INTERNATIONAL STANDARD

ISO 11114-2

Second edition
2013-04-01

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

Part 2: Non-metallic materials

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

Partie 2: Matériaux non métalliques

Reference number
ISO 11114-2:2013(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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

ISO 11114-2 was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, in collaboration with Technical Committee CEN/TC 23, *Transportable Gas cylinders* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition, Clauses 4 and 6, and Table 1 of which have been technically revised. Annex A has been deleted.

ISO 11114 consists of the following parts, under the general title *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 for non-metallic materials in oxygen atmosphere;*

— *Part 4: Test methods for selecting metallic materials resistant to hydrogen embrittlement.*

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Introduction

This part of ISO 11114 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 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 part of ISO 11114.

This part of ISO 11114 is based on current international experience and knowledge. 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.

This part of ISO 11114 has been written to be in conformity with the UN Recommendations on the Transport of Dangerous Goods: Model Regulations. When published it will be submitted to the UN Sub Committee of Experts on the Transport of Dangerous Goods with a request that it be included in the Model Regulations. Where there is any conflict between this part of ISO 11114 and any applicable regulation, the regulation always takes precedence.

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

Part 2: Non-metallic materials

1 Scope

This part of ISO 11114 gives guidance in the selection and evaluation of compatibility between non-metallic materials for gas cylinders and valves and the gas contents. It also covers bundles, tubes and pressure drums.

This part of ISO 11114 can be helpful for composite and laminated materials used for gas cylinders.

It does not cover the subject completely and is intended to give guidance only in evaluating the compatibility of gas/material combinations.

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 properties of the materials, such as mechanical properties, required for design purposes are normally available from the materials supplier and are not considered in this part of ISO 11114.

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 part of ISO 11114.

Other aspects such as quality of delivered gas are not considered.

This part of ISO 11114 is not intended to be used for cryogenic fluids (see ISO 21010).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 11114-3, *Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 3: Autogenous ignition test for non-metallic materials in oxygen atmosphere*

ISO 10297, *Gas cylinders — Refillable gas cylinder valves — Specification and type testing*

ISO 15001, *Anaesthetic and respiratory equipment — Compatibility with oxygen*

3 Terms and definitions

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3.1
competent person
person who has the necessary technical knowledge, qualification, experience and authority to assess and approve materials for use with gases and to define any special conditions of use that are necessary

3.2
acceptable
material/gas combination that is satisfactory under normal conditions of use (as defined in Clause 5), provided that any indicated non-compatibility risks, as given in Table 1, are taken into account

3.3
not acceptable
material/single gas combination that is not safe under normal conditions of use (as defined in Clause 5)

NOTE For gas mixtures special conditions can apply.

3.4
dynamic sealing
where in normal operation the non-metallic material is used to provide a pressure seal between two surfaces that have relative motion to each other

3.5
static sealing
where in normal operation the non-metallic material is used to provide a pressure seal between two surfaces that have not relative motion to each other

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.

If coated materials are used the suitability of the combination shall be assessed and approved if all technical aspects have been considered and validated by a competent person. These technical aspects include but are not limited to compatibility of the coating material with the intended gas, durability of the coating during all its intended use and gas permeability through it.

4.2 Types of material

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

— plastics;

— elastomers;

— fluid lubricants.

NOTE Solid lubricants are sometimes used, e.g. MoS2.

Materials considered in this part of ISO 11114 are as follows:

a) Plastics:

— Polytetrafluoroethylene (PTFE);

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— Polychlorotrifluoroethylene (PCTFE);

— Polyvinylidenefluoride (PVDF);

— Polyamide (PA);

— Polypropylene (PP);

— Polyetheretherketone (PEEK);

— Polypropylene sulphide (PPS);

— Polyvinyl chloride (PVC)

— Polyimide (PI);

— Polyoxymethylene (POM).

b) Elastomers:

— Butyl rubber (IIR);

— Nitrile rubber (NBR);

— Chloroprene rubber (CR);

— Fluorocarbon rubber (FKM);

— Methyl-vinyl-silicone rubber (VMQ);

— Ethylene propylene diene monomer (EPDM);

— Polyacrylate rubber (ACM);

— Polyurethane rubber (PUR);

— Methyl-fluoro-silicone rubber (FVMQ).

