INTERNATIONAL STANDARD

ISO 11114-2

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Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents —

Part 2: Non-metallic materials

Bouteilles à gaz transportables — Compatibilité des matériaux des bouteilles et des robinets avec les contenus gazeux —

Partie 2: Matériaux non métalliques

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 11114 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 1114 was prepared by the European Committee for Standardization (CEN) in collaboration with ISO Technical Committee TC 58, *Gas cylinders*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this standard, read "...this European Standard..." to mean "...this International Standard...".

ISO 11114 consists of the following parts, under the general title *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents*:

— *Part 1: Metallic materials*

— *Part 2: Non-metallic materials*

— *Part 3: Autogenous ignition test in oxygen atmosphere*

— *Part 4: Test method for hydrogen compatibility with metals*

Annex A to this part of ISO 11114 is for information only.

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Foreword

EN ISO 11114-2:2000 has been prepared by Technical Committee CEN/TC 23 "Transportable gas cylinders ", the secretariat of which is held by BSI, in collaboration with Technical Committee ISO/TC 58 "Gas cylinders".

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by xx-xx-xx, and conflicting national standards shall be withdrawn at the latest by June 2001.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standards: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

This European Standard has been submitted for reference into the RID and/or in the technical annexes of the ADR. Therefore in this context the standards listed in the normative references and covering basic requirements of the RID/ADR not addressed within the present standard are normative only when the standards themselves are referred to in the RID and/or in the technical annexes of the ADR.

Introduction

This Standard is one part of a three-part standard concerning compatibility of gases and gas mixtures with materials :

- *Part 1 : Metallic materials* ;
- *Part 2 : Non-metallic materials* ;
- *Part 3 : Autogenous ignition test in oxygen atmosphere.*

This standard deals with the compatibility of non-metallic materials used for gas cylinders and gas cylinder valves with the gas contents of the cylinder. Compatibility of metallic materials is treated in EN ISO 11114-1.

Non-metallic materials are very often used for the construction of gas cylinder valves as seals e.g. O-ring, gland packing, seats, or as lubrication products to avoid friction. They are also commonly used to ensure sealing of the valve/cylinder connection. For gas cylinders, they are sometimes used as an internal coating or as a liner for composite materials.

Non-metallic materials not in contact with the gas are not covered by this standard.

Previously, no recognised compilation has existed for non-metallic cylinder/valve material compatibility with gas contents. This standard therefore presents the current state of the knowledge on the subject.

This standard is based on current international experience and knowledge. It does not cover the subject completely and is intended to give guidance only in evaluating the compatibility of gas/material combinations. Some data are derived from experience involving a mixture of the gas concerned with a dilutant, where no data for single component gases were available.

1 Scope

This Standard gives guidance in the selection and evaluation of compatibility between non-metallic materials for gas cylinders and valves and the cylinders' gas contents. This standard also covers bundles, tubes and pressure drums.

This standard may be helpful for composite and laminated materials.

Only the influence of the gas in changing the material and mechanical properties is considered (for example chemical reaction or change in physical state). The basic mechanical properties of the materials required for design purposes are normally available from the materials supplier and are not considered in this standard.

The compatibility data given are related to single component gases but can be used to some extent for gas mixtures. Ceramics, glasses, and adhesives are not covered by this standard.

Aspects such as quality of delivered gas are not considered.

2 Normative references

This Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 849:1996,	*Transportable gas cylinders - Cylinder valves - Specification and type testing*
EN 1797-1,	*Cryogenic vessels - Gas/material compatibility - Part 1 : Oxygen compatibility*
EN ISO 11114-1,	*Transportable gas cylinders - Compatibility of cylinder and valve materials with gas contents - Part 1 : Metallic materials (ISO 11114-1:1997)*
ISO 10297,	*Gas cylinders - Refillable gas cylinder valves - Specification and type testing*

3 Terms and definitions

For the purposes of this Standard the following terms and definitions apply :

3.1
competent person

a person who has the necessary technical knowledge, experience and authority to assess and approve materials for use with gases and to define any special conditions of use that are necessary. Such a person will also normally be formally qualified in an appropriate technical discipline

3.2
acceptable

a material/gas combination that is satisfactory under normal conditions of use, provided that any indicated non-compatibility risks, as given in Table 1, are taken into account

3.3
not recommended

a material/gas combination that may not be safe. Such combinations can be used where they have been assessed and authorized by a competent person who specifies the conditions of use

4 Materials

4.1 General

Non-metallic materials shall be suitable for the intended service. They are suitable if their compatibility is stated as acceptable in Table 1, or the necessary properties have been proved by tests or long and safe experience to the satisfaction of a competent person.

In particular cases non-compatible materials may be used if suitably plated or protected. This should only be done if all compatibility aspects have been considered and validated by a competent person.

4.2 Types of material

The most commonly used non-metallic materials for gas cylinders and cylinder valves can be grouped as follows :

- plastics materials ;
- elastomer materials ;
- fluid lubricants.

Materials considered in this standard are :

a) Plastics materials

- Polytetrafluoroethylene (PTFE) ;
- Polychlorotrifluoroethylene (PCTFE) ;
- Polyvinylidenefluoride (PVDF) ;
- Polyamide (PA) ;
- Polypropylene (PP).

b) Elastomer materials

- Butyl rubber (IIR) ;
- Nitrile (NBR) ;
- Chloroprene (CR) ;
- Chlorofluorocarbons (FKM) ;
- Silicone (Q) ;
- Ethylene propylene (EPDM).

c) Fluid lubricants

- Hydrocarbon (HC) ;
- Fluorocarbon (FC).

