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Determination of toxicity of a gas or gas mixture

Détermination de la toxicité d'un gaz ou d'un mélange de gaz

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 10298 was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, Subcommittee SC 2, *Cylinder fittings*.

Annexes A, B, C and D of this International Standard are for information only.

Introduction

The purpose of ISO 5145 is to establish practical criteria for the determination of valve outlet connections of gas cylinders of water capacity of 150 litres or less. These criteria are based on certain physicochemical properties of the gases, in particular, the toxicity of the gases considered.

One of the difficulties in the application of ISO 5145 is that it is at times difficult to classify the toxicity level of a gas or gas mixture. In fact,

— in the case of pure gases, there are data in the literature, although conflicting results are to be found depending upon the test methods employed and the criteria considered, but above all,

— in the case of gas mixtures, data in the literature are often non-existent.

With standardized test methods, such as that presented in this International Standard, it will be possible:

— to eliminate the ambiguities in the case of conflicting results in the literature,

— and above all, to supplement existing data (mainly in the case of gas mixtures).

In particular, the application of standardized test methods will eliminate the ambiguities concerning gas mixtures in groups 4, 7, 8, 9, 12 and 13, as defined in ISO 5145, since it is necessary to know, in the case of these mixtures, whether or not they are to be considered as toxic.

Determination of toxicity of a gas or gas mixture

1 Scope

This International Standard specifies a test method to determine whether or not a gas is toxic or very toxic, in order to eliminate difficulties involved in the application of ISO 5145. A calculation method is given to enable the toxicity of gas mixtures to be determined in the absence of valid experimental data.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 5145:1990, *Cylinder valve outlets for gases and gas mixtures — Selection and dimensioning.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 lethal concentration LC_{50}**:** Concentration of a gas (or a gas mixture) in air administered by a single exposure during a short period of time (24 h or less) to a group of young adult albino rats (males and females) which leads to the death of half of the animals in at least 14 days.

3.2 toxicity level: Toxicity of gases and gas mixtures, which are divided into three groups:

— Subdivision 1: nontoxic [when $LC_{50} > 5\ 000$ ppm(V/V)]

— Subdivision 2: toxic [when $200\ \text{ppm}(V/V) < LC_{50} \leqslant 5\ 000\ \text{ppm}(V/V)$]

— Subdivision 3: very toxic [when $LC_{50} \leqslant 200$ ppm(V/V)]

where

LC_{50} values correspond to one hour exposure to gas;

ppm(V/V) indicates parts per million, by volume.

4 Determination of toxicity

For single-component gases, a test method as described in 4.1 shall be used. For reasons of animal welfare and limited capacity of specialized laboratories, inhalation toxicity tests only for the classification of gas mixtures should be avoided if the toxicity of each of the components is available. In this case, toxicity is determined in accordance with 4.2.

4.1 Test method

4.1.1 Test procedure

Groups of rats are exposed to increasing concentrations of the test gas.

Observation of the effects produced is maintained over a period of at least 14 days to determine the 50 % lethal concentration (LC_{50}). For a detailed procedure, see annex B.

4.1.2 Results for pure gases

The toxicity of pure gases is listed in annex A, in which LC_{50} values correspond to 1 h exposure. Some of these values have been estimated in accordance with annex C.

4.2 Calculation method

The LC_{50} value of a gas mixture is calculated using the following formula:

$$LC_{50} = \frac{1}{\sum_i \frac{C_i}{LC_{50i}}}$$

where

C_i is the mole fraction of the ith toxic component present in the gas mixture;

LC_{50i} is the lethal concentration of the ith toxic component [$LC_{50} < 5\ 000$ ppm(V/V)] expressed in ppm by volume.

After the LC_{50} of the gas mixture has been calculated, this mixture is classified in accordance with 3.2.

NOTE 1 Synergistic effects[1] have not been considered in the above, due to a lack of scientific data.

1) For example, B.C. Levin *et al.* Toxicological interactions between carbon monoxide and carbon dioxide. *Toxicol.*, **47**, 1987, pp. 135-164.

Annex A
(informative)

LC_{50} values for the different groups of gas

Clause A.1 of this annex gives the LC_{50} value for the different groups of gases listed in ISO 5145 and the corresponding FTSC codes. For some of them, it is proposed to replace the former FTSC code with the new one, added in bold figures, which corresponds to the new toxicity level (see clause 3).

