

A VAPOUR HAZARD INDEX FOR USE WITH COSHH AND DSEAR

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For workers who may be exposed to chemical vapours the Control of Substances Hazardous to Health Regulations 2002 (amended 2004) and the Dangerous Substances and Explosive Atmospheres Regulations 2002 require risk assessment and control of the hazard. For example, if a cleaning process using solvent is planned, the employer should review possible options and determine if the worker would be exposed to an unsafe level of harmful vapour. If so, steps must be taken to modify the work or protect the worker by ventilation, respiratory protection, etc.

As from April 2005, Workplace Exposure Limits (WEL) have replaced the former Occupational Exposure Standards (OES) and Occupational Exposure Limits (OEL). However, these do not directly measure the hazard because in practice this is also determined by the amount of vapour given off by a liquid, which depends upon its vapour pressure.

A Vapour Hazard Index is therefore proposed and listed for volatile substances and gases with a WEL. This is the ratio of the saturated vapour pressure to the WEL, which is the amount by which the vapour will exceed the WEL in a confined space. It combines both the toxicological standard and physical properties. It can be used for an initial risk assessment, for example to compare the dangers of alternative solvents. It may also be used in specifying control measures, and is comparable with practice in other countries.

For many users, it is suggested that this may be more directly useful than the WEL, so it is therefore proposed that the Vapour Hazard Index should in future be published along with WELs.

INTRODUCTION

For workers who may be exposed to airborne concentrations of hazardous materials, a number of authorities publish lists of concentrations. The best-known of these are the Threshold Limit Values (TLV) published by the Annual Conference of Government Industrial Hygienists (ACGIH) of which they say "... represent the opinion of the scientific community that ... exposure at or below the level of the TLV ... does not create an unreasonable risk of disease or injury". (ACGIH 2005). Similar lists (and often derived from TLVs) are published in many countries and have status under law. In the US one legal version is known as Permitted Exposure Limits (PEL).

In the UK the equivalents are Workplace Exposure Limits (WEL) which as from April 2005 have replaced the former Occupational Exposure Standards (OES) and Occupational Exposure Limits (OEL), (HSE 2005).

For UK workers who may be exposed to chemical vapours the Control of Substances Hazardous to Health Regulations 2002 (amended 2004) and the Dangerous

Substances and Explosive Atmospheres Regulations 2002 require risk assessment and control of the hazard. For example, if a cleaning process using solvent is planned, the employer should review possible options and determine if the worker would be exposed to an unsafe level of harmful vapour. If so, steps must be taken to modify the work or protect the worker by ventilation, respiratory protection, etc.

It is the author's experience that many people use limits such as TLV and WEL as an index of toxicity, and will seek to replace a substance with a high value with one of lower value. In the absence of any more quantitative information this is understandable.

For example the (US) National Research Council in their authoritative handbook say "TLV and PEL values allow the laboratory worker to quickly determine the relative inhalation hazards of chemicals. In general, substances with PELs or TLVs of less than 50 ppm should be handled in a fume hood". (National Research Council 1995, p 42).

However, these values do not directly measure the hazard because in practice this is also determined by the ease by which the material becomes airborne. For example, toluene and xylene have the same WEL but toluene is more volatile and therefore can more readily give a harmful concentration.

The ACGIH stated in a press release that "They {TLVs} are not fine lines between safe and dangerous exposures, nor are they a relative index of toxicity", recognizing that they may often be interpreted in this way (ACGIH 2001).

The idea which is presented in the present paper is as follows. The magnitude of the hazard is represented by the ratio by which the concentration of material in the air exceeds a standard value. For emergency response purposes the standard value might be one which is considered immediately dangerous. However for planned work in the UK an appropriate and accessible concentration is the Workplace Exposure Limit WEL.

The actual danger is represented not by the WEL alone, but by how likely it is that this value will be exceeded. More volatile substances give off more vapour, as measured by their Saturated Vapour Pressure (SVP).

DEFINITION AND EXAMPLES

The Vapour Hazard Index is quite simply defined as:

$$\text{VHI} = \text{SVP}/\text{WEL}$$

That is, the saturated vapour pressure divided by the Workplace Exposure Limit, where both are in consistent units. It is convenient to express them both as a fraction of an atmosphere or, even simpler to consider the working atmosphere to be 1 bar.

