Chapter 27

EXPOSURE LIMITS FOR SAFEGUARDING HEALTH

Carl L. Yaws and Eric L. Jaycox
Lamar University, Beaumont, Texas

ABSTRACT

Results for exposure limits in air for safeguarding health are presented for organic and inorganic chemicals. The results include threshold limit value (TLV of ACGIH), permissible exposure limit (PEL of OSHA), recommended exposure limit (REL of NIOSH) and maximum concentration value in the workplace (MAK of DFG). The results are displayed in easy-to-use tabulations that are especially applicable for rapid engineering usage. The organic chemicals encompass hydrocarbon, oxygen, nitrogen, halogen, silicon, sulfur and other compound types. The results are useful in engineering applications involving exposure of chemicals and mixtures in the workplace.

EXPOSURE LIMITS FOR SAFEGUARDING HEALTH

The results for exposure limits in air for safeguarding health in the workplace are presented in Tables 27-1 and 27-2 for organic and inorganic chemicals. The tabulated values that apply to exposure in the workplace in a 40-hour week are summarized below:

- TLV (ACGIH) – Threshold limit value in air in workplace of the American Conference of Governmental Industrial Hygienists.
- PEL (OSHA) – Permissible exposure limit in air in workplace of the Occupational Safety and Health Administration.
- REL (NIOSH) – Recommended exposure limit in air in workplace of the National Institute for Occupational Safety and Health.
- MAK (DFG) – Maximum concentration value in air in workplace of the Federal Republic of Germany.

In the data collection, a literature search was conducted to identify data source publications for organics (1-13) and inorganics (1-12). The publications were screened and copies of appropriate data were made. These data were then keyed into the computer to provide a database for use in preparing the tabulations.

MIXTURES

If more than one substance is present in the workplace, then exposure limits are needed for gas mixtures. The following equation (1) maybe used for exposure limits of gas mixtures:

$$PEL_{mixture} = \Sigma\, y_i \,/\, \Sigma\, (y_i/PEL_i) \qquad (27\text{-}1)$$

where $PEL_{mixture}$ = permissible exposure limit of mixture, ppm
y_i = mole fraction of component i, ppm

EXAMPLES

The tabulated values maybe used in engineering applications involving exposure of pure components and mixtures in the workplace. Examples are given below.

Example 1 Due to a small leak, the workplace contains methylamine (CH5N) at a concentration of 13.7 ppm (parts per million by volume) in air.

Are the workers overexposed?

Inspection of the table discloses that the permissible exposure level (PEL) = 10 ppm for methylamine. Since the workplace concentration exceed the PEL for methylamine, the workers are overexposed. This is shown below:

Workplace concentration of 13.7 ppm > PEL of 10 ppm

Workers are overexposed.

Example 2 Estimate the permissible exposure level (PEL) for the gas mixture below:

	y_i	PEL_i
	ppm	ppm
Acetonitrile (C2H3N)	10	40
Ethylamine (C2H7N)	2	10
Monoethanolamine (C2H7NO)	2	3

Substitution of y_i and PEL_i into the equations for gas mixtures provides:

$$PEL_{mixture} = \Sigma\, y_i / \Sigma\, (y_i/PEL_i) = (10 + 2 + 2)/(10/40 + 2/10 + 2/3)$$

