Occupational Hygiene – Occupational Exposure Limits Fact Sheets

WHAT IS OCCUPATIONAL HYGIENE?

The occupational hygiene is the branch of occupational health and safety which focuses on the prevention of the occupational diseases. The exposure to health hazards can lead to diseases and illnesses that can manifest either immediately or after a long period of time after the exposure has stopped. Since these diseases are a consequence of exposure to hazards present in the work place, they are known as occupational diseases. Occupational hygiene uses methods for exposure identification and evaluation following the techniques of anticipation, identification, evaluation, and control. The goal is to identify solutions for eliminating or reducing the hazard, and monitoring to ensure no further harm occurs. Occupational exposure limits are one tool or method in this process.

What are the occupational exposure limits?

In general, the occupational exposure limit (OEL) represents the maximum airborne concentration of a toxic substance to which a worker can be exposed over a period of time without suffering any harmful consequences.

The OELs developed by the professional organizations are guidelines. Only the values adopted and prescribed by the legislation are enforceable. In Canada, provinces, territories and the Labour Program (for the federally regulated workplaces) list which occupational exposure limits are enforceable under their health and safety legislation. A list of legislative references for Exposure Limits to Chemical and Biological Agents for Canadian jurisdictions is available. Please note that while you can see the list of legislation for free, you will need a subscription to view the actual documentation.

Remember! A legal limit or guideline (such as an occupational exposure limit) should never be viewed as a line between “safe” and “unsafe”. The best approach is to always keep exposures or the risk of a hazard as low as possible.

As an example, carcinogens are not usually defined by an exposure limit. With many carcinogens, it is difficult to say for certainty that if exposure is below a set point, the agent is not likely to cause harm. For this reason, for carcinogens and other specific agents (such as allergens), the “As Low as Reasonably Practicable” (ALARA) principle should be applied. ALARA, in practical terms, means that exposure should be eliminated or reduced as much as possible.

Are there different types of exposure limits?

ACGIH defines three categories of threshold limit values:

Threshold Limit Value – Time-Weighted Average (TLV-TWA): The concentration of a hazardous substance in the air averaged over an 8-hour workday and a 40-hour workweek to which it is believed that workers may be repeatedly exposed, day after day, for a working lifetime without adverse effects.

Threshold Limit Value – Short-term exposure (TLV-STEL): A 15-minute time weighted average exposure that should not be exceeded at any time during a workday, even if the overall 8-hour TLV-TWA is below the TLV-TWA. Workers should not be exposed more than four times per day to concentrations between TLV-TWA and TLV-STEL. There should be at least a 60 minute interval between exposures. The short-term exposure threshold has been adopted to account for the acute effects of substances that have primarily chronic affects.

Threshold Limit Value – Ceiling (TLV-C): This is the concentration that should not be exceeded during any part of the working exposure. Peak exposures should be always controlled. For substances that do not have TLV-TWA or TLV-C established, the maximum admissible peak concentrations must not exceed:

- Three-times the value of the TLV-TWA for no more than 15 minutes, no more than four times per workday. Exposures must be at least 1 hour apart during the workday.
- Five times the TLV-TWA under any circumstances.

The units of measures for the threshold limit values are ppm and mg/m3. The TLVs for aerosols are expressed usually in mg/m3. The TLVs for gases and vapours are expressed in ppm or mg/m3.

What if I am exposed to several chemical substances at the same time?

In the workplace, a worker may be exposed to several chemical substances at a time. If the toxicological effect of the substances is similar (e.g., each substance affects same target organ or has a similar effect), it can be considered that the combined effect of the chemicals will be the sum of individual effects. A common example is exposure to several organic solvents.

In this case, ACGIH recommends the following calculation:

If the sum of:

C1/T1 + C2/T2 +….Cn/Tn

is higher than 1, the threshold limit of the mixture is exceeded.

(C is the concentration in the air of the substance and T is the threshold limit)

This formula should not be used for:

- mixtures of substances with toxicological effects are not additive (individual toxicological effects and target organs are different),
- mixtures of substances which inhibit each other’s effect,
- substances that may have a synergistic effect,
- carcinogens (exposure to mixtures of carcinogens should be eliminated or as low as possible), and
- complex mixtures (e.g., diesel exhaust).

What if I work more than eight hours per day or 40 hours per week?

The threshold limit values apply for 8-hour workday and 40-hour workweek. When working shifts longer than eight hours, the exposure time is increased and the recovery period between exposures is decreased. In these situations, the threshold exposure limit should be so adjusted that in the end the peak body burden does not exceed the one that would occur during a normal eight hour shift.

There are numerous mathematical models, some simple and some more complex, that can be used to adjust the TLV to a different work schedule. The Brief and Scala model is recommended by ACGIH as a simpler model which reduces the TLV by a factor that takes into account the hours worked daily and the periods of rest between them.

$$\text{Adjusted TLV} = \text{Reduction Factor} \times \text{TLV}$$

$$\text{Reduction Factor} = \frac{8}{\text{daily hours worked}} \times \frac{24 - \text{daily hours worked}}{16}$$

The number of days worked per week is not considered, except for a 7-day-workweek (e.g. for a 56 workdays followed by 21 days off schedule). The formula to be applied for a 7-day workweek is:

$$\text{Weekly Reduction Factor} = \frac{40}{\text{hours worked per week}} \times \frac{(24 \times 7) - \text{hours worked per week}}{128}$$

For example, the modified TLV-TWA for toluene (TLV-TWA = 20 ppm) for a 12-hr/day 14-day pattern shift (five workdays one week and two workdays the next week) will be:

$$\text{Daily Reduction Factor} = \frac{8}{12} \times \frac{24 - 12}{16} = 0.5$$

$$\text{Adjusted TLV} = 20 * 0.5 = 10 \text{ ppm}$$

(The reduction factor is calculated for the 12-hour workday regardless of how many days, 5 or 2, are worked during a week).

One of the shortcomings of the Brief and Scala method is that the reduction factor for a certain amount of worked hours is identical for all chemicals regardless of their individual biological half-lives. This assumption may lead to an overestimation of the degree to which the limit should be lowered.

The formula is not applicable for:

- Work schedules with less than seven to eight hours per day or less than 40 hours per week.
- Work schedules that involve 24-hour continuous exposure (e.g., in submarines and space shuttles).
- Certain irritants.

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