For example, at 20°C, toluene has a vapour pressure of 0.029 bar, and the 8-hour WEL is 50 ppm which is equivalent to 50×10^{-6} bar. Therefore

$$\text{VHI (toluene)} = 0.029/(50 \times 10^{-6}) = 580.$$

The meaning of this is obvious. A spillage of toluene in an enclosed space will give an atmosphere 580 times the WEL. If the toluene is in a closed container, this is a quantitative measure of the danger if anyone is exposed to the headspace, e.g. by opening a manhole or taking a lid off. If liquid is exposed to the atmosphere as part of the work, this is a measure of the degree of dilution which will be required. Equally it is a measure of the reduction in concentration that must be provided by breathing protection by barrier or extract ventilation.

Another solvent, xylene, has the same WEL but only about half the vapour pressure and thus half the VHI.

$$\text{VHI (xylene)} = 0.015 / (50 \times 10^{-6}) = 300$$

However tetrahydrofuran has the same WEL but a much higher vapour pressure.

VHI (tetrahydrofuran) = $0.20 / (50 \times 10^{-6}) = 4000$, so the effective health risk is some seven times higher than for xylene.

The following Table 1 gives data for some liquid materials, arranged in order of VHI.

The WEL's are taken from EH40/2005. The vapour pressure information has come from the following sources: Perry's Handbook of Chemical Engineering, (Perry & Green, 1997), International Critical Tables (Washburn, 1954, 2003), Knovel Solvents (Wypych 2000), and the online Material Safety Data Sheets of J. T. Baker Chemicals. Note that all data and calculations are only to two significant figures for the following reasons. Firstly, the WEL is only a consensus standard with significant uncertainty. It may be changed by a factor of 2 or more in a subsequent publication. Secondly, the saturated vapour pressure varies significantly with temperature, more than 10% over a few degrees. For example, toluene SVP = 2.9 kPa at 20°C, 3.8 kPa at 25°C.

With access to suitable data, it is possible to calculate VHI for liquids at other temperatures. The situation for mixtures is more complex in that the vapour composition will generally be different from the liquid composition. This can be measured or estimated for many systems. In this case the VHI should be calculated for each individual component and should be added, as is standard practice in assuming risks are additive (Craig et al. 1999, HSE 2005).

What is important is the order of magnitude and the relative values when considering options.

GASES

Of course, some inhalation hazards are in the form of gases, and therefore the concentration is not limited by the vapour pressure. Effectively any release could result in an atmosphere totally replaced by the gas. The SVP is therefore replaced by one atmosphere (or bar) in the formula:

$$\text{VHI (gas)} = 1/\text{WEL}$$

Table 1. Vapour Hazard Index for liquids

CAS Number	Substance	VHI	WEL	VP
			8 hr	20 deg C
	More than 10⁶		ppm	bar
107-02-8	Acrylaldehyde (Acrolein)	2900000	0.1	0.29
7726-95-6	Bromine	2300000	0.1	0.23
75-08-1	Ethanethiol	1200000	0.5	0.59
	More than 10⁵			
302-01-2	Hydrazine	700000	0.02	0.014
111-30-8	Glutaraldehyde	460000	0.05	0.023
76-06-2	Trichloronitromethane	270000	0.1	0.027
10025-87-3	Phosphoryl trichloride	245000	0.2	0.049
542-88-1	Bis(chloromethyl ether)	140000	0.001	0.00014
124-40-3	Dimethylamine	125000	2	0.25
75-56-9	Propylene oxide	120000	5	0.59
67-66-3	Chloroform	100000	2	0.21
	More than 10⁴			
71-43-2	Benzene	99000	1	0.099
75-35-4	Vinylidene chloride	66000	10	0.66
56-23-5	Carbon tetrachloride	60000	2	0.12
107-13-1	Acrylonitrile	55000	2	0.11
541-41-3	Ethyl chloroformate	55000	1	0.055
110-89-4	Piperidine	50000	1	0.05
75-07-0	Acetaldehyde	49000	20	0.98
75-15-0	Carbon disulphide	39000	10	0.39
121-44-8	Triethylamine	36000	2	0.072
151-67-7	Halothane	32000	10	0.32
106-93-4	1,2-Dibromoethane (Ethylene dibromide)	30000	0.5	0.015
108-23-6	Isopropyl chloroformate	30000	1	0.03
109-89-7	Diethylamine	26000	10	0.26
107-06-2	1,2-Dichloroethane (Ethylene dichloride)	17000	5	0.087
108-18-9	Diisopropylamine	16000	5	0.08
107-19-7	Prop-2-yn-1-ol	15000	1	0.015
77-78-1	Dimethyl sulphate	13000	0.05	0.00065
107-18-6	Allyl alcohol	12500	2	0.025
108-90-7	Chlorobenzene	12000	1	0.012
1634-04-4	Methyl-tert-butyl ether	11000	25	0.27
95-53-4	o-Toluidine	10000	0.2	0.002

