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Document Name: CGA P-20: Standard for the Classification of Toxic Gas Mixtures

CFR Section(s): 49 CFR 173.115

Standards Body: Compressed Gas Association

APPROVED

Official Incorporator:
THE EXECUTIVE DIRECTOR
OFFICE OF THE FEDERAL REGISTER
WASHINGTON, D.C.

CGA P-20—2003

STANDARD FOR CLASSIFICATION OF TOXIC GAS MIXTURES

THIRD EDITION

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Work Item 00-03
Specialty Gases Committee

NOTE—Technical changes from the previous edition are underlined.

THIRD EDITION: 2003
SECOND EDITON: 1995
FIRST EDITION: 1991

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1 Introduction

Pure gas toxic designations are well known. However, the gases included in this standard vary according to the meaning of "toxic" or "poison," as defined by U.S. Department of Transportation (DOT) and Transport Canada's (TC) Transportation of Dangerous Goods (TDG) Regulations [1, 2].[1] Label requirements and hazard classes for pure gases reflect DOT and TC requirements. Additional labels denoting more than the toxic hazard class may be required.

Information on toxicity of gases has been obtained from a variety of sources. Specifically, LC_{50} and LC_{LO} data were obtained from the National Institute of Occupational Safety and Health (NIOSH), *Registry of Toxic Effects of Chemical Substances (RTECS)* and Sax's *Dangerous Properties of Industrial Materials*, Sixth Edition [3, 4].

2 Scope and purpose

2.1 Scope

This standard applies to all users, transporters, and manufacturers affected by label requirements and addresses classifications for gas mixtures that contain a toxic component(s). This standard categorizes gas mixtures by establishing a measurement criterion based on LC_{50} RAT values. The resultant criterion is the basis for a method to calculate gas mixture toxicity.

2.2 Purpose

The purpose of this standard is to establish a means to classify toxic gas mixtures.

3 Definitions

For the purpose of this standard, the following definitions apply.

3.1 Immediately Dangerous to Life or Health (IDLH)
Level defined by NIOSH determined to be immediately dangerous to life or health. This term is used for the purpose of respirator selection and represents a maximum concentration from which, in the event of respirator failure, one could escape within 30 minutes without experiencing any escape impairing or irreversible health effects.

3.2 Lethal Concentration Fifty (LC_{50})
Concentration of a substance in air, exposure to which for a specified length of time is expected to cause the death of 50% of the entire defined experimental animal population.

NOTE—For this publication, LC_{50} is defined by the following procedure: ten albino rats (five male and five female) are exposed to a test atmosphere for 1 hour and observed for 14 days. If five of the animals die within the 14-day observation period, the concentration level of the test atmosphere is the LC_{50}. Where suitable test data is not available, an LC_{50} value shall be assigned. See 4.2 for the selection of this LC_{50} value.

3.3 Lethal Concentration Low (LC_{LO})
Lowest concentration of a substance in air, other than LC_{50}, that has been reported to have caused death in humans or animals. The reported concentrations may be entered for periods of exposure which are less than 24 hours (acute) or greater than 24 hours (subacute and chronic).

3.4 LD_{50}
Lethal dose to 50% of a specified population.

3.5 Mole fraction
Concentration ratio of a component in a gas mixture.

3.6 ppm
Parts per million, by volume (mole fraction) for gases.

[1] References are shown by bracketed numbers and are listed in order of appearance in the reference section.

3.7 Threshold Limit Value-Time Weighted Average (TLV®-TWA)

Time-weighted average concentration of a substance for a normal 8-hour workday and a 40-hour workweek to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

4 Description of method for determining gas mixture toxicity

4.1 Hazard zones of toxic gas mixtures

This publication classifies toxic gas mixtures into four hazard zones. They are defined as follows:

- Hazard zone A—gases (mixtures) with an $LC_{50} \leq 200$ ppm;
- Hazard zone B—gases (mixtures) with an $LC_{50} > 200$ ppm ≤ 1000 ppm;
- Hazard zone C—gases (mixtures) with an $LC_{50} > 1000$ ppm ≤ 3000 ppm; and
- Hazard zone D—gases (mixtures) with an $LC_{50} > 3000$ ppm ≤ 5000 ppm.

TC TDG Regulations (2.14(c)) classify gases or gas mixtures as toxic if their LC_{50} value is less than or equal to 5000 ppm or if they are known to be toxic or corrosive to humans according to CGA P-20, ISO 10298, *Determination of toxicity of a gas or gas mixture*, or other documentary evidence published in technical journals or government publications [2, 5].

