Misuse of Threshold Limit Values (TLVs) in Scientific Papers, Reports and Discussions-A Note

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The note below is written in the light of commonly misused or inappropriately applied term-“exposure limit” in the media, scientific reports and discussions. One usually notes in the newspapers, TV interviews with a statement such as “…the measured level of a hazardous substance at the plant is X times higher or lower than the international exposure limit…” In often many cases, the person acknowledges or understands the international exposure limit, as Threshold Limit Values (TLVs).

What is the background to these exposure limits? Various countries use different ‘terms’ to express the exposure limits. For example, Occupational Exposure Levels (OELs) as used by the Occupational Safety and Health Administration (OSHA) of USA; Permissible Exposure Levels (PELs) as used by the Mine Safety and Health Administration (MSHA); TLVs as used by the American Conference for Governmental Industrial Hygienists (ACGIH). OELs were first proposed by Emhurst Duckering (1910) in the UK, as a way of limiting exposure to dust, as “…The most scientific way of regulating a dusty trade would be to impose a limit on the amount of dust which may be allowed to contaminate the air breathed by the workpeople and to leave the manufacturer a completely free choice of methods by which this result may be attained…”

To eliminate the health risk of exposure to substances, the exposure limits were developed, applied and promulgated through health studies carried out in the USA, the UK and other European countries by industrial hygiene practitioners. Of these exposure limits, TLVs being the most famous and influential guideline.

TLVs is an abbreviation of Threshold Limit Values for hazardous substances which are developed and updated by the US based non-profit scientific association, called American Conference for Governmental industrial Hygienists (ACGIH) established in 1938. TLVs are based primarily on health considerations refer to airborne concentrations of substances and represent conditions to which it is believed that “nearly all workers” may be repeatedly exposed day after day without adverse health effects. TLV is a copyrighted trademark of the ACGIH and TLVs are not mandatory exposure standards but recommended to be used as a guideline. These limits are updated annually and reflect generally the current professional recommendations on workers’ exposures to specific substances. Every TLV® is developed and based on the available, relevant, scientific data for that substance. It is possible that sometimes, the TLVs of few substances can be retracted based on new evidence (example, Diesel Particulate Matter).

In the light of the past litigations against the ACGIH, the scientific body cautions that the TLVs are an expression of scientific opinion and are not consensus standards. Furthermore, the **published TLVs are based solely on health factors and *no consideration has been given to economic or technical feasibility***. Some 13 countries (excluding USA), have adopted the TLVs of most substances as regulatory standards.

In South Africa, the exposure limits are commonly termed as OELs. However, the use of TLVs as standards is becoming a norm sometimes. Further, these TLVs have presented themselves in the DME regulatory standards. For example, much of the regulatory standards for substances published in the DME Air Pollutant document are mere duplication of the TLVs as published in the latest ACGIH TLV document.

Exposure limits provide the necessary guidance for planning, engineering, monitoring and controlling the hazard and work practices for effective control of exposure to substances. There are wide variations in the exposure limits as defined by regulatory and research authorities or scientific associations. The exposure limits set by regulatory authorities of countries worldwide need not be the same and must not be compared directly with each other because of the differences in each country’s exposure measurement, control and assessment strategies.

Exposure limits must be used in the context of which they were aimed and prepared for. One must also be conscious of the social and economic considerations while setting up or criticizing or using in one’s own advantage of the OELs.

For example, measuring the respirable quartz dust exposure using size-selective measurement devices or commonly called as cyclones where the OELs can be misused. In principle, widely available different cyclones or dust samplers require to follow the specified size-selective sampling curves such as British Medical Research Council (BMRC) curve which is widely known as Johannesburg Curve or the new ISO/CEN/ACGIH curve.

The performance of cyclones is typically described in terms of the 50% (or median) cut-point or D_{50}. The median cut-point reflects the size of dust that the cyclone collects with 50% efficiency. The cut points are defined in relation to the particle penetration into the gas exchange region of the lung. The D_{50} of the BMRC Curve is 5 µm while the D_{50} of the new ISO/CEN/ACGIH curve is 4 µm.

If one determines quartz exposure with a gravimetric cyclone in accordance with BMRC curve, and applying the TLVs or OSHA OELs of quartz dust of 0.1 mg/m^3 would be misleading. Because, OSHA’s OEL or TLVs for quartz dust is applicable when respirable quartz dust is measured using 10 mm Dorr-Oliver cyclone operating at a flow rate of 1.7 L/min with a D_{50} of 3.5 µm. In theory, one records higher dust mass when measured in accordance with the BMRC curve. Therefore,

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interpreting a specific measurement and comparing it with the TLV would result in the biased conclusions or reporting due to the sampling methodology used.

As the particles get smaller, the cyclone gets more efficient; with larger particles, the cyclone gets less efficient. ACGIH now specifies the median cut-point of a respirable dust sampler to be 4 µm in accord with the International Standards Organization/European Standardization Committee (ISO/CEN/ACGIH).

Figure 1 shows the two different size-selective curves that the dust samplers need to follow. From the curve and as demonstrated below, we notice that a cyclone with a 5 µm cut-point will collect higher mass of dust than that with a 3.5 µm cut-point:

$$M_{D50} = \rho \times \pi \times \frac{(D50)^3}{6} \qquad (1)$$

where,

M_{D50} = Mass of the dust particle (cut-point) in mg
ρ = Density of the dust particle in mg/m^3
D50 = Aerodynamic diameter of the cut-point in µm

From the above equation (1), one can calculate that the mass of the quartz dust particle with cut-points of 5 µm and 3.5 µm are 0.000173 ng and 0.000088 ng respectively. Therefore, the respirable quartz dust collected using different size selective curves will result in different dust masses. While the TLV was recommended according to the specific size selective curve in mind, the comparison of measured dust mass collected using a different sampling curve and comparing it to the TLV would be incorrect.

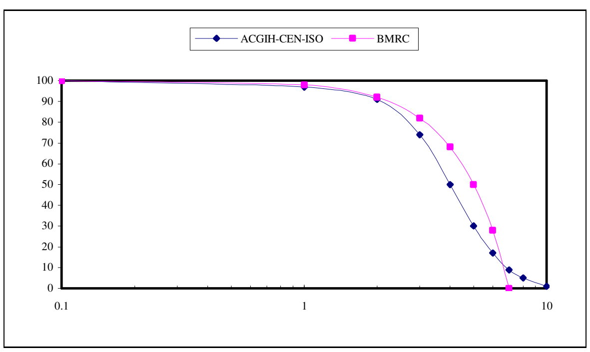

Figure 1: Respirable dust sampling or size-selective curves

In many instances, one observes reports and claims of over exposures and achievement of under exposure with "loosely" defined and less understood exposure limits. Therefore, when exposure limit of a substance is mentioned, it is required of us to ask some pertinent questions such as:

- ✓ What is the exposure reference limit (Local, National, OSHA limit, MSHA limit, TLVs)?
- ✓ Have you used the appropriate measurement device operating at a specified flow rate in accordance with which the respective exposure limit has been set?

Finally, professionals in the field need to be extra vigilant in reporting so as to correct the proliferation of misuse of the exposure limit terminology to one's advantage in general use.

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