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 oxidizing gases).

Lubricants are often used in valves to reduce friction and wear in the moving parts. For valves used for oxidizing gases or for gases supporting combustion, if lubrication is required, it shall be ensured that the lubricant is compatible for the intended application when the lubricated components are in contact with the oxidizing gas or the gas supporting combustion.

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Where the lubricant is listed as "not acceptable" 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 not in contact with the gas.

Where the lubricant is listed as "not acceptable" for the reason of violent reaction (F), it should not be used in any part of the system that can be contacted by the gas, even under abnormal conditions such as in the event of a failure of the gas sealing system. If there is a risk of violent reaction, appropriate safety and suitability tests shall have been carried out for the lubricant application before it is used either on the lubricant itself, as specified in ISO 11114-3, or on the lubricated equipment in which it will be used, as specified in ISO 10297.

The properties of plastics and elastomers including compatibility 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 specified by the cylinder and valve manufacturing standards.

Some materials become brittle at low temperatures, especially at temperatures at the lower end of the normal operating range (e.g. fluorocarbon rubber). Temperatures in the refrigerant or cryogenic ranges affect many materials and caution shall 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 Violent reaction (oxidation/burning) (F)

6.2.1.1 Principle

Historically the majority of serious accidents from rapid oxidation or violent combustion have occurred with oxidizing gas supporting combustion 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 or gases supporting combustion.

Compatibility depends mainly on the operating conditions (pressure, temperature, gas velocity, particles, equipment design, and application). The risk shall particularly be considered with gases such as oxygen, fluorine, chlorine and nitrogen trifluoride. Most of the non-metallic materials can be ignited relatively easily when in contact with oxidizing gases (see ISO 10156) and even when in contact with gases not classified as oxidizing but still supporting combustion.

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 impacts, 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 materials compatibility properties (ease of ignition and energy of combustion); and

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

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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 in a gas mixture, influence of dilutant (e.g. helium), surface contamination,

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

— possible consequence (e.g. effects on the surroundings such as propagation of fire), and

— additional factors (e.g. performance requirements, prior experience, availability).

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 oxygen.

6.2.1.2 Specifications for oxidizing gases

In accordance with 6.2.1.1, it is not possible to make a simple statement concerning the compatibility of non-metallic materials with oxidizing gases such as oxygen, chlorine, nitric oxide, nitrous oxide, nitrogen dioxide, nitrogen trifluoride, etc. (see ISO 10156).

For fluorine, which is the most oxidizing gas, all non-metallic materials would historically fall into the classification "not acceptable".

For fluorine mixtures the gases industry now has evidence of successful testing and safe history of use of PTFE and PCTFE under controlled conditions (e.g. low concentration and low pressure). Therefore following an assessment and authorisation by a competent person, these materials are acceptable in similar conditions. Oxygen and 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). Some materials such as PTFE and FKM are more resistant to ignition than other plastics and elastomers. HC lubricants are normally not acceptable. Under certain conditions other plastics and elastomers listed can be safely used in oxidizing service without presenting some of the disadvantages of PTFE, i.e. poor mechanical properties, and risk of release of toxic products for breathing gas applications, see ISO 15001, or FKM, i.e. swelling, poor mechanical properties at low temperature, risk of release of toxic products in breathing gas applications, 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. ISO 11114-3 and ISO 21010 give testing methods for polymeric materials and fluid lubricants that will result in conservative value. Some non-metallic material can be safely used at higher pressure when they are tested in the final design configuration, e.g. in gas cylinder valves and regulator. Cylinder valves shall be tested according to ISO 10297 for oxygen service.

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.

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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.

6.2.3 Swelling of material (S)

Elastomers and plastics may be 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 with fluorocarbon.

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

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

Regardless of the above compatibility evaluation, the design configuration (e.g. static or dynamic sealing) shall be taken into account before deciding to use elastomers or plastics. In this part of ISO 11114, a swelling of more than approximately 15 % in normal service conditions is marked N (not acceptable for dynamic sealing); a swelling less than this is marked A (acceptable) provided other risks are also acceptable.