4.2 Classification procedures for toxic gas mixtures

The classification for toxicity of a gas mixture is based upon the LC_{50} of the gas mixture. The LC_{50} of a binary (two component) mixture composed of a toxic gas in a nontoxic gas is calculated as follows:

$$LC_{50} \text{ of gas mixture in ppm} = \frac{1}{\dfrac{\text{molar fraction of toxic component}}{\text{ppm } LC_{50} \text{ of toxic component}}}$$

OR

$$= \frac{\text{ppm } LC_{50} \text{ of toxic component}}{\text{ppm of toxic component}} \times 1\,000\,000$$

As indicated above, the LC_{50} of the toxic component must be known, calculated, or provisionally assigned.

The selection of an LC_{50} value for a pure gas shall follow the algorithm in Figure 1. The preferred measurement standard is LC_{50} RAT, 1 hour. Lacking good data for precisely these parameters, LC_{50} RAT values for times different from, but closest to, 1 hour were selected and adjusted to the 1 hour exposed limit. All data for exposures less than 0.5 hour were eliminated. Table 1 shows normalization factors for times other than 1 hour.

If no reliable LC_{50} data for rats were available, the next animals of choice in order, were mouse, rabbit, guinea pig, cat, dog, and monkey. Table 2 ranks the animals of choice. Data for 1 hour were preferred.

If no reliable LC_{50} data were found for any animal, a search was conducted for a reliable LC_{LO} value using the same hierarchy of animals. The same normalization factors for times other than 1 hour were used.

If no reliable LC_{50} or LC_{LO} value was obtained, a value was provisionally assigned based on any one or a combination of the following:

- decomposition or reaction products;
- a correlation to LD_{50} values (not inhalation);

- a comparison to other published hazard levels (e.g., IDLH); and
- an analogy to similar products.

Any data chosen from these four were weighted according to the reliability of the data.

Based on the algorithm in Figure 1 along with normalization factors of Table 1 and the animal rankings of Table 2, LC_{50} values have been obtained for a number of gases. These are listed in Table 3. Limiting concentrations for each gas in each hazard zone are as shown.

