Chemical Exposure

When Are Vapors Harmful To You and Your Students?

Threshold Limit Values (TLV) and Permissible Exposure Limits (PEL) refer to the levels of a chemical above which a person should avoid repeated and prolonged exposure. TLVs and PELs were originally structured to provide guidelines for industrial workers who may be repeatedly exposed to the same chemicals day after day. Science teachers can use these values to provide guidance on which chemicals to use and when to take precautions. TLVs and PELs should be regarded as general standards, since different individuals respond differently to exposure. The amount of exposure and the time period of exposure are the critical issues.

The difference between TLVs and PELs is the agencies from which they come. TLVs are developed by the American Conference of Governmental Industrial Hygienists (ACGIH). PELs are developed by the Occupational Safety and Health Administration (OSHA). They both serve the same purpose and their values are very similar or even identical in many cases. For the remainder of this article, we will refer only to TLVs.

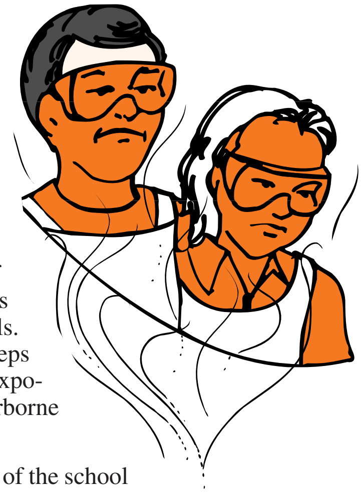
TLVs for vapors or gases are reported in units of either parts per million (ppm) or milligrams per cubic meter (mg/m^3) of air. A cubic meter is approximately the size of a small telephone booth. Exposure limits for dust, particulate matter or mist are always reported as milligrams per cubic meter of air.

Many substances have effects which are acute and fast-acting. A ceiling limit has been established for these items. This ceiling suggests that the limit not be exceeded even for an instant. For example, the ceiling TLV for iodine is 0.1 ppm or 1 mg/m^3.

For those chemicals that are acute or fast-acting through skin absorption, gloves must be worn; the substances must also be handled in either an operating fume hood or a well-ventilated room.

The threshold of smell of many chemicals is usually below that of the TLV. Strong smell may act as a warning that the TLV is being approached. Since human smelling ability can be impaired by some odors, one should not depend on smell as a reliable indicator of a hazard. Chlorine gas, as an example, has a TLV of 0.5 ppm or 1.5 mg/m^3. The odor threshold for chlorine is approximately 0.3 ppm. If you can smell chlorine, you are probably at or near the level of concern.

Biology teachers in particular should note the very low TLV for formaldehyde (0.3 ppm), and make plans to eliminate formaldehyde from their program, use it only under a hood, or be sure the room air in their laboratory is being changed (not recirculated) a minimum of 10–12 times per hour. Fortunately, many preserved materials now contain only very small amounts of free formaldehyde.



The best practice is to maintain concentrations of all atmospheric contaminants to the lowest practical levels. There are three primary steps that will help reduce your exposure to volatile or other airborne chemical substances.

1. **Ventilation.** Ventilation of the school science laboratory should be of paramount importance to the science teacher. Two types of ventilation should be incorporated in the science laboratory. A purge ventilation system should be available to provide a quick air exchange in the laboratory whenever the level of a hazardous chemical vapor or dust approaches the TLV. Also, fume hoods should be available and used whenever volatile and hazardous materials are used. A reaction that is performed in a properly operating fume hood will not release any vapors into the laboratory.
2. **Substitution.** Use the TLV table on the following page to substitute a less hazardous chemical for the experiment or activity. For example, if an alcohol is required for an experiment and methyl, ethyl, or isopropyl alcohol can be used, the smart choice is to use ethyl alcohol because it has the highest TLV. Another example is melting point determinations. Many teachers have used naphthalene or para-dichlorobenzene, both of which have a TLV of 10 ppm. Why not substitute a less hazardous material such as cetyl alcohol, stearic acid, or t-octyl phenol?
3. **Microscale.** Scaling down the quantity of material used will reduce the amount that will volatilize into the atmosphere. If a typical class (15 lab groups, 280 m^3 room) performs a lab where sulfur is burned to form sulfur dioxide and the lab is microscaled to use only 0.05 g of sulfur, the average level of sulfur dioxide in the room will probably not exceed 3 mg/m^3, below the TLV of 5.2 mg/m^3. However, if 0.2 g or more are used by each group, the TLV would quickly be exceeded.

TLVs are not well-defined limits between what is safe or unsafe. Rather, they should be used as guidelines for the teacher. Most students are in the laboratory for only short periods each week. The teacher's exposure is, of course, much greater. Following the above steps will greatly reduce your exposure to hazardous chemicals.