NOTE There is also a risk of cross bonding between sulphur vulcanised rubbers and copper alloys.

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. ISO 1817 gives testing methods to check the influence of the gas on the mechanical properties.

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 intended materials (e.g. acetone in acetylene, hydrogen sulphide in methane).

6.2.5.2 Contamination of the material (C)

Some materials become contaminated in toxic gas use 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 (e.g. toxic products). This risk shall be considered in particular for breathing gases as specified in ISO 15001.

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1) Dimethylformamide.

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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 plastic materials are particularly subject to ageing; some gases like oxygen and in general exposure to high temperatures may accelerate the ageing process, leading to degradation such as cracking, brittleness, etc.

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 radius of the gas and the specific formulation of plasticizers and other additives can cause a wide range of permeation rates for a particular type of plastic or elastomer.

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

7 Compatibility data

7.1 Table of compatibility

Table 1 lists the gases in alphabetic order with the UN number in bracket. In this table, the compatibility data is given using the symbols and abbreviations defined in 7.2.1 and 7.2.2. When a gas/material combination is not acceptable, 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.

If no UN number is listed in the table for a gas (or a liquid), this means that this gas has no official UN number but it may be transported using a generic NOS (Not Otherwise Specified) number (e.g. compressed gas, flammable, NOS, UN 1954).

Compatibility evaluations are based on the following documents:

— literature data;

— operational experiences; and

— laboratory tests.

The resistance to gases can be estimated by simple immersion tests in the respective gas with approximately the same or intensified exposure conditions (increase of temperature, pressure or flow rate). Time- and equipment-consuming test methods to evaluate the permeation, the absorption as well as the resistance to stress cracking are required in many cases.

Apart from the visual evaluation of detectable changes, changes in weight and dimension as well as the course of mechanical and other physical characteristics, depending on the immersion time are the parameters of immersion tests. They are consulted as classification characteristics.

In literature and company leaflets frequently used classifications are “resistant”, "conditionally resistant" and "not resistant".

Test procedures are described in ISO 1817 and in ISO 9539.

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7.2 Symbols and abbreviations

7.2.1 Symbols for compatibility

A = acceptable (see 3.2)

NOTE There can be a secondary risk associated (see 7.2.4).

N = not acceptable for use under normal service conditions (see 3.3)

a = No reliable recommendation can be made due to a lack of definitive information

u = The compatibility depends on the conditions of use (e.g. oxygen). 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

Abbreviation	Material
PTFE	Polytetrafluoroethylene
PCTFE	Polychlorotrifluoroethylene
PVDF	Polyvinylidenefluoride
PA	Polyamide
PI	Polyimide
PP	Polypropylene
POM	Polyoxymethylene
PEEK	Polyetheretherketone
PPS	Polypropylene sulphide
PVC	Polyvinyl chloride
IIR	Butyl rubber
NBR	Nitrile rubber
CR	Chloroprene rubber
FKM	Fluorocarbon rubber
VMQ	Methyl-vinyl-silicone rubber
EPDM	Ethylene propylene diene monomer
FVMQ	Methyl-fluoro-silicone rubber
ACM	Polyacrylate rubber
PUR	Polyurethane rubber
HC	Hydrocarbon
FC	Fluorocarbon

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7.2.3 Abbreviations for non-compatibility risks

Symbols	Risk
a	No reliable recommendation can be made due to a lack of definitive information
A	Acceptable
C	Contamination of material
u	The compatibility depends on the conditions of use
D	Dangerous product release
F	Flammable (Violent reaction)
G	Ageing
I	Impurities in the gas
M	Change of mechanical properties
N	Not acceptable for use under all normal service conditions
P	Permeation
S	Swelling
W	Weight loss

7.2.4 Examples

EXAMPLE 1

$\mathbf{A}_{\mathrm{P}}$

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 the risk of permeation has been evaluated and found negligible.