Moreover, clause A.2 lists for each gas the LC_{50} values and the literature references.

A.1 Tables of gas groups

See tables A.1 to A.6.

NOTE 2 Certain gases listed in tables A.1 to A.6 are considered as toxic according to ISO 5145:1990, but are no longer considered so. The next edition of ISO 5145 will be modified accordingly.

A.2 Literature sources of LC_{50} values

See table A.7.

Table A.1 — Group 4: Non-flammable, toxic and corrosive (or corrosive by hydrolysis) gases and gas mixtures

Gas	FTSC Code	Synonym	LC_{50} [ppm(*V*/*V*)]
Antimony pentafluoride	0303		30
Boron trichloride	0230	Boron chloride	2 541
Boron trifluoride	0253; 0263	Boron fluoride	387
Bromoacetone	0303; **0203**		260
Carbonyl fluoride	0213		360
Cyanogen chloride	0303		80
Deuterium chloride	0213		3 120
Deutérium fluoride	0203		1 100
Dibromodifluoromethane	0200; **0100**	R12B2	27 000
Dichloro(2-chlorovinyl)arsine	0303	Lewisite	8
Diphosgene	0303		2
Ethyldichloroarsine	0303		7
Hexafluoroacetone	0203	Hexafluoropropan-2-one; Perfluoroacetone	470
Hydrogen bromide	0230	Hydrobromic acid (anhydrous)	2 860
Hydrogen chloride	0213	Hydrochloric acid (anhydrous)	3120
Hydrogen fluoride	0203	Hydrofluoric acid (anhydrous)	966
Hydrogen iodide	0203	Hydroiodic acid (anhydrous)	2 860
Iodotrifluoromethane	0200; **0100**	Trifluoromethyl iodide	—
Methyl bromide	0300; **0200**	Bromomethane	850
Methyldichloroarsine	0303		10
Mustard gas	0303		4
Nitrosyl chloride	0203; **0303**		35
Perfluorobut-2-ene	0200; **0100**		12 000
Phenylcarbylamine chloride	0303		5
Phosgene	0303	Carbonyl chloride	5
Phosphorus pentafluoride	0203; **0303**		190
Phosphorus trifluoride	0203		420
Silicon tetrachloride	0203		750
Silicon tetrafluoride	0253; 0263	Tetrafluorosilane	450
Sulfur dioxide	0201		2 520
Sulfur tetrafluoride	0203; **0303**		40
Sulfur fluoride	0300		3 020
Tungsten hexafluoride	0303		160
Uranium hexafluoride	0303		25

Table A.2 — Group 7: Flammable, toxic and corrosive (basic) gases and gas mixtures

Gas	FTSC Code	Synonym	LC_{50} [ppm(V/V)]
Ammonia	0202; **2102**	R717	7 338
Dimethylamine	2202; **2102**		11 100
Monoethylamine	2202; **2102**	Ethylamine R631	16 000
Monomethylamine	2202; **2102**	Methylamine R630	7 000
Trimethylamine	2202; **2102**		7 000

Table A.3 — Group 8: Flammable, toxic and corrosive (acid) or non-corrosive gases and gas mixtures

Gas	FTSC Code	Synonym	LC_{50} [ppm(V/V)]
Arsine	2300		20
Carbon monoxide	2250; 2260		3 760
Carbonyl sulfide	2301; **2201**	Carbonoxyl sulfide	1 700
Chloromethane	2200; **2100**	Methyl chloride R40	8 300
Coal gas	Mixture		—
Cyanogen	2300; **2200**		350
Cyclopropane	2200; **2100**	Trimethylene	22 000
Deuterium selenide	2301		2
Deuterium sulfide	2301; **2201**		710
Dichlorosilane	2203		314
Dimethylsilane	2300; **2100**		—
Fluoroethane	2300; **2100**	Ethyl fluoride	—
Germane	2300		20
Heptafluorobutyronitrile	2300		10
Hexafluorocyclobutene	2100		—
Hydrogen selenide	2301		2
Hydrogen sulfide	2301; **2201**		712
Methyl mercaptan	2201	Methanethiol	1350
Methylsilane	2300; **2100**		—
Nickel carbonyl	2300	Nickel tetracarbonyl	20
Pentafluoropropionitrile	2300		10
Tetraethyl lead	2300		63
Tetramethyl lead	2300; **2200**		800
Trifluoroacetonitrile	2300; **2200**		500
Trifluoroethylene	2200		2 000
Trimethylsilane	2300; **2100**		—