(Continued)

Table 1. *Continued*

CAS Number	Substance	VHI	WEL	VP
More than 1000				
108-24-7	Acetic anhydride	9400	0.5	0.0047
64-18-6	Formic acid	8800	5	0.044
110-54-3	<i>n</i> -Hexane	8000	20	0.16
140-88-5	Ethyl acrylate	7800	5	0.039
25154-54-5	Dinitrobenzene, all isomers	6700	0.15	0.001
60-29-7	Diethyl ether	5900	100	0.59
75-09-2	Dichloromethane	5800	100	0.58
109-99-9	Tetrahydrofuran	4000	50	0.2
141-32-2	<i>n</i> -Butyl acrylate	4300	1	0.0043
110-86-1	Pyridine	4200	5	0.021
79-46-9	2-Nitropropane	3400	5	0.017
108-01-0	2-Dimethylaminoethanol	3000	2	0.006
591-78-6	Hexan-2-one	3000	5	0.015
109-94-4	Ethyl formate	2600	100	0.26
75-05-8	Acetonitrile	2400	40	0.096
100-44-7	Benzyl chloride	2400	0.5	0.0012
75-34-3	1,1-Dichloroethane	2400	100	0.24
71-55-6	1,1,1-Trichloroethane	1650	100	0.165
100-74-3	4-Ethylmorpholine	1600	5	0.008
109-86-4	2-Methoxyethanol	1600	5	0.008
540-59-0	1,2-Dichloroethylene, <i>cis</i> trans isomers 60:40	1500	200	0.3
98-01-1	2-Furaldehyde (furfural)	1000	2	0.002
123-91-1	1,4-Dioxane, tech. grade	1440	25	0.036
64-67-5	Diethyl sulphate	1400	0.05	0.00007
108-91-8	Cyclohexylamine	1200	10	0.012
100-61-8	<i>N</i> -Methylaniline	1200	0.5	0.0006
79-20-9	Methyl acetate	1200	200	0.23
110-82-7	Cyclohexane	1000	100	0.1
More than 100				
79-01-6	Trichloroethylene	920	100	0.092
80-62-6	Methyl methacrylate	740	50	0.037
110-80-5	2-Ethoxyethanol	700	10	0.007
67-56-1	Methanol	650	200	0.13
108-20-3	Diisopropyl ether	640	250	0.16
75-65-0	2-Methylpropan-2-ol	600	100	0.06

(Continued)

Table 1. *Continued*

CAS Number	Substance	VHI	WEL	VP
108-88-3	Toluene	580	50	0.029
110-49-6	2-Methoxyethyl acetate	520	5	0.0026
127-18-4	Tetrachloroethylene	500	50	0.025
67-64-1	Acetone	500	500	0.25
78-93-3	Butan-2-one (methyl ethyl ketone)	490	200	0.097
141-78-6	Ethyl acetate	490	200	0.097
109-87-5	Dimethoxymethane	440	1000	0.44
108-10-1	4-Methylpentan-2-one (MIBK)	420	50	0.021
108-94-1	Cyclohexanone	420	10	0.0042
120-82-1	1,2,4-Trichlorobenzene	400	1	0.0004
62-53-3	Aniline	400	1	0.0004
68-12-2	Dimethylformamide	390	10	0.0039
75-52-5	Nitromethane	370	100	0.037
79-09-4	Propionic acid	350	10	0.0035
127-19-5	<i>N,N</i> -Dimethylacetamide	330	10	0.0033
111-15-9	2-Ethoxyethyl acetate	300	10	0.003
1330-20-7	Xylene, <i>o</i> -, <i>m</i> -, <i>p</i> -or mixed isomers	300	50	0.015
110-12-3	5-Methylhexan-2-one	300	20	0.006
541-85-5	5-Methylheptan-3-one	270	10	0.0027
78-83-1	2-Methylpropan-1-ol (isobutyl alcohol)	240	50	0.012
98-95-3	Nitrobenzene	200	1	0.0002
107-87-9	Pentan-2-one	180	200	0.036
98-82-8	Cumene	180	25	0.0044
141-43-5	2-Aminoethanol	180	3	0.00053
96-22-0	Pentan-3-one	180	200	0.035
78-92-2	Butan-2-ol	170	100	0.017
109-60-4	<i>n</i> -Propyl acetate	170	200	0.034
	Pentyl acetates (all isomers)	130	50	0.0065
107-98-2	1-Methoxypropan-2-ol	120	100	0.012
110-19-0	Isobutyl acetate	110	150	0.017
67-63-0	Propan-2-ol	110	400	0.044
138-22-7	Butyl lactate	110	5	0.00053
79-27-6	1,1,2,2-Tetrabromoethane	110	0.5	0.000053
123-86-4	Butyl acetate	100	150	0.015
108-65-6	1-Methoxypropylacetate	100	50	0.005