$$PEL_{mixture} = 12.5 \text{ ppm}$$

REFERENCES – ORGANIC COMPOUNDS

1. Crowl, D. A. and J. F. Louvar, CHEMICAL PROCESS SAFETY, Prentice Hall, Inc., Englewood Cliffs, NJ (1990).
2. NIOSH POCKET GUIDE TO CHEMICAL HAZARDS, U. S. Dept. of Health and Human Services, Superintendent of Documents, Washington, DC (June, 1994).
3. GUIDE TO OCCUPATIONAL EXPOSURE VALUES – 1997, American Conference of Governmental Industrial Hygienists, ACGIH, Inc., Cincinnati, OH (1997).
4. 1997 TLVs and BEIs, American Conference of Governmental Industrial Hygienists, ACGIH, Inc., Cincinnati, OH (1997).
5. June 1993 Air Contaminants Final Rule, specified in Tables Z-1, Z-2 and Z-3 (Federal Register, 58:35388-35351, June 30, 1993; corrected in Federal Register, 58:40191, July 27, 1993; and subsequent amendments).
6. Lees, F. P., LOSS PREVENTION IN THE PROCESS INDUSTRIES, Vols. 1 and 2, Butterworth-Heinemann, London, England (1992).
7. CONDENSED CHEMICAL DICTIONARY, 10th and 11th eds., G. G. Hawley (10th) and Sax, N. I. and R. J. Lewis, Jr. (11th), Van Nostrand Reinhold Co., New York, NY (1981, 1987).
8. Sax, N. I., DANGEROUS PROPERTIES OF INDUSTRIAL MATERIALS, 9th ed., Vols. 1, 2 and 3, Van Nostrand Reinhold Company, New York, NY (1996).
9. CRC HANDBOOK OF CHEMISTRY AND PHYSICS, 75th - 77th ed., CRC Press, Inc., Boca Raton, FL (1994-1996).
10. Springer, C. and J. R. Welker, INDUSTRIAL HYGIENE: AN INTRODUCTION FOR CHEMICAL ENGINEERS, American Institute of Chemical Engineers, New York, NY (1995).
11. Fawcett, H. H. and W. C. Wood, eds., SAFETY AND ACCIDENT PREVENTION IN CHEMICAL OPERATIONS, 2nd ed., John Wiley and Sons, New York, NY (1982).
12. Williams, P. L. and J. L. Burson, eds., INDUSTRIAL TOXICOLOGY, SAFETY AND HEALTH APPLICATIONS IN THE WORKPLACE, Van Nostrand Reinhold Company, New York, NY (1985).
13. de la Cruz, P. L. and D. G. Sarvadi, Am. Ind. Hyg. Assoc. J., 55(10), 894 (1994).

REFERENCES – INORGANIC COMPOUNDS

1. Crowl, D. A. and J. F. Louvar, CHEMICAL PROCESS SAFETY, Prentice Hall, Inc., Englewood Cliffs, NJ (1990).
2. NIOSH POCKET GUIDE TO CHEMICAL HAZARDS, U. S. Dept. of Health and Human Services, Superintendent of Documents, Washington, DC (June, 1994).
3. GUIDE TO OCCUPATIONAL EXPOSURE VALUES – 1997, American Conference of Governmental Industrial Hygienists, ACGIH, Inc., Cincinnati, OH (1997).
4. 1997 TLVs and BEIs, American Conference of Governmental Industrial Hygienists, ACGIH, Inc., Cincinnati, OH (1997).
5. June 1993 Air Contaminants Final Rule, specified in Tables Z-1, Z-2 and Z-3 (Federal Register, 58:35388-35351, June 30, 1993; corrected in Federal Register, 58:40191, July 27, 1993; and subsequent amendments).
6. Lees, F. P., LOSS PREVENTION IN THE PROCESS INDUSTRIES, Vols. 1 and 2, Butterworth-Heinemann, London, England (1992).
7. CONDENSED CHEMICAL DICTIONARY, 10th and 11th eds., G. G. Hawley (10th) and Sax, N. I. and R. J. Lewis, Jr. (11th), Van Nostrand Reinhold Co., New York, NY (1981, 1987).
8. Sax, N. I., DANGEROUS PROPERTIES OF INDUSTRIAL MATERIALS, 9th ed., Vols. 1, 2 and 3, Van Nostrand Reinhold Company, New York, NY (1996).
9. CRC HANDBOOK OF CHEMISTRY AND PHYSICS, 75th - 77th ed., CRC Press, Inc., Boca Raton, FL (1994-1996).
10. Springer, C. and J. R. Welker, INDUSTRIAL HYGIENE: AN INTRODUCTION FOR CHEMICAL ENGINEERS, American Institute of Chemical Engineers, New York, NY (1995).
11. Fawcett, H. H. and W. C. Wood, eds., SAFETY AND ACCIDENT PREVENTION IN CHEMICAL OPERATIONS, 2nd ed., John Wiley and Sons, New York, NY (1982).
12. Williams, P. L. and J. L. Burson, eds., INDUSTRIAL TOXICOLOGY, SAFETY AND HEALTH APPLICATIONS IN THE WORKPLACE, Van Nostrand Reinhold Company, New York, NY (1985).