5 General considerations

It is important to note that these materials are generic types. Within each material type there are variations in the properties of the materials due to polymer differences and formulations used by manufacturers to modify physical and chemical properties of the material. The user of the material should therefore consult the manufacturer and if necessary carry out tests before using the material (for example for critical services such as oxygen and other highly oxidizing gases).

Lubricants are often used in valves to reduce friction and wear in the moving parts. For valves used for oxidizing gases, if lubrication is required and this lubricant is not oxygen compatible, then the lubricated components shall not be in contact with the gas. Where the lubricant is listed as "not recommended" in Table 1 for reasons other than violent reaction (F), it may be used safely and usually satisfactorily in applications which do not involve contact in normal operation with the gas. An example of such an application is the lubrication of the valve actuating mechanism on the side of the valve sealing system open to the atmosphere. Where the lubricant is listed as "not recommended" for the reason of violent reaction (F), it may not be used in any part of the system that can be contacted by the gas, even under abnormal conditions e.g. in the event of a failure of the gas sealing system. Where the lubricant may not be used, it may be possible to specify suitable and safe alternatives (e.g. PTFE or molybdenum disulfide). Appropriate safety and suitability tests should have been carried out for the lubricant application before it is used.

The properties of plastics and elastomers are dependent on temperature. Low temperature can cause hardening and the possibility of embrittlement, whereas high temperature can cause softening and the possibility of material flow. Users of such materials shall check to ensure their suitability over the entire operating temperature range, normally considered to be - 50 °C to + 65 °C for cylinders and - 20 °C to + 65 °C for cylinder valves.

Some materials become brittle at low temperatures, even temperatures at the lower end of the normal operating range (e.g. chlorofluorocarbons). Temperatures in the refrigerant or cryogenic ranges affect a great many materials and great caution should be exercised at temperatures below - 50 °C. This risk shall be considered in particular when transfilling by thermal siphoning at low temperature or similar procedures, or for cylinders regularly filled at low temperatures (e.g. CO_2).

6 Specific considerations

6.1 General

The compatibility of gases with non-metallic materials is affected by chemical reactions and physical influences, which can be classified as follows.

6.2 Non-compatibility risks

6.2.1 Explosion and fire (oxidation/burning) (F)

6.2.1.1 Principle

NOTE 1: Historically the majority of serious accidents from rapid oxidation or violent combustion have been with oxidizing gas at high pressure. Thorough investigation of all materials and factors should be conducted with great care and all data should be considered before designing or using equipment to handle oxidizing gases.

Compatibility depends mainly on the operating conditions (pressure, temperature, gas velocity, particles, equipment design, and application). The risk should particularly be considered with gases such as oxygen, fluorine, and chlorine. Most of the non-metallic materials can be ignited relatively easily when in contact with highly oxidizing gases.

The selection of a material for use with oxygen and/or an oxygen enriched atmosphere is primarily a matter of understanding the circumstances that cause the material to react with oxygen. Most materials in contact with oxygen will not ignite without a source of ignition energy (e.g. friction, heat of compression, particle impact, etc.). When an energy input rate, as converted to heat, is greater than the rate of heat dissipation, and the resulting heat increase is continued for sufficient time, ignition and combustion will occur.

Thus, two general factors shall be considered :

a) the material's ease of ignition ;

b) the different energy sources that will produce a sufficient increase in the temperature of the material.

NOTE 2: These general factors should be viewed in the context of the entire system design so that the specific factors listed below will assume the proper relative significance.

The specific factors to take into consideration are :

- the properties of the materials, which include the factors affecting ease of ignition and the conditions affecting potential resulting damage (heat of reaction) ;

- the operating conditions : e.g. pressure, temperature, oxygen and/or oxidizing gas concentrations , influence of dilutant (e.g. helium), surface contamination ;

- the potential sources of ignition (e.g. friction, heat of compression, heat from mass impact, heat form particle impact, static electricity, electrical arc, resonance, internal flexing) ;

- possible consequence (e.g. effects on the surroundings such as propagation of fire) ;

- additional factors (e.g. performance requirements, prior experience, availability and cost).

In conclusion the evaluation of compatibility of non-metallic materials is more critical than that of metallic materials, which generally perform well when in contact with liquid/gaseous oxygen.

6.2.1.2 Specifications for oxidizing gases

In accordance with 6.2.1.1, it is not possible to make a simple specification concerning the compatibility of non-metallic materials with oxidizing gases such as oxygen, chlorine, nitric oxide, nitrous oxide, nitrogen dioxide, etc.

For fluorine, which is the most oxidizing gas, all non metallic materials are "not recommended", normally only metallic materials should be used.

Oxygen and the other oxidizing gases can react violently when tested with all non-metallic materials listed in 4.2 a), 4.2 b) and 4.2 c). PTFE and FKM are more resistant to ignition than the other plastics and elastomers. HC lubricants are not recommended. Under certain conditions all the other plastics and elastomers listed can be safely used in oxidizing service without presenting some of the disadvantages of PTFE (poor mechanical properties, risk of release of toxic products for breathing gas applications) or FKM (swelling, bad mechanical properties at low temperature,etc.)

Consequently, non-metallic materials may only be used if it has been proven by tests (or long and safe service experience), taking into account all the operating conditions and especially the design of the equipment, that their use is safe. For example, gas cylinder valves shall be tested according to EN 849:1996 or ISO 10297 for oxygen service. Fluid lubricants shall be tested according to EN 1797-1.

6.2.2 Weight loss (W)

6.2.2.1 Extraction

Solvent extraction of plasticizers from elastomers can cause shrinkage, especially in highly plasticized products.

Some solvents, e.g. acetone or DMF[1)] used for dissolved gases such as acetylene, can damage non-metallic materials.

Liquefied gases can act as solvents.