EXAMPLE 2

$\mathbf{N}_{\mathrm{F,C}}$

Symbol for compatibility = **N**

Abbreviation for non-compatibility risk:

1st risk = F

2nd risk = C

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

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Table 1 — Compatibility of non-metallic materials with gases

				Plastics										Elastomers									Fluid lubricant		MoS2
N° (UN-No)	Name	Formula	R #	PTFE	PI	PCTFE	PVDF	PA	PP	POM	PEEK	PPS	PVC	IIR	NBR	CR	FKM	VMQ	EPDM	FVMQ	ACM	PUR	HC	FC	
98 (2035)	**1,1,1-TRIFLUOROETHANE**	$C_2H_3F_3$	R143a	A	-	AS	A	a	NS	A	A	A	NS	NS	NS	NS	A	NS	NS	NS	NS	NS	NW	NW	A
39 (1030)	**1,1-DIFLUOROETHANE**	$C_2H_4F_2$	R152a	A	A	AS	A	A	NS	NS	NS	NS	NS	AS	A	A	NS	NS	A	NS	A	NS	NW	NW	A
40 (1959)	**1,1-DIFLUOROETHYLENE**	$C_2H_2F_2$	R1132a	A	-	AS	A	A	NS	NS	NS	A	NS	NS	A	A	NS	NS	NS	NS	NS	NS	NW	NW	A
97 (**3082**)	**2-TRICHLORO-1,2,2-TRIFLUOROETHANE**	$C_2Cl_3F_3$	**R 113**	A	-	AS	A	AW	A	AS	A	A	NW	NS	AS	AS	AS	NS	NS	NS	NS	NS	NW	NW	A
36 (1958)	**1,2-**DICHLORO**-1,1,2,2-**TETRAFLUOROETHANE	$C_2Cl_2F_4$	R114	A	A	AS	A	A	NS	NS	NS	A	NS	AS	A	A	AS	NS	A	NS	A	A	NW	NW	A
38 (2517)	**1-CHLORO-1,1-DIFLUOROCHLORO-ETHANE**	$C_2H_3ClF_2$	R142b	A	A	AS	A	A	NS	NS	NS	NS	NS	AS	AS	AS	NS	NS	A	NS	A	NS	NW	NW	A
24 (1021)	**1-**CHLORO**-1,2,2,2-**TETRAFLUOROETHANE	C_2HClF_4	R124	A	-	A	A	A	NS	NS	NS	NS	NS	NS	NS	NS	A	NS	NS	NS	NS	NS	NW	NW	A
113 (3161)	1-CHLORO-1,2-DIFLUOROETHANE	$C_2H_3ClF_2$		A	-	A	A	A	NS	NS	NS	NS	NS	NS	NS	NS	A	NS	NS	NS	NS	NS			A
25 (1983)	**1-**CHLORO**-2,2,2-**TRIFLUOROETHANE	$C_2H_2ClF_3$	R133a	A	A	AS	A	A	NS	NS	NS	NS	NS	a	a	a	A	NS	a	NS	NS	NS	NW	NW	A
117 (2044)	**2,2-**DIMETHYLPROPANE	C_5H_{12}		A	-	A	A	A	NS	A	A	A	A	NS	A	A	A	NS	NS	A	NS				A
1 (1001)	ACETYLENE 2)	C_2H_2		A	-	A	A	A W,I	A	A	A	A	A	A	NW,I	NW,I	NW,I	NW,I	A	A	NW,I	NW,I	NW,I	NW,I	A