(Continued)

Table 1. *Continued*

CAS Number	Substance	VHI	WEL	VP
71-23-8	Propan-1-ol	100	200	0.02
100-41-4	Ethylbenzene	100	100	0.01
Less than 100				
142-82-5	<i>n</i> -Heptane	94	500	0.047
106-46-7	1,4-Dichlorobenzene (para)	92	25	0.0023
108-83-8	2,6-Dimethylheptan-4-one (DIBK)	92	25	0.0023
25551-13-7	Trimethylbenzenes, all isomers	85	25	0.00212
101-84-8	Diphenyl ether	71	1	0.000071
100-42-5	Styrene	70	100	0.007
583-60-8	2-Methylcyclohexanone	66	50	0.0033
95-50-1	1,2-Dichlorobenzene (ortho)	64	25	0.0016
8006-64-2	Turpentine	60	100	0.006
64-17-5	Ethanol	59	1000	0.059
106-35-4	Heptan-3-one (ethyl butyl ketone)	51	35	0.0018
111-76-2	2-Butoxyethanol	48	25	0.0012
110-43-0	Heptan-2-one (methyl amyl ketone)	40	50	0.002
25639-42-3	Methylcyclohexanol	30	50	0.0015
123-51-3	3-Methylbutan-1-ol (isopentyl alcohol)	27	100	0.0027
108-93-0	Cyclohexanol	20	50	0.001
872-50-4	1-Methyl-2-pyrrolidone	18	25	0.00045
112-07-2	2-Butoxyethyl acetate	15	20	0.0003
26952-21-6	Iso-octyl alcohol (mixed isomers)	10	50	0.0005

For example, ammonia gas has an 8-hour WEL of 25 ppm so:

$$\text{VHI (ammonia)} = 1/(25 \times 10^{-6}) = 40000 = 4.0 \times 10^5$$

Hydrogen chloride (the gas, not the aqueous acid) has a WEL of 1 ppm and thus

$$\text{VHI (HCl)} = 1/(1 \times 10^{-6}) = 1.0 \times 10^6.$$

The same rule applies for any volatile liquid which is used above its normal boiling point, or where the workplace is above its boiling point. For example, acetaldehyde boils at 20.8°C. It may be chilled or pressurized in use, but any release in a workplace above this temperature could displace all the air, thus:

$$\text{VHI (acetaldehyde)} = 1/(20 \times 10^{-6}) = 5.0 \times 10^4.$$

The following Table 2 gives VHI values for gases.

Obviously, this just goes in the order of the reciprocal of WEL, but it may be easier to grasp the dangers of different gases by comparing them in this way. Mixtures can be combined. For example a mixture of 98% CO₂ and 2% CO would have a VHI of $(0.98 \times 200 + 0.02 \times 3300) = 860$. A 1% mixture of ammonia in air would have a VHI of 400, (representing the fact that it has already been diluted by 100 times).

SOLUTIONS

Certain materials are used as gases dissolved in liquid, usually water – for example aqueous ammonia and hydrochloric acid. Rather more information is required to calculate a VHI, but the results are so interesting that they are worthwhile.

The following Table 3 shows the partial pressure of HCl (gas) above hydrochloric acid, which is HCl dissolved in water. This is far from an ideal solution, so it is important to use experimental data (Manufacturing Chemists Association, 1970).

