Occupational Exposure Limits For Novel Work Schedules

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Work schedules other than 7 to 8 hr/day and 40 hr/week are being introduced in many industrial operations. Novel work schedules, such as four 10-hour workdays per week or three 12-hour workdays per week for three weeks followed by four 12-hour workdays for three weeks and several other plans are presently being used. The Threshold Limit Values (TLV) do not apply to such novel schedules. Modified occupational limits, which are calculable from the methods suggested in this report, estimate the needed reduction in the TLV to provide protection for exposed workers. A simple system is suggested, but should be cautiously applied with good medical surveillance. Industrial hygiene experience with novel work schedules will ultimately provide the real requirements for acceptable exposures under such work conditions.

Introduction

THE PREFACE OF THE ACGIH Limit Value (TLV)[1] tables notes that the TLVs "represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect." The values refer to "time-weighted concentrations for a 7- or 8-hour workday and a 40-hour workweek." In their recent recommended standard for occupational exposure to inorganic arsenic, the National Institute for Occupational Safety and Health2 proposed a time-weighted average (TWA) limit for up to a 10-hour workday, 40-hour workweek.

In many industrial operations, novel work schedules have been introduced in recent years. These may come about to permit more efficient use of manpower, to conserve energy, and in remote locations, to permit adequate time off the job. Among the novel schedules are: four 10-hour workdays per week, a 6-week cycle of three 12-hour workdays for three weeks followed by four 12-hour workdays for three weeks, a 56/21 schedule involving 56 continuous days of work of 8 hours per day followed by 21 days off, a 14/7 schedule involving 14 continuous days of work of 8 to 12 hours per day followed by 7 days off, and various modifications or combinations of these.

In February 1974, we contacted the Chairman of the ACGIH TLV Committee who indicated that they had set no exposure standards for novel work schedules nor had they evolved any approach to this issue.

In light of the obvious need for these modified TLVs, we have prepared some preliminary calculations and recommendations for novel work schedules.

Basic Premise

Whenever novel work schedules are utilized an uncertainty exists concerning the effects of exposure to chemical agents. The modified occupational limits, which are calculable from the methods suggested in this report, estimate the needed reduction in the TLV to provide protection for the exposed workers. However, these reduced limits are no guarantee that an adequate safety margin will have been achieved. Therefore, we suggest that close medical surveillance be maintained for some reasonable period until it is assured that the modified limits do indeed protect the workers.

The TLV must be reduced by some amount to take into account not only the increased hours of exposure per day but also the decreased hours of recovery. This will be expressed as the product of each factor

calculated for a workday.

Reduction of TLV = effect of increased exposure time × effect of decreased exposure-free time

TLV Reduction Factor (RF) =

$$\frac{8}{h} \times \frac{24 - h}{16}$$

h = hours worked per day

The RF value should be applied (a) to TLVs expressed as a time-weighted average with respect to the mean and permissible excursion and (b) to TLVs which have a C (ceiling) notation except where the C notation is based solely on sensory irritation. In this case the irritation response threshold is not likely to be altered downward by an increase in number of hours worked and modification of the TLV is not needed.

Conditions

The basis for the TLV of each chemical must be considered in the application of the TLV Reduction Factor.

(1) Where the TLV is based on systemic effect (acute or chronic), the TLV reduction factor will be applied and the reduced TLV will be considered as a time-weighted average (TWA). Acute responses are viewed as falling into two categories: (a) rapid with immediate onset and (b) manifest with time during a single exposure. The former are guarded by the C notation and the latter are presumed time and concentration dependent and hence, are amenable to the modifications proposed. Number of days worked per week is not considered, except for a 7-day workweek discussed later.

(2) Excursion factors for TWA limits (Appendix D of 1974 TLV publication) will be reduced according to the following equation:

$$EF = [(EF_8 - 1)RF + 1]$$

where EF = desired excursion factor

EF_8 = value in Appendix D for 8-hour TWA

RF = TLV Reduction Factor

(3) Special case of 7-day workweek. Determine the TLV Reduction Factor based on exposure hours *per week* and exposure-free hours *per week.*

(4) When the novel work schedule involves 24-hour continuous exposure, such as in a submerged habitat or other totally enclosed environment designed for living and working, the TLV reduction technique cannot be used. In such cases, the 90-day continuous exposure limits of the National Academy of Science3 should be used, where applicable limits apply.

(5) The techniques are not applicable to work schedules less than seven to eight hours per day or 35 hours per week.