105 (1002)	**AIR** 3)			AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	AF	A
2 (1005)	AMMONIA	NH_3		A	NW	A	NG,W	A	A	A	A	A	A	A	NW	A	NW	NW	A	NW	NW	NW	NW	A	A
3 (1006)	ARGON	Ar		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
4 (2188)	ARSINE	AsH_3		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	NW	NC,d	NC,d	A
5 (1741)	BORON TRICHLORIDE	BCl_3		A	-	A	A	NW	A	NW	A	A	A	NW	NW	NW	A	NW	NW	A	NW	NW	NW	A	A
6 (1008)	BORON TRIFLUORIDE	BF_3		A	-	A	A	NW	A	A	A	A	A	NR	NW	NW	A	NW	NW	A	NW	NW	NW	A	A
9 (2419)	BROMOTRIFLUORO-ETHYLENE	C_2BrF_3	R123B1	A	-	AS	A	NS	NS	NS	NS	NS	NS	NS	NS	NS	A	NS	NS	NS	NS	NS	AW	AW	A
8 (1009)	BROMOTRIFLUORO-METHANE	$CBrF_3$	R13B1	A	A	AS	A	A	AS,W	A	NS	NS	NS	AS	AS	AS	NS	NR	AS	NS	A	A	AW	AW	A
10 (1010)	**BUTADIENES**	C_4H_6		A	A	A	A	A	A	A	A	A	A	NS,M	NS,M	NS,M	A	NS,M	NS,M	A	NS,M	NS,M	NW	A	A
12 (1011)	BUTANE	C_4H_{10}		A	A	A	A	A	A	A	A	A	A	NS	A	A	A	NS,M	NS,M	A	A	A	NW	A	A
13 (1012)	BUT**YL**ENE	C_4H_8		A	A	A	A	A	A	A	A	A	NS,M	NS,M	A	NS	A	NS,M	NS,M	A	NS,M	NS,M	NW	A	A
16 (1013)	CARBON DIOXIDE	CO_2		A	A	A	A	A	A	NS,W	A	A	A	NS	NS,W	NS,W	NS,W	AP	AS,W1)	A	A	A	A	A	A
17 (1016)	CARBON MONOXIDE	CO		A	A	A	A	A	A	A	A	A	A	AG	A	A	NS	A	A	A	A	A	A	A	A
109 (2417)	CARBONYL FLUORIDE	COF_2		A	NW	A	NW	NW	NW	NW	NW	NW	NW	A	A	NW	A	NW	A	A	NW	NW	NC,d	NC,d	A
19 (2204)	CARBONYL SULPHIDE	COS		A	NW	A	A	A	NW	NW	NW	NW	A	NW	NW	NW	A	A	NW	A	NW	NW	NC	NC	A
20 (1017)	**CHLORINE**	Cl_2		see 6.2.1.2 Warning : There is a risk of violent reactions																					N
				A	NF	A	A	NF	NF	NF	NF	NS	NF	NF	NF	NF	A	NW	NF	NF	NF	NF	NF	A	A
110 (1589)	CHLORINE CYANIDE	ClCN		A	-	A	A			A	A	A	A				A								A
111 (2548)	CHLORINE PENTAFLUORIDE	ClF_5		A	NW	A	A	NW	A	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW			A
112 (1749)	CHLORINE TRIFLUORIDE	ClF_3		A	NW	A	NW	NW	A	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW			A