From this, we can derive VHI values as follows (Table 4):

If we take standard concentrated HCl of 36% at 20°C, this has a VHI of 1400. However, using the slightly lower standard concentration of 32% reduces the vapour hazard more than 4 times. Using half the concentration, 18%, reduces this by more than 1000 times, and the use of even lower concentrations reduces the VHI to less than 1, which means that its vapour is considered tolerable in the workplace.

We can see that in many industrial situations where the strongest acid is not strictly necessary, then the vapour hazard can be reduced, and we have a quantitative way of expressing this.

The following Table 5 has been derived from Perry (1997) by converting to SI units and interpolating. Industrial strength aqueous ammonia is about 28%, but lower concentrations down to 10% can be supplied. Domestic solutions are about 5%.

As the WEL for ammonia is 25 ppm, we can derive a Table 6 for the VHI.

It may be noted that at 30 °C the vapour pressure from the strongest solution is virtually one atmosphere. We can see the effect of reducing the temperature or concentration on the vapour hazard. A 20% ammonia solution has less than half the VHI of a 28% solution, a 5% solution less than a tenth.

Carrithers et al. (1996) described a process where aqueous ammonia was used instead of anhydrous ammonia to make a more inherently safe system.

Table 2. Vapour Hazard Index for gases

CAS Number	Substance	VHI	WEL
			8 hr
	More than 10⁷		ppm
75-44-5	Phosgene	5000000	0.02
7803-51-2	Phosphine	3300000	0.03
7784-42-1	Arsine	2000000	0.05
10049-04-4	Chlorine dioxide	1000000	0.1
	More than 10⁶		
7782-65-2	Germane	500000	0.2
7782-50-5	Chlorine	200000	0.5
7803-62-5	Silane	200000	0.5
463-51-4	Ketene	200000	0.5
74-93-1	Methanethiol	200000	0.5
7782-41-4	Fluorine	100000	1
7647-01-0	Hydrogen chloride	100000	1
	More than 10⁵		
50-00-0	Formaldehyde	50000	2
75-04-7	Ethylamine	50000	2
7664-39-3	Hydrogen fluoride	55000	1.8
74-83-9	Bromomethane	20000	5
10035-10-6	Hydrogen bromide	33000	3
75-01-4	Vinyl chloride	33000	3
7783-06-4	Hydrogen sulphide	20000	5
2699-79-8	Sulphuryl difluoride	20000	5
75-21-8	Ethylene oxide	20000	5
75-43-4	Dichlorofluoromethane	10000	10
74-90-8	Hydrogen cyanide	10000	10
	More than 10⁴		
7664-41-7	Ammonia, anhydrous	4000	25
630-08-0	Carbon monoxide	3300	30
75-00-3	Chloroethane	2000	50
74-87-3	Chloromethane	2000	50
10024-97-2	Nitrous oxide	1000	100
	More than 1000		
115-10-6	Dimethyl ether	2500	400
811-97-2	1,1,1,2-Tetrafluoroethane	1000	1000
2551-62-4	Sulphur hexafluoride	1000	1000
75-45-6	Chlorodifluoromethane	1000	1000
	More than 100		
124-38-9	Carbon dioxide	200	5000

Table 3. Partial Pressure (Pa) of HCl above aqueous HCl solutions

% HCl	10°C	20°C	30°C
6	0.03	0.10	0.30
8	0.08	0.24	0.69
10	0.18	0.53	1.48
12	0.41	1.17	3.12
14	0.95	2.61	6.67
16	2.13	5.71	14.1
18	4.93	12.7	30.4
20	11.2	27.3	64.0
22	24.9	60.0	136
24	57.3	133	289
26	131	289	608
28	303	653	1320
30	697	1413	2800
32	1570	3130	5930
34	3520	6730	12300
36	7520	14100	25100
38	15600	28000	48000
40	31100	53200	83600

SOLIDS

It should be noted that dust hazards are not controlled by equilibrium vapour, so a VHI cannot be calculated in this way. It should in principle be possible to calculate an equivalent value for certain very well-characterized processes, but this is outside the scope of this paper, which has the intention of providing a simple method. While some solids do have a vapour pressure, this is unlikely to be the main risk component, so it is advised that the VHI should not be used.

OTHER HAZARDS

The index does not take into account the formation of dusts or mists that could increase the airborne concentration above the Saturated Vapour Pressure. It does not include the risk of asphyxiation by very high levels nor toxic exposure by skin contact.