Table A.4 — Group 9: Spontaneously flammable gases and gas mixtures

Gas	FTSC Code	Synonym	LC_{50} [ppm(*V*/*V*)]
Diethyl zinc	3300		10
Pentaborane	3300		10
Phosphine	3310		20
Silane	3150; 3160	Silicon tetrahydride	19 000
Triethyl aluminium	3300		10
Triethylborane	3300		1 400
Triethylstibine	3300		20

Table A.5 — Group 12: Oxidant, toxic and corrosive gases and gas mixtures

Gas	FTSC Code	Synonym	LC_{50} [ppm(*V*/*V*)]
Bis(trifluoromethyl)peroxide	4300		10
Bromine pentafluoride	4303		25
Bromine trifluoride	4303		180
Chlorine	4203		293
Chlorine pentafluoride	4303		122
Chlorine trifluoride	4303; **4203**		299
Dinitrogen trioxide	4301	Nitrogen sesquioxide Nitrogen trioxide Nitrogen oxide	57
Fluorine	4343		185
Iodine pentafluoride	4303		120
Nitric oxide	4351; 4361	Nitrogen oxide	115
Nitrogen dioxide	4301	Liquid dioxide Nitrogen oxide Dinitrogen tetraoxide Nitrogen peroxide Nitrogen tetraoxide	115
Oxygen difluoride	4343		2,6
Ozone	4330		9
Tetrafluorohydrazine	4343		100

Table A.6 — Group 13: Flammable gases and gas mixtures subject to decomposition or polymerization

Gas	FTSC Code	Synonym	LC_{50} [ppm(*V*/*V*)]
Buta-1,3-diene (inhibited)	5100		—
Chlorotrifluoroethylene	5200		2 000
Diborane	5330; 5360		80
Ethylene oxide	5200	Oxirane	2900
Hydrogen cyanide	5301	Hydrocyanic acid (anhydrous)	140
Propylene oxide	5200; **5100**	Methyl oxirane	7200
Stibine	5300	Antimony hydride	20
Vinyl bromide (inhibited)	5200; **5100**		—
Vinyl chloride (inhibited)	5200; **5100**	Chloroethylene R1140	—
Vinyl fluoride (inhibited)	5100	Fluoroethylene R1141	—
Methyl vinyl ether (inhibited)	5200; **5100**	Methoxyethylene	—

Table A.7 — Group 13: List of gases giving the literature sources of LC_{50} values

Gas	FTSC Code	LC_{50}	Remarks	Literature reference (see annex D)
Ammonia	2102	7 338	"Nontoxic"	[1]
Antimony pentafluoride	0303	30	Mouse	[2]
Arsenic trifluoride	0303	20	By analogy with arsine	
Arsine	2300	20	Mouse, time-adjusted	[3]
Arsenic pentafluoride	0303	20	By analogy with arsine	
Bis(trifluoromethyl)peroxide	4300	10	Assumed (conservative)	
Boron tribromide	0203	380	By analogy with BF_3	
Boron trichloride	0203	2 541		[1]
Boron trifluoride	0253; 0263	387		[1]
Bromine chloride	4203	290	Estimated from chlorine	
Bromine pentafluoride	4303	25	Time- and effect-adjusted	[4]
Bromine trifluoride	4303	180	Estimated from F_2	
Bromoacetone	0203	260	By analogy with chloroacetone	
Buta-1,3-diene (inhibited)	5100	—	"Nontoxic"	
Carbon monoxide	2250; 2260	3760	Time-adjusted	[6]
Carbonyl fluoride	0213	360		[5]
Carbonyl sulfide	2301	1700	Time-adjusted	[7]
Chlorine	4203	293		[1]
Chlorine pentafluoride	4303	122		[8]
Chlorine trifluoride	4203	299		[8]
Chlorotrifluoroethylene	5200	2 000	Time-adjusted	[10]
Chloromethane	2100	8 300	"Nontoxic" - Mouse - Time-adjusted	
Cyanogen	2200	350		[11]