2) Some materials are not compatible because of the solvent used.

3) At high pressure risk of violent reaction due to oxygen.

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Table 1 (*continued*)

				Plastics										Elastomers									Fluid lubricant		MoS2
N° (UN-No)	**Name**	**Formula**	**R #**	**PTFE**	**PI**	**PCTFE**	**PVDF**	**PA**	**PP**	**POM**	**PEEK**	**PPS**	**PVC**	**IIR**	**NBR**	**CR**	**FKM**	**VMQ**	**EPDM**	**FVMQ**	**ACM**	**PUR**	**HC**	**FC**	
7 (1974)	BROMOCHLORODI-FLUOROMETHANE	$CBrClF_2$	R12B1	A	A	AS	A	A	A	NS	NS	NS	NS	NS	NS	A	A	NS	NS	A	NS	NS	NW	AW	A
21 (1018)	CHLORODIFLUORO-METHANE	$CHClF_2$	R22	AP	A	AS	A	A	AP	A	AS	AS	NS	AS	NS	AS	NS	NS	A	NS	NS	NS	NW	NW	A
23 (1020)	CHLOROPENTAFLUORO-ETHANE	C_2ClF_5	R115	A	A	AS	A	A	NS	NS	NS	NS	NS	A	A	A	A	NS	A	NS	A	A	NW	NW	A
27 (1022)	CHLOROTRIFLUORO-METHANE	$CClF_3$	R13	A	A	AS	A	A	NS	NS	NS	NS	NS	A	A	AS	A	NS	A	NS	A	NS	NW	NW	A
37 (1026)	**CYANOGEN**	C_2N_2		A	-	A	A	a	A	a	a	a	a	NS,W	NS,W	NR	A	A	A	A			NC	NC	A
28 (1027)	CYCLOPROPANE	C_3H_6		A	A	A	A	A	A	A	A	A	A	NS	A	NS	A	NS	NS	A	A	A	NW	A	A
29 (1957)	DEUTERIUM	^2H ou D		AP	A	A	A	A	AP	A	A	A	A	A	A	A	A	AP	A	A	A	A	A	A	A
32 (1911)	DIBORANE	B_2H_6		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	NC	NC	A
30 (1941)	DIBROMODIFLUORO-METHANE	CBr_2F_2	R12B2	AP	-	AS	A	A	NS	NS	NS	NS	NS	NS	NS	A	A	NS	NS	NS	NS	NS	NW	AW	A
31 (no UN yet assigned)	DIBROMOTETRAFLUORO-ETHANE	$C_2Br_2F_4$	R114B2	A	-	AS	A	A	NS	NS	NS	NS	NS	NS	NS	AS	NS	NS	NS	NS	NS	NS	NW	NW	A
33 (1028)	DICHLORODIFLUORO-METHANE	CCl_2F_2	R12	AP	A	AS	A	A	NS	A	NS	NS	A	NS	AS	A	AS	NS,P	NS	NS	A	A	NW	NW	A
34 (1029)	DICHLOROFLUORO-METHANE	$CHCl_2F$	R21	A	A	AS	A	A	AP	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NW	NW	A
35 (2189)	DICHLOROSILANE	SiH_2Cl_2		A	-	A	A	NW	NW	NW	NW	NW	NW	NW	NW	NW	A	A	NW	A	NW	NW	NC	NC	A
116 (3252)	DIFLUOROMETHANE	CH_2F_2	**R 32**	A	A	NS	A	A	NS	NS	NS	NS	NS	A	A	A	NS	NS	A	NS	NS	NS	-	-	A
41 (1032)	DIMETHYLAMINE	C_2H_7N		A	A	A	NG,W	A	A	A	A	NW	NW	A	NW	NW	NW	NW	A	NW	NW	NW	NW	A	A
42 (1033)	DIMETHYLETHER	C_2H_6O		A	-	A	A	NS	NS	A	A	A	NS	NS	NS	NS	NS	A	NS	A	NS	NS	NW	NW	A
118 (3161)	DiMETHYLSILANE	C_2H_8Si		A	-	A	A	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW			A