6.2.2.2 Chemical attack

Some non-metallic materials can be chemically attacked by gases. This attack can sometimes lead to the complete destruction of the material, e.g. the chemical attack of silicone elastomer by ammonia.

[1)] Dimethylformamide

6.2.3 Swelling of material (S)

Elastomers are subject to swelling due to gas (or liquid) absorption. This can lead to an unacceptable increase of dimensions (especially for O-rings) or the cracking due to sudden out-gassing when the partial pressure is decreased, e.g. carbon dioxide and chlorofluorocarbons.

Appreciable swelling can be masked by extraction of plasticizers and fillers. Other important effects such as changes in mechanical strength and hardness should also be considered.

Differences in the compounding and formulation of a given elastomer can cause significant differences in the swelling of the material.

In this standard a swelling of more than approximately 15 % in normal service conditions is marked NR (not recommended) ; a swelling less than this is marked A (acceptable) provided other risks are acceptable.

6.2.4 Change in mechanical properties (M)

Gases can lead to an unacceptable change of mechanical properties in some non-metallic materials. This can result, for example, in an increase in hardness or a decrease in elasticity.

6.2.5 Other compatibility considerations

6.2.5.1 Impurities in the gas (I)

Some gases contain typical impurities which may not be compatible with the candidate materials (e.g. acetone in acetylene, H_2S in methane).

6.2.5.2 Contamination of the material (C)

Some materials become contaminated in toxic gas usage by the toxic gas and become hazardous themselves (e.g. during maintenance of equipment).

6.2.5.3 Release of dangerous products (D)

Many materials when subjected to extreme conditions (such as elevated temperature) can release dangerous products. This risk shall be considered in particular for breathing gases.

6.2.5.4 Ageing (G)

Ageing is a gradual change in the mechanical and physical properties of the material due to the environment in which it is used or stored. Many elastomer and plastics materials are particularly subject to ageing ; some gases like oxygen can accelerate the ageing process, leading sometimes to brittleness.

6.2.5.5 Permeation (P)

Permeation is a slow process by which gas passes through materials.

The permeation of some gases (e.g. helium, hydrogen, carbon dioxide) through non-metallic material can be significant. For a given material, the permeation rate mainly depends on temperature, pressure, thickness, and surface area of the material in contact with the gas. The molecular weight and the specific formulation of plasticizers and other additives can cause a wide range of permeation rates for a particular type of plastics or elastomers.

This risk shall be considered for effects to the surroundings (e.g. toxicity, fire potential).

7 Compatibility data

7.1 Table of compatibility

In Table 1, compatibility data are given using the symbols and abbreviations defined in 7.2.1 and 7.2.2. When a gas/material combination is not recommended, the main reason is given, using the appropriate abbreviation for the non-compatibility risk (see 6.2). The abbreviations are also sometimes used for acceptable combinations to show a limited risk.

NOTE : Table A.1 is the list of gases from table 1 presented in alphabetical order together with the UN number.

7.2 Symbols and abbreviations

7.2.1 Symbols for compatibility

A = acceptable for use under normal service conditions

NR = not recommended for general use but may be used where it has been assessed or authorised by a competent person who specifies the conditions of use.

? = no recommendation is possible due to a lack of definitive information or because the compatibility depends on the conditions of use. The material may be used where it has been assessed and authorised by a competent person who specifies the conditions of use.

7.2.2 Abbreviations for materials

See 4.2.

7.2.3 Abbreviations for non-compatibility risks

See 6.2.

7.2.4 Examples

$\mathbf{A}_{P}$

Symbol for compatibility = **A**
Abbreviation for non-compatibility risk = P

This example shows an acceptable material/gas combination, suitable for use in normal service conditions, provided due account is taken of the risk of permeation.

$\mathbf{NR}_{F,C}$

Symbol for compatibility = **NR**
Abbreviation for non-compatibility risk :
1st risk = F
2nd risk = C

This example shows a material/gas combination, not recommended for general use, with non-compatibility risks of explosion and fire (1st risk) and contamination of material (2nd risk).