HISTORY AND OTHER VERSIONS

It was because of the widespread use of TLVs has an index of toxic vapour hazard that the author proposed the basic idea given in this paper, entitled a Vapour Hazard Index in 1982 (Pitt, 1982). At that time there was little legislative pressure for formal risk assessment and

Table 4. Vapour Hazard Index for aqueous HCl solutions

% HCl	10°C	20°C	30°C
6	0.003	0.01	0.03
8	0.008	0.024	0.069
10	0.018	0.053	0.15
12	0.041	0.12	0.31
14	0.095	0.26	0.67
16	0.21	0.57	1.4
18	0.49	1.3	3.0
20	1.1	2.7	6.4
22	2.5	6.0	14
24	5.7	13	29
26	13	29	61
28	30	65	130
30	70	140	280
32	160	310	590
34	350	670	1200
36	750	1400	2500
38	1600	2800	4800
40	3100	5300	8400

the concept was not generally adopted in the UK, though it was taken up in German and French literature. However, the same name and idea was also proposed by Popenorf (1984) in an American publication. He also used the term Vapor Hazard Ratio. The concept was taken up by the US EPA (Environmental Protection Agency), and OSHA (Occupational Safety and Health Administration). Under the name “Substance Hazard Index” (SHI) it has been adopted into legislation in a number of states in the USA during the 1990s. (Substances with SHI above a certain value are subject to controls.)

Table 5. Vapour Pressure of NH₃ (bar) above aqueous solutions

Mass % NH ₃ °C	5	10	15	20	25	28
10	0.034	0.066	0.114	0.195	0.324	0.429
15	0.044	0.086	0.147	0.244	0.407	0.537
20	0.057	0.108	0.187	0.312	0.509	0.668
25	0.071	0.136	0.235	0.391	0.630	0.823
30	0.089	0.170	0.293	0.482	0.772	1.004

Table 6. Vapour Hazard Index of NH₃ above aqueous solutions

Mass % NH ₃ °C	5	10	15	20	25	28
10	1400	2600	4600	7800	13000	17000
15	1700	3400	5900	9700	16000	21000
20	2300	4300	7500	12000	20000	27000
25	2800	5400	9400	1600	25000	33000
30	3600	6800	12000	19000	31000	40000

In 1998 Quest Consultants proposed the same idea as a Toxicity Index (TI) based on the IDLH (Immediately Dangerous to Life and Health) standards in the US (Quest 1998). The US Department of the Environment also used the term “Hazard Index” for the ratio of the (estimated) concentration of a released chemical to its PEL or 15 minute TLV (Craig et al., 1999). The VHI is effectively that at the point of release of liquid or gas. The International Labour Organization (ILO) now uses this concept called “Relative Inhalation Risk” (RIR) in determining the risk phrases for their International Chemical Safety Cards, using the ratio of the SVP to the Short Term Exposure Limit (STEL). Categories are: up to 1, up to 12, up to 120, up to 4000, beyond 4000, (ILO 2005).

The concept has also been taken up in Austria, Denmark, Germany and Sweden and is known (in English) as the Vapour Hazard Ratio, particularly used for solvents in considering substitution and working practice. It is used in regulations such as the German TRGS420 [Technical Regulations for Hazardous Material] where it is called the Gefährdungszahl or GZ. The GZ for dichloromethane is 4400 compared with VHI of 5800 because of the difference in the prescribed concentration level (100 ppm UK, 350 mg/m³ Germany).

It is thus not new, if relatively unknown in the UK. What is presented here is a revised definition and suggestion for use, which it is felt may be helpful for rapid and quantitative risk assessment under COSHH and DSEAR. Having numbers to deal with, means that the effect of substituting materials or changing work practice can be assessed in strategies for control of risk.

CONCLUSION

A simple quantitative system has been described for assessing the potential risk to health in using gases or volatile liquids that have been assigned a Workplace Exposure Limit. The tables given represent the 8-hour limit. Equivalent Index values can be derived for other exposure standards, such as the 15-minute WEL, or the US standards of TLV, PEL or IDLH, and are already used by some authorities.

This allows consideration of possible changes to materials or work practice and a numerical assessment of the alternatives under COSHH or DSEAR. The principle can be adapted to other temperatures than those given in the table. For mixtures it should be assumed that risks are additive.

REFERENCES

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