76 (1067)	**DINITROGEN TETROXIDE (NITROGEN DIOXIDE) 3)**	NO_2/N_2O_4		see 6.2.1.2 Warning : There is a risk of violent reactions																					A
				A	NF	A	A	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF,C	NC	A
43 (3161)	DISILANE	Si_2H_6		A	-	A	A	a	a	A	A	A	a	A	a	A	A	A	A	A	A	A	NC	NC	A
44 (1035)	ETHANE	C_2H_6		A	A	A	A	A	A	A	A	A	A	NS	A	NS	A	NS,W	NS	NS	A	A	A	A	A
46 (1037)	ETHYL CHLORIDE	C_2H_5Cl	R160	A	-	AS	A	A	NS	NS	NS	NS	NS	A	A	A	A	NS,W	A	A	NW	NW	NW	NW	A
50 (2453)	**ETHYL FLUORIDE**	C_2H_5F	R161	A	-	AS	A	A	AP	A	A	A	NS	NS	A	NS	A	NS	NS	A	NS	NS	NW	NW	A
121 (1039)	**ETHYL METHYL ETHER**	C_3H_8O	**R 227**	A	-	A	A	NS	NS	A	A	A	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-	-	A
120 (2452)	ETHYLACETYLENE	C_4H_6		A	A	A	A	A	A	A	A	A	A	A	A	A	A	-	-	A	A	A	-	-	A
45 (1036)	ETHYLAMINE	C_2H_7N		A	-	A	A	NW	A	A	A	NW	NW	NW	NW	NW	NW	NW	A	NW	NW	NW	NW	NW	A
47 (1962)	ETHYLENE	C_2H_4		A	A	A	A	A	A	A	A	A	A	A	A	A	A	NS	NS	A	A	A	A	A	A
48 (1040)	ETHYLENE OXIDE	C_2H_4O		A	A	A	A	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NW	NR	A
49 (1045)	FLUORINE	F_2		see 6.2.1.2 Warning : There is a risk of violent reactions																					
				NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF
53 (2192)	GERMANE	GeH_4		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	NC,d	NC,d	A
54 (1046)	HELIUM	He		AP	A	A	A	A	AP	A	A	A	A	A	A	A	A	AP	A	A	A	A	A	A	A
122 (3296)	HEPTAFLUOROPROPANE	C_3HF_7		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
123 (2420)	HEXAFLUOROACETONE	C_3F_6O		A	NSW	A	A	-	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	A	NS,W	NS,W	NS,W	NS,W	NS,W	-	-	A
55 (2193)	HEXAFLUOROETHANE	C_2F_6	R116	A	A	AS,W	A	A	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	A	NS,W	NS,W	NS,W	NS,W	NS,W	NW	NW	A
56 (1858)	HEXAFLUOROPROP**YL**EN E	C_3F_6		A	A	AS	A	A	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	A	NS,W	NS,W	NS,W	NS,W	NS,W	NW	NW	A
57 (1049)	HYDROGEN	H_2		AP	A	A	A	A	AP	A	A	A	A	A	A	A	A	A P	A	AP	AP	A	A	A	A
58 (1048)	HYDROGEN BROMIDE	HBr		A	-	A	A	NW	A	NW	NW	NW	A	NW	NW	NW	A	NW	A	NW	NW	NW	NC	NC	A
59 (1050)	HYDROGEN CHLORIDE	HCl		A	A	A	A	NW	A	NW	NW	NW	A	NW	NW	NW	A	NW	A	NW	NW	NW	NC	NC	A