Table 1 - Compatibility of non-metallic materials with gases

				Plastics material					Elastomer material						Fluid lubricant	
N°	Name	Formula	R #	PTFE	PCTFE	PVDF	PA	PP	IIR	NBR	CR	FKM	Q	EPDM	HC	FC
1	ACETYLENE	C_2H_2		A	A	A	$A_{W,I}$	A	A	$NR_{W,I}$	$NR_{W,I}$	$NR_{W,I}$	$NR_{W,I}$	A	$NR_{W,I}$	$NR_{W,I}$
2	AMMONIA	NH_3		A	A	$NR_{G,W}$	A	A	A	A_W	?	NR_W	NR_W	A	NR_W	A
3	ARGON	Ar		A	A	A	A	A	A	A	A	A	A	A	A	A
4	ARSINE	AsH_3		A	A	A	A	?	A	A	A	A	A	A	$NR_{C,D}$	$NR_{C,D}$
5	BORON TRICHLORIDE	BCl_3		A	A	A	NR_W	A	NR_W	NR_W	NR_W	A	NR_W	NR_W	NR_W	A
6	BORON TRIFLUORIDE	BF_3		A	A	A	NR_W	A	NR	NR_W	NR_W	A	NR_W	NR_W	NR_W	A
7	BROMOCHLORODIFLUOROMETHANE	$CBrClF_2$	R12B1	A	A_S	A	A	A	?	NR_S	A	A	?	?	NR_W	A_W
8	BROMOTRIFLUOROMETHANE	$CBrF_3$	R13B1	A	A_S	?	A	$A_{S,W}$	A_S	A_S	A_S	NR_S	NR	?	A_W	A_W
9	BROMOTRIFLUOROETHYLENE	C_2BrF_3	R123B1	A	A_S	?	?	?	?	?	?	?	?	?	A_W	A_W
10	BUTADIENE (1,2)	C_4H_6		A	A	A	A	A	$NR_{S,M}$	$NR_{S,M}$	$NR_{S,M}$	A	$NR_{S,M}$	$NR_{S,M}$	NR_W	A
11	BUTADIENE (1,3)	C_4H_6		A	A	A	A	A	$NR_{S,M}$	$NR_{S,M}$	$NR_{S,M}$	A	$NR_{S,M}$	$NR_{S,M}$	NR_W	A
12	BUTANE	C_4H_{10}		A	A	A	A	A	NR_S	A	A	A	$NR_{S,M}$	$NR_{S,M}$	NR_W	A
13	BUTENE	C_4H_8		A	A	A	A	A	$NR_{S,M}$	A	NR_S	A	$NR_{S,M}$	$NR_{S,M}$	NR_W	A
14	BUTENE cis	C_4H_8		A	A	A	A	A	$NR_{S,M}$	A	NR_S	A	$NR_{S,M}$	$NR_{S,M}$	NR_W	A
15	BUTENE trans	C_4H_8		A	A	A	A	A	$NR_{S,M}$	A	NR_S	A	$NR_{S,M}$	$NR_{S,M}$	NR_W	A
16	CARBON DIOXIDE	CO_2		A	A	A	A	A	NR_S	$NR_{S,W}$	$NR_{S,W}$	$NR_{S,W}$	A_P	$A_{S,W}$ [1)]	A	A
17	CARBON MONOXIDE	CO		A	A	A	A	A	A_G	A	A	NR_S	A	A	A	A
18	TETRAFLUOROMETHANE	CF_4	R14	A	$A_{S,W}$	A	A	A	A	A	A	A	A	A	NR_W	A
19	CARBONYL SULPHIDE	COS		A	A	A	A	?	NR_W	NR_W	NR_W	A	A	NR_W	NR_C	NR_C
20	CHLORINE	Cl_2		see 6.2.1.2 Warning : There is a risk of violent reactions												
20	CHLORINE	Cl_2		A	A	A	NR_F	NR_F	NR_F	NR_F	NR_F	A	NR_W	NR_F	NR_F	A
21	CHLORODIFLUOROMETHANE	$CHClF_2$	R22	A_P	A_S	?	A	A_P	A_S	NR_S	A_S	NR_S	NR_S	A	NR_W	NR_W

"to be continued"

Table 1 *(continued)*

				Plastics material					Elastomer material						Fluid lubricant	
N°	Name	Formula	R #	PTFE	PCTFE	PVDF	PA	PP	IIR	NBR	CR	FKM	Q	EPDM	HC	FC
22	CHLOROMETHANE	CH_3Cl	R40	A	A	?	?	?	NR_S	NR_S	NR_S	A	NR_S	NR_S	NR_W	NR_W
23	CHLOROPENTAFLUOROETHANE	C_2ClF_5	R115	A	A_S	?	A	?	A	A	A	A	?	A	NR_W	NR_W
24	CHLOROTETRAFLUOROETHANE	C_2HClF_4	R124	A	?	?	?	?	?	?	?	?	?	?	NR_W	NR_W
25	CHLOROTRIFLUOROETHANE	$C_2H_2ClF_3$	R133a	A	?	?	?	?	?	?	?	?	?	?	NR_W	NR_W
26	CHLOROTRIFLUOROETHYLENE	C_2ClF_3	R1113	A	?	?	?	?	?	?	?	?	?	?	NR_W	NR_W
27	CHLOROTRIFLUOROMETHANE	$CClF_3$	R13	A	A_S	?	A	A	A	A	A_S	A	NR_S	A	NR_W	NR_W
28	CYCLOPROPANE	C_3H_6		A	A	?	?	?	NR_S	A	NR_S	A	NR_S	NR_S	NR_W	A
29	DEUTERIUM	D_2		A_P	A	A	A	A_P	A	A	A	A	A_P	A	A	A
30	DIBROMODIFLUOROMETHANE	CBr_2F_2	R12B2	A_P	A_S	?	A	?	?	?	A	A	?	?	NR_W	A_W
31	DIBROMOTETRAFLUOROETHANE	$C_2Br_2F_4$	R114B2	A	A_S	?	A	?	NR_S	NR_S	A_S	NR_S	NR_S	NR_S	NR_W	NR_W
32	DIBORANE	B_2H_6		A	A	A	A	A	A	A	A	A	A	A	NR_C	NR_C
33	DICHLORODIFLUOROMETHANE	CCl_2F_2	R12	A_P	A_S	?	A	A	NR_S	A_S	A	A_S	$NR_{S,P}$	NR_S	NR_W	NR_W
34	DICHLOROFLUOROMETHANE	$CHCl_2F$	R21	A	A_S	?	A	A_P	NR_S	NR_S	NR_S	NR_S	NR_S	NR_S	NR_W	NR_W
35	DICHLOROSILANE	SiH_2Cl_2		A	A	A	NR_W	?	NR_W	?	NR_W	A	A	NR_W	NR_C	NR_C
36	DICHLOROTETRAFLUOROETHANE	$C_2Cl_2F_4$	R114	A	A_S	?	A	?	A_S	A	A	A_S	NR_S	A	NR_W	NR_W
37	DICYANOGEN	C_2N_2		A	A	A	?	A	$NR_{S,W}$	$NR_{S,W}$	NR	A	A	$NR_{S,W}$	NR_C	NR_C
38	DIFLUORO(1.1)-1-CHLOROETHANE	$C_2H_3ClF_2$	R142b	A	A_S	?	A	?	A_S	A_S	A_S	NR_S	?	A	NR_W	NR_W
39	DIFLUOROETHANE (1.1)	$C_2H_4F_2$	R152a	A	A_S	?	A	?	A_S	A	A	NR_S	?	A	NR_W	NR_W
40	DIFLUOROETHYLENE (1.1)	$C_2H_2F_2$	R132a	A	A_S	A	?	?	?	?	?	NR_S	?	?	NR_W	NR_W
41	DIMETHYLAMINE	C_2H_7N		A	?	$NR_{G,W}$	?	?	A	A_W	NR_W	NR_W	NR_W	A	NR_W	A
42	DIMETHYLETHER	C_2H_6O		A	?	A	?	?	?	A	NR_S	?	?	A	NR_W	NR_W