The following is a list of common school laboratory chemicals and their TLV values. This is not a comprehensive listing. TLV values are subject to change as new information is developed.

CHEMICAL EXPOSURE continued on next page.

Some Common Chemical TLVs

Substance	TLV (ppm)	TLV (mg/m³)
Acetic Acid	10	25
Acetic Anhydride[1]	5	21
Acetone	750	1188
Alumina[2]	—	10
Aluminum Metal[2]	—	10
Ammonia	25	17
Ammonium Chloride[2]	—	10
Ammonium Dichromate[2]	—	0.5
n-Amyl Acetate	100	532
Aniline and Homologs[3]	2	7.6
Antimony and Compounds	—	0.5
Arsenic and Soluble Compounds	—	0.01
Barium and Barium Compounds	—	0.5
Barium Sulfate	—	10
Benzene	0.5	1.6
Benzoyl Peroxide	—	5
Bromine and Bromine Water	0.1	0.66
Bromoform	0.5	5.2
Butane	800	1900
2-Butanone	200	590
n-Butyl Alcohol[1,3]	50	152
sec-Butyl Alcohol	100	300
tert-Butyl Alcohol	100	303
Cadmium and Cadmium Compounds[2]	—	0.01
Calcium Carbonate	—	10
Calcium Hydroxide	—	5
Calcium Oxide	—	2
Calcium Sulfate	—	10
Camphor, synthetic	2	12
Carbon Dioxide	5000	9000
Carbon Disulfide[3]	10	31
Cellulose	—	10
Charcoal	—	3.5
Chlorine, gas	0.5	1.5

Substance	TLV (ppm)	TLV (mg/m³)
Chloroform	10	49
Chromates and Dichromates	—	0.05
Chromium (III) Compounds	—	0.5
Chromium Metal and Insoluble Salts	—	0.5
Cobalt	—	0.02
Copper[2]	—	1
Cyclohexane	300	1030
Cyclohexanol[3]	50	206
Cyclohexanone[3]	25	100
Cyclohexene	300	1010
p-Dichlorobenzene	10	60
Dioxane[3]	25	90
Ether, Ethyl	400	1210
Ethyl Acetate	400	1440
Ethyl Alcohol	1000	1880
Ethylenediamine[3]	10	25
Ethylene Dichloride[3]	10	40
Ethylene Glycol[1]	—	100
Formaldehyde	0.3	0.37
Formic Acid	5	9.4
n-Heptane	400	1640
n-Hexane	50	176
Hydrochloric Acid[1]	5	7.5
Hydrogen Fluoride[1]	3	2.3
Hydrogen Peroxide	1	1.4
Hydrogen Sulfide (gas)	10	14
Hydroquinone	—	2
Iodine[1]	0.1	1
Isoamyl alcohol	100	361
Isopropyl Alcohol	400	983
Lead, Metal and Compounds[2]	—	0.05
Magnesium Oxide[2]	—	10
Manganese[2]	—	0.2
Mercury	—	0.025

Substance	TLV (ppm)	TLV (mg/m³)
Methyl Alcohol[3]	200	262
Methyl Chloroform	350	1910
Methyl-t-Butyl Ether	40	144
Methyl Ethyl Ketone	200	590
Methyl Isobutyl Ketone	50	205
Methyl Methacrylate	100	410
Naphthalene	10	52
Nicotine[3]	—	0.5
Nitric Acid	2	5.2
Oxalic Acid	—	1
Pentane	600	1770
Phenol[3]	5	19
Phosphorus	0.02	0.1
Phthalic Anhydride[1]	1	6.1
Potassium Hydroxide[1]	—	2
Propane	2500	4508
n-Propyl Alcohol[3]	200	492
Pyridine	5	16
Silver Nitrate (as silver)	—	0.01
Sodium Bisulfite	—	5
Sodium Hydroxide[1]	—	2
Styrene[3]	50	213
Sulfur Dioxide (gas)	2	5.2
Sulfur Hexafluoride	1000	5970
Sulfuric Acid	—	1
Tetrahydrofuran	200	590
Tin (inorganic)	—	2
Titanium Dioxide[2]	—	10
Toluene	50	188
Trichloroethylene	50	269
Turpentine	100	556
Xylenes	100	434
Zinc Chloride[2]	—	1
Zinc Oxide[2]	—	5

A RESPONSIBLE TEACHER WILL USE A HOOD!

[1] Ceiling TLVs. Chemicals where the TLVs should not be exceeded even for a second. These substances are acute and fast-acting.
[2] TLV for dust or fume.
[3] These chemicals are rapidly absorbed by the skin, eyes, and mucous membranes. TLVs should be strictly observed for these substances.