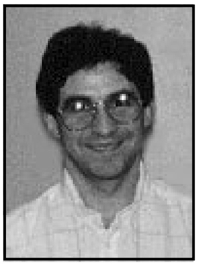

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# Extended Work Shift PELs or TLVs

The U.S. Occupational Safety and Health Administration (OSHA) has promulgated Permissible Exposure Limits (PELs), and the American Conference of Governmental Industrial Hygienists has developed Threshold Limit Values (TLVs) to protect the average worker who is exposed to a hazardous compound during eight-hr work shifts, five days per week, for a typical work life. Obviously, reducing the work shift duration to something less than eight hr/day and/or five days/week can only result in a reduced employee exposure, assuming all else—such as the airborne concentration—is kept equal.

On the other hand, when the work shift is increased in duration each day and/or in the number of days each week, the dynamics of the toxicology (also referred to as toxicokinetics) of the contaminant *may* be changed. This is a big "may," because little focused work has been carried out in this area.

## What Are "Normal" Conditions?

Under "normal" conditions, when the body is insulted by a contaminant, there are several responses that the body may undergo, depending on the chemistry of the compound and the characteristics of the exposure (*i.e.*, airborne concentration and exposure duration). These responses include:

- The body may metabolize or process the compound to an end product that is less hazardous. Nevertheless, overloading the biological pathway (by excessive airborne concentrations, for example) may result in the compound causing a toxic outcome.
- Conversely, the body may metabolize the compound to an end product that actually is more hazardous than the original compound, and possibly result in a toxic outcome.
- The body may clear the compound by filtration in the liver or kidney, or even through exhalation. As noted in the first bullet above, if excessive concentrations are presented to the body, more of the compound may persist in the body longer, possibly resulting in a toxic outcome.
- There are reportedly certain compounds that may have concentration thresholds below which they do not appear to cause toxic outcomes, perhaps because the body is able to process them efficiently enough, or perhaps because the body is sufficiently resilient to accept a certain amount of damage without an obvious toxic outcome. This involves the concept of "recovery time." Recovery time is the period during which the body is not further exposed and has an opportunity to metabolize the compound, or otherwise repair the damage.

Modification of any part of the exposure equation (*e.g.*, the airborne concentration, duration of work exposure, metabolic dynamics or repair mechanisms) may "upset the apple cart," resulting in a toxic or more severe outcome. Based upon this information, the toxic outcome may be experienced even if the number of days of exposure is reduced to, say, working three 12-hr days/week vs. five eight-hr days, because the metabolic pathways, removal mechanisms, or repair systems may be saturated. This is an important point for particularly ambitious employees to understand, because they may be inclined to seek out a second job (with similar health effects) to fill the time left in the week that longer work days with shorter work weeks provide. Other influences, including habits such as cigarette smoking or the use of prescription drugs, may also have an impact on the toxic outcome because of synergistic effects.

The toxic outcome may be something relatively benign, such as superficial dermatitis, or severe, such as cancer or death. The outcome may be described as acute (short term) or chronic (long term). The exposure and toxicokinetics of the compound/outcome process will determine the acute and/or chronic nature of the outcome. Many solvents—formaldehyde, for example—may cause an acute effect of dizziness, headaches or nausea. Over time, the solvent may also cause liver and kidney damage, and perhaps cancer.

## What Protective Measures Can Be Taken?

Presuming that the PELs and TLVs have been based upon toxicokinetic data for an eight-hr work shift, how can these PELs and TLVs be modified to protect an employee exposed during longer work shifts?

One approach is to back-calculate the value as shown in the following example. If we know the eight-hr PEL for a chemical, then the allowable PEL for an extended shift is:

$$PEL_{EX} = (8/t)PEL_8$$

where:

$PEL_{EX}$ = the allowable PEL for an extended work shift
$PEL_8$ = the allowable PEL for an 8-hr work shift

$t$ = exposure duration in hr, or fractions thereof
8 = the number of hr in a typical work shift/day

The time-weighted average (TWA)—*i.e.*, the average measured airborne concentration of the chemical over the length of the work shift—should not exceed the $PEL_{EX}$.

If the work shift is 12 hr ($t$ = 12), for example, and the eight-hr PEL is 0.75 ppm ($PEL_8$ = 0.75 ppm), then the average concentration to which the employee may be exposed would be:

$$C < (0.75)(8/12) = 0.5 \text{ ppm}$$

where C = the average measured concentration of the chemical, *i.e.*, the TWA.

Therefore, C must be reduced to an average of 0.5 ppm or less to maintain the equivalent of an eight-hr TWA of 0.75 ppm. Note, however, that even at the reduced concentration (0.5 ppm vs. 0.75 ppm), the body's recovery mechanisms may be saturated, and it is possible that a mild to severe toxic effect may occur. This formula, therefore, cannot be used for all hazardous chemicals.

Another approach, described by Brief and Scala, would modify the PEL or TLV based upon a "reduction factor" calculated as follows:

$$PEL_{RF} = [8/t][(24-t)/16][PEL_8]$$

For example, if $t$ = 12 and $PEL_8$ = 0.75, then the maximum allowable TWA would be:

$$TWA = [8/12][(24-12)/16][0.75] = (0.5)(0.75 \text{ ppm}) = 0.375 \text{ ppm}$$

The concentration of the chemical, therefore, must be reduced by 50 percent to 0.375 ppm. As with the first method, however, it is possible, even at a reduced concentration, for the recovery mechanisms to be saturated, leading to the toxic outcome. Research on the specific compound is therefore necessary.

There are conditions under which Brief and Scala feel that this approach would be inappropriate. They do not want to apply this formula, for example, to work shifts shorter than eight hr, because it would tend to increase the apparent PEL or TLV.

It is important to remember when applying either formula (or some other option) that not all chemicals act in the same manner. Likewise, when the body is stressed, not all people react in the same way. Brief and Scala recommend that their formula be applied only under medical surveillance.

Biological exposure indices, where they exist for particular compounds, may be used in conjunction with air quality monitoring to determine employee exposure. We would add that whenever the duration of exposure is modified from the norm, special emphasis be placed upon control technologies to engineer out or reduce exposure where possible.

## Monitor With Care

We have learned from recent conversations with the regional OSHA office in Boston and OSHA's Technical Assistance Office in Salt Lake City, that this issue is currently being debated, and no definitive policy of

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