"to be continued"

Table 1 *(continued)*

				Plastics material					Elastomer material						Fluid lubricant	
N°	Name	Formula	R #	PTFE	PCTFE	PVDF	PA	PP	IIR	NBR	CR	FKM	Q	EPDM	HC	FC
43	DISILANE	Si_2H_6		A	A	A	?	?	A	?	A	A	?	A	NR_C	NR_C
44	ETHANE	C_2H_6		A	A	A	A	A	NR_S	A	NR_S	A	$NR_{S,W}$	NR_S	A	A
45	ETHYLAMINE	C_2H_7N		A	?	?	NR_W	?	NR_W	NR_W	NR_W	NR_W	NR_W	A	NR_W	NR_W
46	ETHYL CHLORIDE	C_2H_5Cl	R160	A	A_S	?	?	?	A	A	A	A	$NR_{S,W}$	A	NR_W	NR_W
47	ETHYLENE	C_2H_4		A	A	A	A	A	A	?	?	?	?	?	A	A
48	ETHYLENE OXIDE	C_2H_4O		A	A	?	?	?	$NR_{S,W}$	$NR_{S,W}$	$NR_{S,W}$	$NR_{S,W}$	$NR_{S,W}$	$NR_{S,W}$	NR_W	NR
49	FLUORINE [2)]	F_2		NR_F	NR_F	NR_F	NR_F	NR_F	NR_F	NR_F	NR_F	NR_F	NR_F	NR_F	NR_F	NR_F
50	FLUOROETHANE	C_2H_5F	R161	A	A_S	?	A	A_P	?	?	?	?	?	?	NR_W	NR_W
51	FLUOROMETHANE	CH_3F	R41	A	A_S	?	A	?	?	?	?	?	?	?	NR_W	NR_W
52	TRIFLUOROMETHANE	CHF_3	R23	A	$A_{S,W}$	A	A	A	A	A	A	A	A	A	NR_W	A
53	GERMANE	GeH_4		A	A	A	A	?	A	A	A	A	A	A	$NR_{C,D}$	$NR_{C,D}$
54	HELIUM	He		A_P	A	A	A	A_P	A	A	A	A	A_P	A	A	A
55	HEXAFLUOROETHANE	C_2F_6	R116	A	$A_{S,W}$	A	A	A	A	A	A	A	A	A	NR_W	NR_W
56	HEXAFLUOROPROPENE	C_3F_6		A	A_S	?	A	?	?	?	?	?	?	?	NR_W	NR_W
57	HYDROGEN	H_2		A_P	A	A	A	A_P	A	A	A	A	A_P	A	A	A
58	HYDROGEN BROMIDE	HBr		A	A	A	NR_W	?	NR_W	NR_W	NR_W	A	NR_W	A	NR_C	NR_C
59	HYDROGEN CHLORIDE	HCl		A	A	A	NR_W	?	NR_W	NR_W	NR_W	A	NR_W	A	NR_C	NR_C
60	HYDROGEN CYANIDE	HCN		A	A	A	NR_W	?	NR_W	NR_W	NR_W	A	NR_W	A	NR_C	NR_C
61	HYDROGEN FLUORIDE	HF		A	A	A	NR_W	?	NR_W	NR_W	NR_W	A	NR_W	A	NR_C	NR_C
62	HYDROGEN IODIDE	HI		A	A	A	NR_W	?	NR_W	NR_W	NR_W	A	NR_W	A	NR_C	NR_C
63	HYDROGEN SULFIDE	H_2S		A	A	A	A	?	A_W	NR_W	NR_W	NR_W	NR_W	A	NR_C	NR_C

"to be continued"