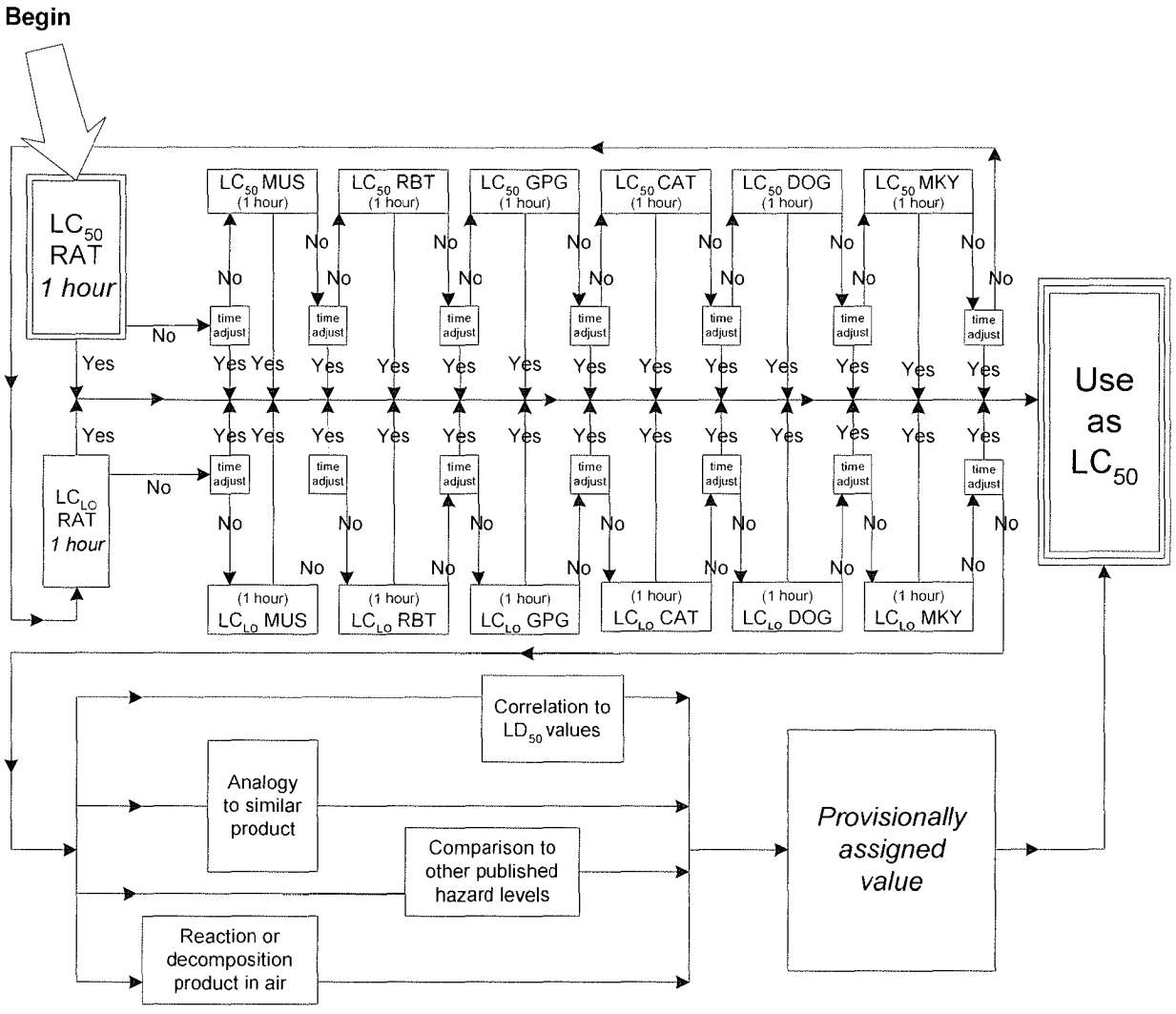

Figure 1—LC_{50} selection algorithm

Table 1—Modified Haber factors for time normalization of LC_{50} data to 1 hour

Time (hours)	Multiply by
0.5	0.707
1.0	1.000
1.5	1.225
2.0	1.414
3.0	1.732
4.0	2.000
5.0	2.236
6.0	2.449
7.0	2.646
8.0	2.828

Table 2—Animal ranking (in order of preference)

RAT	rat
MUS	mouse
RBT	rabbit
GPG	guinea pig
CAT	cat
DOG	dog
MKY	monkey

4.3 Limiting concentrations for gas mixture toxicity

The limiting concentrations for each gas mixture shown in Table 3 were calculated as follows:

$\frac{LC_{50} \text{ of pure gas in ppm}}{LC_{50} \text{ 200 ppm}}$ = lowest molar fraction of a toxic component in a gas mixture that places the mixture in Hazard zone A (x 100 for %)

$\frac{LC_{50} \text{ of pure gas in ppm}}{LC_{50} \text{ 1000 ppm}}$ = lowest molar fraction of a toxic component in a gas mixture that places the mixture in Hazard zone B (x 100 for %)

$\frac{LC_{50} \text{ of pure gas in ppm}}{LC_{50} \text{ 3000 ppm}}$ = lowest molar fraction of a toxic component in a gas mixture that places the mixture in Hazard zone C (x 100 for %)

$\frac{LC_{50} \text{ of pure gas in ppm}}{LC_{50} \text{ 5000 ppm}}$ = lowest molar fraction of a toxic component in a gas mixture that places the mixture in Hazard zone D (x 100 for %)

For example, fluorine has an LC_{50} of 185 ppm, therefore:

$$\frac{185\text{ ppm}}{200} = 0.925 \text{ for Hazard zone A (92.5\%)}$$

$$\frac{185\text{ ppm}}{1000} = 0.185 \text{ for Hazard zone B (18.5\%)}$$

$$\frac{185\text{ ppm}}{3000} = 0.062 \text{ for Hazard zone C (6.2\%)}$$

$$\frac{185\text{ ppm}}{5000} = 0.037 \text{ for Hazard zone D (3.7\%)}$$

As can be seen by the above, a fluorine gas mixture of 92.5% or more falls into Hazard zone A. A Hazard zone D fluorine gas mixture contains more than or is equal to 3.7% but less than 6.2%.

5 Principles of method for determining gas mixture toxicity

5.1 More than one toxic component

If there is more than one toxic component in a gas mixture, a summation may be made. The LC_{50} of a gas mixture (in ppm) containing more than one toxic component is calculated as follows:

$$LC_{50} \text{ of gas mixture ppm} = \frac{1}{\frac{\text{ppm of Toxic \#1}}{\text{ppm } LC_{50} \text{ of Toxic \#1}} + \frac{\text{ppm of Toxic \#2}}{\text{ppm } LC_{50} \text{ of Toxic \#2}} + \ldots\ldots} \times 1\,000\,000$$

5.2 Determination of appropriate hazard zone

Next, the ppm value should be compared to the appropriate hazard zone as defined in 4.1 to determine the hazard zone designation.

