritation, CNS & PNS nerve damage. damage esp. with hexane. Skin absorbs.
Methyl Isobutyl Ketone , MIBK	50 (NIC 20)	0.88	64	MED	URT & eye irritant. Kidney damage. Skin absorbs.
Methyl Butyl Ketone , MBK	5	0.07- 0.09	77	MED	Do not use. PNS & testicular damage.
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MISCELLANEOUS					
Turpentine & other monoterpenes	20	50- 200	95	SLOW	Causes allergies (dermatitis, asthma), URT & skin irritation. CNS impairment, lung damage. Use odorless paint thinner.
Limonene , d-limonene, citrus oil, citrus turps, menthadiene, dipentene	20 (German MAK- TWA)	Unk.	Unk.	VERY SLOW	A pesticide, food additive. Acutely toxic by ingestion. Kidney damage, skin allergies. Damages indoor air quality.
Morpholine	20	0.011- 0.07	100	SLOW	Avoid. Skin absorbs. Eye damage, URT irritant.
Tetrahydrofuran	50	31	1.4	VERY FAST	Becomes explosive when old or exposed to air. URT irritant, CNS impairment, kidney damage. Skin absorbs.
Dioxane , 1,4-dioxane	20	12	65	FAST	Avoid. Carcinogen. Skin absorbs. Liver damage.
Cyclohexane , hexamethylene	100	780	1.4	FAST	CNS impairment. Chronic effects unknown.
Texanol ® 2,2,4-trimethyl- 1,3-pentandiol monoisobutyrate	—	250	—	—	Found in many latex paints and craft products. Little is known about its long term effects.