Table 1 *(continued)*

				Plastics material					Elastomer material						Fluid lubricant	
N°	Name	Formula	R #	PTFE	PCTFE	PVDF	PA	PP	IIR	NBR	CR	FKM	Q	EPDM	HC	FC
64	ISO-BUTANE	C_4H_{10}		A	A	A	A	A	NR_S	A	A	A	$NR_{S,M}$	$NR_{S,M}$	NR_W	A
65	ISO-BUTYLENE	C_4H_8		A	A	A	A	A	$NR_{S,M}$	A	NR_S	A	$NR_{S,M}$	$NR_{S,M}$	NR_W	A
66	KRYPTON	Kr		A	A	A	A	A	A	A	A	A	A	A	A	A
67	METHANE	CH_4		A	A	A	A	A	NR_S	A	A	A	NR ?	NR_S	A	A
68	METHYLACETYLENE	C_3H_4		A	A	A	A_W	A	A	?	?	?	?	?	$NR_{W,I}$	A
69	METHYLBROMIDE	CH_3Br	R40B1	A	A	?	?	?	NR_S	NR_S	NR_S	A	?	NR_S	NR_W	NR_W
70	METHYLMERCAPTAN	CH_4S		A	A	A	A	?	NR_W	NR_W	NR_W	NR_W	A	A	NR_C	NR_C
71	METHYLSILANE	CH_6Si		A	A	A	?	?	A	?	A	A	?	A	NR_C	NR_C
72	METHYLAMINE	CH_5N		A	A	$NR_{G,W}$	A	A	A	A_W	NR_W	NR_W	NR_W	A	NR_W	A
73	NEON	Ne		A	A	A	A	A	A	A	A	A	A	A	A	A
74	NITRIC OXIDE	NO		see 6.2.1.2 Warning : There is a risk of violent reactions												
74	NITRIC OXIDE	NO		A_D	A_D	A_D	$NR_{F,W}$	NR_F	$NR_{F,W}$	$NR_{F,W}$	$NR_{F,W,D}$	A_D	NR_F	$NR_{F,W}$	$NR_{F,C}$	$NR_{C,D}$
75	NITROGEN	N_2		A	A	A	A	A	A	A	A	A	A	A	A	A
76	NITROGEN DIOXIDE [3]	NO_2/N_2O_4		see 6.2.1.2 Warning : There is a risk of violent reactions												
76	NITROGEN DIOXIDE [3]	NO_2/N_2O_4		A	A	NR_F	NR_F	NR_F	NR_F	NR_F	NR_F	NR_F	NR_F	NR_F	$NR_{F,C}$	NR_C
77	NITROUS OXIDE	N_2O		see 6.2.1.2 Warning : There is a risk of violent reactions												
77	NITROUS OXIDE	N_2O		A	A	A_F	$A_{F,S}$	A_F	$NR_{F,S}$	$NR_{F,S}$	$NR_{F,S}$	NR_S	A	$NR_{F,S}$	NR_F	A
78	NITROGEN TRIFLUORIDE	NF_3		A	A	A	?	?	?	?	?	?	?	?	NR_W	A
79	OCTAFLUORO-BUTENE	C_4F_8		A	A_S	?	A	?	A	A	A	A_S	?	A	NR_W	NR_W
80	OCTAFLUORO-CYCLOBUTANE	C_4F_8	RC318	A	A_S	?	A	?	A	A	A	A_S	?	A	NR_W	NR_W
81	OCTAFLUORO PROPANE	C_3F_8	R218	A	A_S	?	A	?	A	A	A	A	A_S	A	NR_W	NR_W
82	OXYGEN	O_2		see 6.2.1.2 Warning : There is a risk of violent reactions												
82	OXYGEN	O_2		$?_{F,D}$	$?_{F,D}$	$?_{F,D}$	$?_F$	$?_F$	$?_F$	$?_F$	$?_{F,D}$	$?_{F,S,D}$	$?_F$	$?_F$	NR_F	$?_{F,D}$
83	PHOSGENE	$COCl_2$		A	A	A	NR_W	?	NR_W	NR_W	NR_W	A	NR_W	A	NR_C	NR_C
84	PHOSPHINE	PH_3		A	A	A	NR_G	?	A	A	A	A	A	A	NR_C	NR_C

"to be continued"

Table 1 *(concluded)*

				Plastics material					Elastomer material						Fluid lubricant	
N°	Name	Formula	R ##	PTFE	PCTFE	PVDF	PA	PP	IIR	NBR	CR	FKM	Q	EPDM	HC	FC
85	PROPANE	C_3H_8		A	A	A	A	A	NR_S	A	NR_S	A	$NR_{S,M}$	$NR_{S,M}$	NR_W	A
86	PROPADIENE	C_3H_4		A	A	A	A_W	A	A	?	?	?	?	?	$NR_{W,I}$	A
87	PROPYLENE	C_3H_6		A	A	A	?	A	NR_S	NR_S	NR_S	?	NR_S	NR_S	NR_W	A
88	PROPYLENE OXIDE	C_3H_6O		A	A	?	?	?	$NR_{S,W}$	$NR_{S,W}$	$NR_{S,W}$	$NR_{S,W}$	$NR_{S,W}$	$NR_{S,W}$	NR_W	NR_W
89	SILANE	SiH_4		A	A	A	?	?	A	?	A	A	?	A	NR_C	NR_C
90	SILICON TETRACHLORIDE	$SiCl_4$		A	A	A	NR_W	?	NR_W	NR_W	NR_W	A	NR_W	A	NR_C	NR_C
91	SILICON TETRAFLUORIDE	SiF_4		A	A	A	NR_W	?	NR_W	NR_W	NR_W	A	NR_W	A	NR_C	NR_C
92	SULPHUR DIOXIDE	SO_2		A	A	A	NR_W	A	?	NR_W	NR_W	NR_W	NR_W	A	$NR_{W,C}$	NR_C
93	SULPHUR HEXAFLUORIDE	SF_6		A	A	A	A	A	A	A	A	A	A	A	A	A
94	SULPHUR TETRAFLUORIDE	SF_4		A	A	A	A	A	A	A	A	A	A	A	A	A
95	TETRAFLUOROETHYLENE	C_2F_4	R114	A	A	A	?	?	A	A	A	A	NR_S	A	NR_W	NR_W
96	TRICHLOROSILANE	$SiHCl_3$		A	A	A	NR_W	?	NR_W	NR_W	NR_W	A	NR_W	A	NR_C	NR_C
97	TRICHLORO-TRIFLUORO ETHANE	$C_2Cl_3F_3$	R113	A	A_S	A	A_W	A	NR_S	A_S	A_S	A_S	NR_S	NR_S	NR_W	NR_W
98	TRIFLUORETHANE (1.1.1)	$C_2H_3F_3$	R143a	A	A_S	?	?	?	?	?	?	A	?	?	NR_W	NR_W
99	TRIMETHYLAMINE	C_3H_9N		A	NR_G	$NR_{G,W}$	NR_W	?	A	A_W	NR_W	NR_W	NR_W	A	NR_W	NR_A
100	TUNGSTEN HEXAFLUORIDE	WF_6		A	A	A	?	?	NR_W	NR_W	NR_W	?	NR_W	A	NR_C	NR_C
101	VINYL BROMIDE	C_2H_3Br	R140B1	A	A_S	?	?	?	?	?	?	A	?	?	NR_W	NR_W
102	VINYL CHLORIDE	C_2H_3Cl	R140	A	A_S	?	?	?	?	?	?	A	A_S	?	NR_W	NR_W
103	VINYL FLUORIDE	C_2H_3F	R141	A	A_S	?	?	?	?	?	?	A	?	?	NR_W	NR_W
104	XENON	Xe		A	A	A	A	A	A	A	A	A	A	A	A	A