For example:

12% (120 000 ppm) boron trichloride [LC_{50} of 2541 ppm], 8% (80 000 ppm) chlorine [LC_{50} of 293 ppm], balance argon calculates as follows:

$$\frac{1}{\frac{120\,000}{2541} + \frac{80\,000}{293}} \times 1\,000\,000 = 3122 \text{ ppm}$$

Since the LC_{50} of the gas mixture is 3122 ppm, it is in Hazard zone D.

NOTE—Synergistic effects have not been considered in the above due to a lack of scientific data.

6 Method for selecting labels for toxic gas mixtures

To select labels for toxic gas mixtures:

a) Determine if the gas mixture contains a component designated as toxic by the DOT and/or TDG (See Table 4) [1, 2].

b) If it is a binary gas mixture (of a toxic in a nontoxic component), obtain the toxicity level for the component of interest from Table 3, and select the hazard zone for the concentration of that particular gas mixture.

c) If there are two or more toxic components in the gas mixture, apply the formula in 5.1 and determine the LC_{50} of the gas mixture. Then select the appropriate hazard zone as shown in 4.1.

d) After categorizing the gas mixture, apply DOT/TDG rules. The four hazard zones are useful in establishing classes, divisions, labels, warnings, and packing groups.

Other labels may be required for proper shipping and handling.

7 Sample calculations

Examples of some common gas mixtures containing toxic components and calculations to determine hazard zones are provided below:

Calculation formula for gas mixture containing one toxic component (see 4.2):

$$LC_{50} \text{ of gas mixtures in ppm} = \frac{\text{ppm } LC_{50} \text{ of toxic component}}{\text{ppm of toxic component}} \times 1\,000\,000$$

Example 1
10% phosphine
90% hydrogen

Calculation:

$$\frac{20}{100\,000} \times 1\,000\,000 = 200 \text{ ppm}$$

Hazard zone = A

Example 2
100 ppm arsine
balance hydrogen

Calculation:

$$\frac{20}{100} \times 1\,000\,000 = 200\,000 \text{ ppm}$$

Hazard zone = None

Calculation formula for gas mixtures containing more than one toxic component (see 5.1):

$$LC_{50} \text{ of gas mixtures in ppm} = \frac{1}{\frac{\text{ppm of Toxic \#1}}{\text{ppm } LC_{50} \text{ of Toxic \#1}} + \frac{\text{ppm of Toxic \#2}}{\text{ppm } LC_{50} \text{ of Toxic \#2}} + \ldots\ldots} \times 1\,000\,000$$

Example 3
500 ppm sulfur dioxide
500 ppm nitrogen dioxide
balance nitrogen

Calculation:

$$\frac{1}{\frac{500}{115} + \frac{500}{2520}} \times 1\,000\,000 = 219\,962 \text{ ppm}$$