Sample Calculations

(1) For a 6-week schedule of three 12-hour workdays for three weeks followed by four 12-hour workdays for three weeks, what should the new TLV be for methanol? (1974 TLV = 200 ppm)

$$RF = \frac{8}{12} \times \frac{24 - 12}{16} = 0.5$$

New TLV = RF × TLV
= 0.5 × 200 ppm
= 100 ppm

Note: The TLV Reduction Factor of 0.5 applies to the 12-hour work schedule whether 3 or 4 days per week.

(2) For 10 hours per day, 4 days per week, what should be the new TLV be for MEK? (1974 TLV = 200 ppm)

$$RF = \frac{8}{10} \times \frac{24-10}{16} = 0.7$$

New TLV = 0.7 × 200 = 140 ppm.

(3) A TLV has been adjusted from 10 ppm to 5 ppm based on a 12-hour workday. What is the permitted excursion?

From Appendix D (for 10 ppm), $EF_8 = 2$

RF = 0.5

EF = [(2 − 1)] 0.5 + 1] = 1.5

Permitted excursion = EF × new TLV
= 1.5 × 5 ppm
= 7.5 ppm

(4) In an 8-hour day, 7-day workweek situation, such as the 56/21 or 14/7 schedules, what should the TLV for H_2S be? (1974 TLV = 10 ppm). This is the special case of a 7-day workweek.

Exposure hours per week = 8 × 7
= 56 hrs.

Exposure-free hours per week = (24 × 7) − 56 = 112 hr.

$$RF = \frac{40}{56} \times \frac{112}{128} = .625$$

New TLV = RF × TLV
= .625 × 10 ppm = 6 ppm.

(5) For an 11-hour per day exposure, 4 days per week what should the new TLV be for benzene? (1974 TLV = 25 C ppm) Since the C notation has been assigned to benzene because of its chronic toxicity and not because of irritation, the TLV Reduction Factor approach can be used. The "Skin" notation in the TLV table signals the contribution of the cutaneous route to overall benzene exposure.

$$RF = \frac{8}{11} \times \frac{24-11}{16} = 0.6$$

New TLV = 0.6 × 25 = 15 C ppm.

In summary, novel work schedules are becoming more common and widespread. Occupational exposure limits developed for 8 hours per day and 5-day workweeks need to be modified to meet the differing work-rest situations. A simple system is suggested, but should be cautiously applied with good medical surveillance. Industrial hygiene experience with novel work schedules will ultimately provide the real requirements for acceptable exposures under such work conditions.

The authors welcome comments and hope to develop a useful dialogue among interested and knowledgeable individuals.

References

1. Threshold Limits Committee: *Threshold Limit Values for Chemical Substances in the Workroom Air Adopted by ACGIH for 1974.* American Conference of Governmental Industrial Hygienists, P.O. Box 1937, Cincinnati, Ohio 45201 (1974).
2. _____: *Criteria for a Recommended Standard—Occupational Exposure to Inorganic Arsenic.* U.S. DHEW, National Institute for Occupational Safety and Health, Rockville, Md. (1973).
3. _____: *Atmospheric Contaminants in Spacecraft.* Report of the Panel on Air Standards for Manned Space Flight. Space Science Board, National Academy of Sciences, Washington, D.C. (October 1969) 86 p.

Comments On "Occupational Exposure Limits For Novel Work Schedules"

The proposal by Brief and Scala to adjust the TLVs according to vaned work schedules is very much in order, particularly for those substances with a small TLV safety factor, and when there is large departure from the seven- to eight-hour work schedule. Certainly, some such stopgap procedure is needed in the absence of any toxicologic information that has been tailored to particular work schedules. And even more so, when it is realized that the development of toxicologic criteria for all the permutations and combinations of work schedules for the 600 or so industrial substances with TLVs is an utter impossibility.

But, at the same time, it should be recognized that the general formula approach is a first approximation only, guarantees no exact solution. Brief and Scala have recognized this, and have pointed out the necessity for cautious application of the formulae with appropriate medical surveillance. With such surveillance, information will accumulate that, in turn, will permit the development of firmly based TLVs.

A limited amount of toxicologic information does exist on a few industrial substances for the extreme case of continuous (24 hours/day, round-the-clock) exposures. This information unquestionably supports the need for TLV reduction for increased exposure periods; some substances that are well tolerated under TLV conditions, suddenly become lethal or near lethal when exposure at the TLV is continuous. In addition, the data clearly show that not all substances behave in this manner, and that the TLV for some is satisfactory without adjustment even for continuous exposure. In these instances, the use of the reduction factor will obviously add an increased safety factor.