1) Only some grades are compatible.

2) Warning : this gas is a very powerful oxidant and can react violently with non-metallic materials that are not fully fluorinated. Such a reaction can result in ignition/explosion and the ignition of surrounding materials in contact with the gas including some metals.

3) Some special elastomers have been used with success.

Annex A
(informative)
Index of gases

Table A.1 - Index of gases

Order number of table 1	English	French	German	UN Number
1	Acetylene	Acétylène	Acetylen	1001
2	Ammonia	Ammoniac	Ammoniak	1005
3	Argon	Argon	Argon	1006
4	Arsine	Arsine	Arsin	2188
5	Boron trichloride	Trichlorure de bore	Bortrichlorid	1741
6	Boron trifluoride	Trifluorure de bore	Bortrifluorid	1008
7	Bromochlorodifluoromethane (R12B1)	Bromochlorodifluorométhane (R12B1)	Bromchlordifluormethan (R12B1)	1974
9	Bromotrifluoroethylene	Bromotrifluoréthylène	Bromtrifluorethen	2419
8	Bromotrifluoromethane (R13B1)	Bromotrifluorométhane (R13B1)	Bromtrifluormethan (R13B1)	1009
10	Butadiene-1,2	Butadiène-1,2	Butadien-1,2	1010
11	Butadiene-1,3	Butadiène-1,3	Butadien-1,3	1010
12	n-Butane	n-Butane	n-Butan	1011
13	Butylene-1	Butène-1 Butylène-1	Buten-1	1012
14	cis-Butylene-2	cis-Butylène-2	cis-Buten-2	1012
15	trans-Butylene-2	trans-Butylène-2	trans-Buten-2	1012
16	Carbon dioxide	Dioxyde de carbone	Kohlendioxid	1013
17	Carbon monoxide	Monoxyde de carbone	Kohlenmonoxid	1016
19	Carbonyl sulphide	Sulfure de carbonyle	Carbonylsulfid	2204
20	Chlorine	Chlore	Chlor	1017
38	Chlorodifluoroethane (R142b)	Chloro-1-difluoro-1,1-éthane (R142b)	1-Chlor-1,1-difluorethan (R142b)	2517
21	Chlorodifluoromethane	Chlorodifluorométhane	Chlordifluormethan	1018
23	Chloropentafluoroethane (R115)	Chloropentafluoroéthane (R115)	Chlorpentafluorethan (R115)	1020
24	Chlorotetrafluoroethane (R124)	Chloro-1 tétrafluoro-1,2,2,2 éthane (R124)	1-Chlor-1,1, 2,2-tetrafluorethan (R124)	1021
25	Chlorotrifluoroethane (R133a)	Chloro-1 trifluoro-2,2,2 éthane (R133a)	1-Chlor-2,2,2-trifluorethan (R133a)	1983
26	Chlorotrifluoroethylene (R1113)	Chlorotrifluoréthylène Trifluorochloréthylène (R1113)	Chlortrifluorethen (R1113)	1082
27	Chlorotrifluoromethane (R13)	Chlorotrifluorométhane (R13)	Chlortrifuormethan (R13)	1022
37	Cyanogen	Cyanogène	Dicyan	1026
28	Cyclopropane	Cyclopropane	Cyclopropan	1027
29	Deuterium	Deutérium	Deuterium	1957
32	Diborane	Diborane	Diboran	1911
30	Dibromodifluoromethane	Dibromodifluorométhane	Dibromdifluormethan	see note
31	Dibromotetrafluoroethane	Dibromotétrafluoroéthane	Dibromtetrafluorethan	see note
33	Dichlorodifluoromethane (R12)	Dichlorodifluorométhane (R12)	Dichlordifluormethan (R12)	1028
34	Dichlorofluoromethane (R21)	Dichlorofluorométhane (R21)	Dirchlorfluormethan (R21)	1029
35	Dichlorosilane	Dichlorosilane	Dichlorsilan	2189
36	Dichlorotetrafluoroethane (R114)	Dichloro-1,2 tétrafluoro-1,2,2,2 éthane (R114)	1,2-Dichlor-1,1, 2,2-tetrafluorethan (R114)	1958
39	1,1-Difluoroethane (R152a)	Difluoro-1,1-éthane (R152a)	1,1-Difluorethan (R152a)	1030
40	1,1-Difluoroethylene (R1132a)	Difluoro-1,1-éthylène (R1132a)	1,1-Difluorethen (R1132a)	1959
41	Dimethylamine	Diméthylamine	Dimethylamin	1032
42	Dimethyl ether	Ether méthylique	Dimethylether	1033
43	Disilane	Disilane	Disilan	1954
44	Ethane	Ethane	Ethan	1035
45	Ethylamine	Monoéthylamine	Ethylamin	1036
46	Ethyl chloride	Monochloroéthane Chlorure d'éthyle	Chlorethan	1037

"to be continued"