Hazard zone = None

Table 3—Toxic hazard zone limits

Component	Hazard zone A ≥ %	Hazard zone B ≥ %	Hazard zone C ≥ %	Hazard zone D ≥ %	LC_{50}	
					ppm	Origin
Ammonia	N/A	N/A	N/A	N/A	7 338	LC_{50} RAT (Vernot)
Antimony pentafluoride	15.00	3.00	1.00	0.60	30	ISO
Arsenic pentafluoride	10.00	2.00	0.67	0.40	20	ISO
Arsenic trifluoride	10.00	2.00	0.67	0.40	20	ISO
Arsine	10.00	2.00	0.67	0.40	20	LC_{50} MUS time adj.
Bis-trifluoromethyl peroxide	5.00	1.00	0.33	0.20	10	ISO
Boron trichloride	N/A	N/A	84.70	50.82	2 541	LC_{50} RAT
Boron trifluoride	N/A	80.60	26.87	16.12	806	LC_{50} RAT time adj.
Boron tribromide	N/A	38.00	12.67	7.60	380	ISO
Bromine chloride	N/A	29.00	9.67	5.80	290	Est. from Chlorine
Bromine pentafluoride	25.00	5.00	1.67	1.00	50	LC_{LO}
Bromine trifluoride	90.00	18.00	6.00	3.60	180	ISO
Bromoacetone	N/A	26.00	8.67	5.20	260	ISO
Butadiene 1,3	N/A	N/A	N/A	N/A	220 000	same as Cyclopropane
Carbon monoxide	N/A	N/A	N/A	75.20	3 760	LC_{50} RAT time adj.
Carbonyl fluoride	N/A	36.00	12.00	7.20	360	LC_{50} RAT
Carbonyl sulfide	N/A	N/A	56.67	34.00	1 700	LC_{50} MUS time adj.
Chlorine	N/A	29.30	9.77	5.86	293	LC_{50} RAT
Chlorine pentafluoride	61.00	12.20	4.07	2.44	122	LC_{50} RAT
Chlorine trifluoride	N/A	29.90	9.97	5.98	299	LC_{50} RAT
Chloromethane	N/A	N/A	N/A	N/A	8 300	ISO
Chlorotrifluoroethylene	N/A	N/A	66.67	40.00	2 000	ISO
Chlorotrifluoropyridine	N/A	N/A	N/A	N/A	>5 000	> 5000 (DOT)
Cyanogen	N/A	35.00	11.67	7.00	350	LC_{50} RAT
Cyanogen chloride	40.00	8.00	2.67	1.60	80	LC_{50} RAT time adj.
Cyclopropane	N/A	N/A	N/A	N/A	220 000	ISO
Deuterium chloride	N/A	N/A	N/A	62.40	3 120	ISO
Deuterium fluoride	N/A	N/A	36.67	22.00	1 100	ISO
Deuterium selenide	1.00	0.20	0.07	0.04	2	ISO
Deuterium sulfide	N/A	71.00	23.67	14.20	710	ISO
Diborane	40.00	8.00	2.67	1.60	80	LC_{50} RAT time adj.
Dibromodifluorom ethane	N/A	N/A	N/A	N/A	27 000	ISO
Dichloro-2-chlorovinyl-arsine	4.00	0.80	0.27	0.16	8	ISO
Dichlorosilane	N/A	31.40	10.47	6.28	314	LC_{50} RAT
Diethylamine	N/A	N/A	N/A	N/A	8 000	ISO
Diethylzinc	5.00	1.00	0.33	0.20	10	ISO
Dimethylsilane	N/A	N/A	N/A	N/A	>5 000	ISO: not toxic
Diphosgene	1.00	0.20	0.07	0.04	2	ISO
Ethylamine	N/A	N/A	N/A	N/A	16 000	ISO
Ethyldichloroarsine	18.00	3.60	1.20	0.72	36	LC_{50} RAT time adj. (DOT)
Ethylene oxide	N/A	N/A	N/A	58.40	2 920	LC_{50} RAT
Fluorine	92.50	18.50	6.17	3.70	185	LC_{50} RAT
Fluoroethane	N/A	N/A	N/A	N/A	260 000	ISO
Germane	N/A	62.20	20.73	12.44	622	LC_{50} RAT time adj.

Component	Hazard zone A ≥ %	Hazard zone B ≥ %	Hazard zone C ≥ %	Hazard zone D ≥ %	LC_{50}	
					ppm	Origin
Heptafluorobutyronitrile	5.00	1.00	0.33	0.20	10	ISO
Hexafluoroacetone	N/A	47.00	15.67	9.40	470	LC_{50} RAT time adj.
Hexafluorocyclobutene	N/A	N/A	N/A	N/A	>5 000	ISO: not toxic
Hydrogen bromide	N/A	N/A	95.33	57.20	2 860	LC_{50} RAT
Hydrogen chloride	N/A	N/A	N/A	62.40	3 120	LC_{50} RAT
Hydrogen cyanide	70.00	14.00	4.67	2.80	140	ISO & RTECS
Hydrogen fluoride	N/A	N/A	42.53	25.52	1 276	LC_{50} RAT, (Darmer)
Hydrogen iodide	N/A	N/A	95.33	57.20	2 860	Est. same as HBr
Hydrogen selenide	1.00	0.20	0.07	0.04	2	LC_{50} GPG
Hydrogen sulfide	N/A	71.20	23.73	14.24	712	LC_{50} RAT
Hydrogen telluride	1.00	0.20	0.07	0.04	2	ISO
Iodine pentafluoride	60.00	12.00	4.00	2.40	120	ISO
Iodotrifluoromethane	N/A	N/A	N/A	N/A	>5 000	ISO: not toxic
Methyl bromide	N/A	85.00	28.33	17.00	850	LC_{50} RAT time adj.
Methyl chloride	N/A	N/A	N/A	N/A	8 300	ISO
Methyl chlorosilane	N/A	60.00	20.00	12.00	600	Est. as $SiCl_2HCH_3$
Methyl dichlorosilane	N/A	60.00	20.00	12.00	600	LC_{50} RAT time adj.
Methyl isothiocyanate	N/A	63.50	21.17	12.70	635	LC_{50} RAT (DOT)
Methyl mercaptan	N/A	N/A	45.00	27.00	1 350	LC_{50} RAT time adj.
Methyl silane	N/A	N/A	N/A	N/A	>5 000	ISO: not toxic
Methyl vinyl ether	N/A	N/A	N/A	N/A	>5 000	ISO: not toxic
Methylamine	N/A	N/A	N/A	N/A	7 000	ISO
Mustard gas (dichlorodiethyl sulfide)	2.00	0.40	0.13	0.08	4	ISO
Nickel carbonyl	10.00	2.00	0.67	0.40	20	ISO
Nitric oxide	57.50	11.50	3.83	2.30	115	LC_{50} RAT for NO_2
Nitrogen dioxide	57.50	11.50	3.83	2.30	115	LC_{50} RAT
Nitrogen fluoride oxide	N/A	N/A	N/A	N/A	>5 000	DOT RSPA: not toxic
Nitrogen trifluoride	N/A	N/A	N/A	N/A	6 700	ISO
Nitrogen trioxide	57.50	11.50	3.83	2.30	115	calc. N_2O_3 = $NO+NO_2$
Nitrosyl chloride	17.50	3.50	1.17	0.70	35	LC_{LO} CAT
Oxygen difluoride	1.30	0.26	0.09	0.05	2.6	LC_{50} RAT
Ozone	4.50	0.90	0.30	0.18	9	ISO
Pentaborane	5.00	1.00	0.33	0.20	10	ISO
Pentafluoropropionitrile	5.00	1.00	0.33	0.20	10	ISO
Perchloryl fluoride	N/A	77.00	25.67	15.40	770	LC_{50} RAT time adj.
Perfluoro-2-butene	N/A	N/A	N/A	N/A	12 000	ISO
Phenylcarbylamine chloride	2.50	0.50	0.17	0.10	5	ISO
Phosgene	2.50	0.50	0.17	0.10	5	LC_{50} RAT time adj.
Phosphine	10.00	2.00	0.67	0.40	20	LC_{50} RAT time adj.
Phosphorous pentafluoride	N/A	25.50	8.50	5.10	255	Est. 1/5 of HF
Phosphorous trifluoride	N/A	42.50	14.17	8.50	425	ISO
Propylene oxide	N/A	N/A	N/A	N/A	7 200	ISO
Selenium hexafluoride	25.00	5.00	1.67	1.00	50	LC_{50} RAT adj.
Silane	N/A	N/A	N/A	N/A	19 000	ISO
Silicon tetrachloride	N/A	75.00	25.00	15.00	750	ISO
Silicon tetrafluoride	N/A	45.00	15.00	9.00	450	LC_{50} MUS

Component	Hazard zone A ≥ %	Hazard zone B ≥ %	Hazard zone C ≥ %	Hazard zone D ≥ %	LC_{50}	
					ppm	Origin
Stibine	10.00	2.00	0.67	0.40	20	Est. same as AsH_3
Sulfur chloride pentafluoride	N/A	N/A	N/A	N/A	>5 000	DOT RSPA: not toxic
Sulfur dioxide	N/A	N/A	84.00	50.40	2 520	LC_{50} RAT
Sulfur tetrafluoride	20.00	4.00	1.33	0.80	40	LC_{50} RAT
Sulfuryl fluoride	N/A	N/A	N/A	60.40	3 020	LC_{50} RAT
Tellurium hexafluoride	12.50	2.50	0.83	0.50	25	LC_{50} RAT adj.
Tetraethyl lead	31.50	6.30	2.10	1.26	63	ISO
Tetrafluoro hydrazine	50.00	10.00	3.33	2.00	100	ISO
Thionyl chloride	N/A	N/A	39.20	23.52	1 176	LC_{50} RAT (DOT)
Trichlorosilane	N/A	N/A	34.67	20.80	1 040	ISO
Triethyl aluminum	5.00	1.00	0.33	0.20	10	ISO
Triethyl borane	N/A	N/A	46.67	28.00	1 400	ISO
Trifluoroacetonitrile	N/A	50.00	16.67	10.00	500	ISO
Trifluoroacetylchloride	N/A	20.80	6.93	4.16	208	LC_{50} RAT Limit Test (DOT)
Trifluorochloroethylene	N/A	N/A	66.67	40.00	2 000	LC_{50} RAT adj. (DOT)
Trifluoroethylene	N/A	N/A	66.67	40.00	2 000	ISO
Trimethylamine	N/A	N/A	N/A	N/A	7 000	ISO
Trimethylsilane	N/A	N/A	N/A	N/A	>5 000	ISO: not toxic
Trimethylstibine	10.00	2.00	0.67	0.40	20	ISO
Tungsten hexafluoride	N/A	21.30	7.10	4.26	213	Est. 1/6 of HF
Vinyl bromide	N/A	N/A	N/A	N/A	>5 000	ISO: not toxic
Vinyl chloride	N/A	N/A	N/A	N/A	>5 000	ISO: not toxic
Vinyl fluoride	N/A	N/A	N/A	N/A	>5 000	ISO: not toxic