Table A.1 - Index of gases *(continued)*

Order number of table 1	English	French	German	UN Number
47	Ethylene	Ethylène	Ethen	1962
48	Ethylene oxide	Oxyde d'éthylène	Ethylenoxid	1040
50	Ethyl fluoride (R161)	Monofluoroéthane Fluorure d'éthyle (R161)	Fluorethan (R161)	2453
49	Fluorine	Fluor	Fluor	1045
51	Fluoromethane	Fluorométhane	Fluormethan	see note
53	Germane	Germane	German	2192
54	Helium	Hélium	Helium	1046
55	Hexafluoroethane (R116)	Hexafluoréthane (R116)	Hexafluorethan (R116)	2193
56	Hexafluoropropylene (R1216)	Hexafluoropropylène (R1216)	Hexafluorpropen (R216)	1858
57	Hydrogen	Hydrogène	Wasserstoff	1049
58	Hydrogen bromide	Bromure d'hydrogène	Bromwasserstoff	1048
59	Hydrogen chloride	Chlorure d'hydrogène	Chlorwasserstoff	1050
60	Hydrogen cyanide	Cyanure d'hydrogène	Cyanwasserstoff	1051
61	Hydrogen fluoride	Fluorure d'hydrogène	Fluorwasserstoff	1790
62	Hydrogen iodide	Iodure d'hydrogène	Iodwasserstoff	2197
63	Hydrogen sulfide	Sulfure d'hydrogène	Schwefelwasserstoff	1053
64	Isobutane	Méthylpropane Isobutane	Isobutan	1969
65	Isobutylene	Méthylpropène Isobutylène	Isobuten	1055
66	Krypton	Krypton	Krypton	1056
67	Methane	Méthane	Methan	1971
68	Methyl acetylene	Propyne	Propin	1954
72	Methylamine	Monométhylamine	Methylamin	1061
69	Methyl bromide	Monobromométhane Bromure de méthyle	Brommethan	1062
22	Methyl chloride (R40)	Monochlorométhane Chlorure de méthyle (R40)	Chlormethan (R40)	1063
70	Methyl mercaptan	Méthylmercaptan Mercaptan méthylique	Methylmercaptan	1064
71	Methyl silane	Monométhylsilane	Methylsilan	1954
73	Neon	Néon	Neon	1065
74	Nitric oxide	Monoxyde d'azote Oxyde nitrique	Stickstoffmonoxid	1660
75	Nitrogen	Azote	Stickstoff	1066
76	Nitrogen tetroxide	Dioxyde d'azote Tétroxyde de diazote	Stickstoffdioxid	1067
78	Nitrogen trifluoride	Trifluorure d'azote	Stickstofftrifluorid	2451
77	Nitrous oxide	Hémioxyde d'azote Protoxyde d'azote	Distickstoffoxid	1070
79	Octafluoro-2-butene	Octafluorobutène-2	Octafluorbuten-2	2422
80	Octafluorocyclobutane (RC318)	Octafluorocylobutane (RC318)	Octofluorcyclobutan (RC318)	1976
81	Octafluoropropane (R218)	Octafluoropropane (R218)	Octafluorpropan (R218)	2424
82	Oxygen	Oxygène	Sauerstoff	1072
83	Phosgene	Chlorure de carbonyle Phosgène	Carbonylchlorid	1076
84	Phosphine	Phosphine	Phosphin	2199
86	Propadiene	Propadiène	Propadien	2200
85	Propane	Propane	Propan	1978
87	Propylene	Propylène	Propen	1077
89	Silane	Monosilane	Silan	2203
90	Silicon tetrachloride	Tétrachlorure de silicium	Siliciumtetrachlorid	see note
91	Silicon tetrafluoride	Tétrafluorure de silicium	Siliciumtetrafluorid	1859
92	Sulphur dioxide	Dioxyde de soufre	Schwefeldioxid	1079
93	Sulphur hexafluoride	Hexafluorure de soufre	Schwefelhexafluorid	1080

"to be continued"

Table A.1 - Index of gases *(end)*

Order number of table 1	English	French	German	UN Number
94	Sulphur tetrafluoride	Tétrafluorure de soufre	Schwefeltetrafluorid	2418
95	Tetrafluoroethylene	Tétrafluoréthylène	Tetrafluorethen	1081
18	Tetrafluoromethane (R14)	Tétrafluorure de carbone Tétrafluorométhane (R14)	Tetrafluormethan (R14)	1982
96	Trichlorosilane	Trichlorosilane	Trichlorsilan	see note
97	Trichloro-Trifluoroethane	Trichloro-Trifluoroéthane	Trichlortrifluorethan	see note
98	Trifluoroethane (R143a)	Trifluoro-1,1,1 éthane (R143a)	1,1,1-Trifluorethan (R143a)	2035
52	Trifluoromethane (R23)	Trifluorométhane (R23)	Trifluormethan (R23)	1984
99	Trimethylamine	Triméthylamine	Trimethylamin	1083
100	Tungsten hexafluoride	Hexafluorure de tungstène	Wolframhexafluorid	2196
101	Vinyl bromide	Monobromoéthylène Bromure de vinyle	Vinylbromid	1085
102	Vinyl chloride	Monochloroéthylène Chlorure de vinyle	Vinylchlorid	1086
103	Vinyl fluoride	Monofluoroéthylène Fluorure de vinyle	Vinylfluorid	1860
88	Vinyl methyl ether	Ether méthylvinylique	Methylvinylether	1087
104	Xenon	Xénon	Xenon	2036
NOTE : For six gases the UN number could not be given because the "generic or n.o.s." number can only be given after determination of the physical state of the products in the packings and the subsidiary risks inherent.				

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Price based on 16 pages