Table 4—Labeling of pure products

Chemical name	Chemical formula	UN number	DOT class [1)]	DOT label [1)]	TC label
Ammonia (Domestic only)	NH_3	1005	2.2	NFG	2.2 (8)
Arsine	AsH_3	2188	2.3	PG & FG	2.3 (2.1)
Boron trichloride	BCl_3	1741	2.3	PG & CORR	2.3 (8)
Boron trifluoride	BF_3	1008	2.3	PG	2.3 (8)
Bromine chloride	BrCl	2901	2.3	PG & CORR & OX	2.3 (5.1) (8)
Carbon monoxide	CO	1016	2.3	PG & FG	2.1 (2.1)
Carbonyl fluoride	COF_2	2417	2.3	PG	2.3 (8)
Carbonyl sulfide	COS	2204	2.3	PG & FG	2.3 (2.1)
Chlorine	Cl_2	1017	2.3	PG	2.3 (8)
Chlorine pentafluoride	ClF_5	2548	2.3	PG & OX & CORR	2.3 (5.1) (8)
Chlorine trifluoride	ClF_3	1749	2.3	PG & OX & CORR	2.3 (5.1)(8)
Cyanogen, liquefied	C_2N_2	1026	2.3	PG & FG	2.3 (2.1)
Cyanogen chloride	CNCl	1589	2.3	PG & FG	2.3 (8)
Diborane	B_2H_6	1911	2.3	PG & FG	2.3 (2.1)
Dichlorosilane	SiH_2Cl_2	2189	2.3	PG & FG	2.3 (2.1) (8)
Diethylamine	$(C_2H_5)_2NH$	1154	3	FL	3 (8)
Dimethylamine	$(CH_3)_2NH$	1032	2.1	FG	2.1 (8)
Ethyl fluoride	C_2H_5F	2453	2.1	FG	2.1
Ethylamine	$C_2H_5NH_2$	1036	2.1	FG	2.1
Ethylene oxide	C_2H_4O	1040	2.3	PG & FG	2.3 (2.1)
Fluorine	F2	1045	2.3	PG & OX	2.3 (5.1) (8)
Germane	GeH_4	2192	2.3	PG & FG	2.3 (2.1)
Hexefluoroacetone	C_3OF_6	2420	2.3	PG	2.3 (8)
Hydrogen bromide, anhydrous	HBr	1048	2.3	PG & CORR	2.3 (8)
Hydrogen chloride, anhydrous	HCl	1050	2.3	PG & CORR	2.3 (8)
Hydrogen fluoride, anhydrous	HF	1052	8	CORR & P	8 (6.1)
Hydrogen ioide, anhydrous	HI	2197	2.2	NFG & CORR	2.3 (8)
Hydrogen selenide, anhydrous	H_2Se	2202	2.3	PG & FG	2.3 (2.1)
Hydrogen sulfide, liquefied	H_2S	1053	2.3	PG & FG	2.3 (2.1)
Methylamine	CH_3NH_2	1061	2.3	PG & FG	2.1
Methyl bromide	CH_3Br	1062	2.3	PG	2.3
Methyl chloride	CH_3Cl	1063	2.1	FG	2.1
Methyl chlorosilane	$SiClH_2CH_3$	2534	2.3	PG & FG	2.3 (2.1) (8)
Methyl dichlorosilane	$SiCl_2HCH_3$	1242	4.3	DWW & CORR & FL	4.3 (3) (8)
Methyl mercaptan	CH_3SH	1064	2.3	PG & FG	2.3 (2.1)
Nitric oxide (+some N_2O_4).	NO	1660	2.3	PG	2.3 (5.1) (8)
Nitrogen dioxide	NO_2	1067	2.3	PG & OX	2.3 (5.1) (8)
Nitrogen trifluoride	NF_3	2451	2.2	NGF & OX	2.2 (5.1)
Nitrogen trioxide	N_2O_3	2421	2.3	PG&OX	2.3 (5.1) (8)
Nitrosyl chloride	NOCl	1069	2.3	PG & CORR	2.3 (8)

Chemical name	Chemical formula	UN number	DOT class [1]	DOT label [1]	TC label
Oxygen difluoride	OF_2	2190	2.3	PG & OX	2.3 (5.1) (8)
Perchloryl fluoride	$ClFO_3$	3083	2.3	PG & OX	2.3 (5.1)
Phosgene	$COCl_2$	1076	2.3	PG & CORR	2.3 (8)
Phosphine	PH_3	2199	2.3	PG & FG	2.3 (2.1)
Phosphorous pentafluoride	PF_5	2198	2.3	PG	2.3 (8)
Selenium hexafluoride	SeF_6	2194	2.3	PG	2.3 (8)
Silicon tetrafluoride	SiF_4	1859	2.3	PG & CORR	2.3 (8)
Stibine	SbH_3	2676	2.3	PG & FG	2.3 (2.1)
Sulfur dioxide, liquified	SO_2	1079	2.3	PG	2.3 (8)
Sulfur tetrafluoride	SF_4	2418	2.3	PG	2.3 (8)
Sulfuryl fluoride	SO_2F_2	2191	2.3	PG	2.3
Tellurium hexafluoride	TeF_6	2195	2.3	PG	2.3 (8)
Trifluoroacetylchloride	C_2F_3OCl	3057	2.2	NFG & CORR	2.3 (8)
Tungsten hexafluoride	WF_6	2196	2.3	PG	2.3 (8)

[1] Authorized 5/15/93

LEGEND	
Symbol	**Definition**
CORR	Corrosive
DWW	Dangerous when wet
FG	Flammable gas
FL	Flammable liquid
NFG	Nonflammable gas
OX	Oxidizer
P	Poison
PG	Poison gas
DOT	
2.1	Flammable gas
2.2	Nonflammable gas
2.3	Poison gas
3	Flammable liquid
4.3	Dangerous when wet
8	Corrosive materials
TC	
2.1	Flammable gas
2.2	Non-flammable and non-toxic gas
2.3	Toxic gas
3	Flammable liquid
4.3	Water-reactive substance
5.1	Oxidizing substance
6.1	Toxic substance
8	Corrosive

8 References

Unless otherwise specified, the latest edition shall apply.

[1] *Code of Federal Regulations*, 49 CFR Parts 100-180 (Transportation), Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. www.gpoaccess.gov

[2] *Transportation of Dangerous Goods Regulations*, (Transport Canada), Canadian Government Publishing, Public Works and Government Services Canada, Ottawa, ON K1A 0S9, Canada. www.tc.gc.ca

[3] *Registry of Toxic Effects of Chemical Substances (RTECS)*, National Institute for Occupational Safety and Health, Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. www.gpoaccess.gov

[4] *Sax's Dangerous Properties of Industrial Materials*, Richard J. Lewis, Wiley Publishing, Inc., Hoboken, NJ 07030. www.wiley.com

[5] ISO 10298, *Determination of toxicity of a gas or gas mixture*, Compressed Gas Association, Inc., 4221 Walney Rd., 5th Floor, Chantilly, VA 20151. www.cganet.com

9 Additional references

Threshold Limit Values and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Dr., Cincinnati, OH 45240. www.acgih.org

Documentation of the Threshold Limit Values and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Dr., Cincinnati, OH 45240. www.acgih.org

Handbook of Compressed Gases, Compressed Gas Association, Inc., 4221 Walney Rd., 5th Floor, Chantilly, VA 20151. www.cganet.com

Pocket Guide to Chemical Hazards, National Institute for Occupational Safety and Health, Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. www.gpoaccess.gov

Emergency and Continuous Exposure Limits for Selected Airborne Contaminants, National Research Council Committee on Toxicology, National Academy Press, Washington, DC 20418.

World Health Organization Technical Report 707, *Recommended Health Based Occupational Exposure Limits for Respiratory Irritants*, World Health Publications, Albany, NY 12210.