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Table 1 (*continued*)

N° (UN-No)	Name	Formula	R #	Plastics PTFE	PI	PCTFE	PVDF	PA	PP	POM	PEEK	PPS	PVC	Elastomers IIR	NBR	CR	FKM	VMQ	EPDM	FVMQ	ACM	PUR	Fluid lubricant HC	FC	MoS2
60 (1051)	HYDROGEN CYANIDE	HCN		A	-	A	A	NW	A	NW	NW	NW	A	NW	NW	NW	A	NW	A	NW	NW	NW	NC	NC	A
61 (1052)	HYDROGEN FLUORIDE	HF		A	-	A	A	NW	A	NW	NW	NW	A	NW	NW	NW	A	NW	A	NW	NW	NW	NC	NC	A
62 (2197)	HYDROGEN IODIDE	HI		A	-	A	A	NW	A	NW	NW	NW	A	NW	NW	NW	A	NW	A	NW	NW	NW	NC	NC	A
124 (2202)	HYDROGEN SELENIDE	H_2Se		A	A	A	A	A	A	A	A	A	-	-	NW	-	A	-	-	-	-	-	-	-	A
63 (1053)	HYDROGEN SUL**PH**IDE	H_2S		AP	A	A	A	A	A	NW	A	A	A	AW	NW	NW	NW	NW	A	NW	NW	NW	NC	NC	A
64 (1969)	**ISOBUTANE**	C_4H_{10}		A	A	A	A	A	A	A	A	A	A	NS	A	A	A	NS,M	NS,M	A	A	A	NW	A	A
65 (1055)	**ISOBUTYLENE**	C_4H_8		A	A	A	A	A	A	A	A	A	A	NS,M	A	NS	A	NS,M	NS,M	A	NS	NS	NW	A	A
66 (1056)	KRYPTON	Kr		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
67 (1971)	METHANE	CH_4		A	A	A	A	A	A	A	A	A	A	NS	A	A	A	NR	NS	NS	A	NS	A	A	A
69 (1062)	**METHYL BROMIDE**	CH_3Br	R40B1	A	A	A	A	NS	NS	A	A	NS	NS	NS	NS	NS	A	NS	NS	A	NS	NS	NW	NW	A
51 (2454)	**METHYL FLUORIDE**	CH_3F	R41	A	A	AS	A	A	NS	A	A	A	NS	NS	NS	NS	A	NS	NS	A	NS	NS	NW	NW	A
70 (1064)	**METHYL MERCAPTAN**	CH_4S		A	-	A	A	A	a	A	A	A	A	NW	NW	NW	NW	A	A	NW	-	-	NC	NC	A
126 (2455)	METHYL NITRITE	CH_3NO_2		A	-	A	A	-	-	-	-	-	-	-	NW	-	A	-	-	-	-	-	-	-	A
68 (3161)	METHYLACETYLENE	C_3H_4		A	A	A	A	AW	A	A	A	A	A	A	-	-	a	a	a	-	-	-	NW,I	A	A
72 (1061)	METHYLAMINE	CH_5N		A	A	A	NG,W	A	A	A	A	NW	NW	A	NW	NW	NW	NW	A	NW	NW	NW	NW	A	A
22 (1063)	**METHYL CHLORIDE**	CH_3Cl	R40	A	A	A	A	A	NS	NS	A	NS	NS	NS	NS	NS	A	NS	NS	NS	NS	NS	NW	NW	A
125 (2534)	METHYLCHLOROSILANE	CH_5SiCl		A	-	A	A	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-	-	A
71 (3161)	METHYLSILANE	CH_6Si		A	-	A	A	-	-	A	A	A	A	A	-	A	A	A	A	A	A	A	NC	NC	A
73 (1065)	NEON	Ne		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
74 (1660)	**NITRIC OXIDE**	**NO**		see 6.2.1.2 Warning : There is a risk of violent reactions																					
				Ad	NF	Ad	Ad	NF,W	NF	NF	NF	NF	NF	NF,W	NF,W	NF,W, d	Ad	NF	NF,W	NF	NF	Ad	NF,C	NC,d	A
75 (1066)	NITROGEN	N_2		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
78 (2451)	NITROGEN TRIFLUORIDE	NF_3		see 6.2.1.2 Warning : There is a risk of violent reactions																					
				A	F	A	A	F	F	F	F	F	F	F	F	F	A	F	F	F	F	F	F	A	A
119 (2421)	**NITROGEN TRIOXIDE**	N_2O_3		see 6.2.1.2 Warning : There is a risk of violent reactions																					A
				A	NF	A	A	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	NF	F	A
77 (1070)	**NITROUS OXIDE**	N_2O		see 6.2.1.2 Warning : There is a risk of violent reactions																					A
				A	-	A	AF	A	NF	NF	AF	NF	NF	NF,S	NF,S	NF,S	NS	A	AF,S	A	A	A	NF	A	A
81 (2424)	OCTAFLUORO PROPANE	C_3F_8	R218	A	A	AS	A	A	NS	A	A	A	NS	A	A	A	A	AS	A	AS	NS	NS	NW	NW	A
79 (2422)	**OCTAFLUOROBUT-2-ENE**	C_4F_8	**R 1318**	A	-	AS	A	A	NS	A	A	A	NS	A	A	A	AS	AS	A	AS	NS	NS	NW	NW	A
80 (1976)	OCTAFLUORO-CYCLOBUTANE	C_4F_8	RC318	A	A	AS	A	A	NS	A	A	A	NS	A	A	A	AS	AS	A	AS	NS	NS	NW	NW	A
82 (1072)	**OXYGEN**	O_2		see 6.2.1.2 Warning : There is a risk of violent reactions																					A
				F,D	F	F,D	F,D	F	F	F	F	F	F	F	F	F,D	F,S,D	F	F	F	F	F	NF	F,D	A
127 (3220)	PENTAFLUOROETHANE	C_2HF_5	**R 125**	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
128 (3083)	PERCHLORYL FLUORIDE	ClO_3F		A	-	A	-	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	-	-	A
129 (3154)	PERFLUORO (ETHYL VINYL ETHER)	C_4F_8O		A	NS	A	-	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-	-	A
130 (3153)	PERFLUORO (METHYL VINYL ETHER)	C_3F_6O		A	NS	A	-	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-	-	A
83 (1076)	PHOSGENE	$COCl_2$		A	-	A	NW	NW	NW	A	NW	NW	NW	A	A	NW	A	NW	A	A	NW	NW	NC	NC	A
84 (2199)	PHOSPHINE	PH_3		A	-	A	A	NG	-	A	A	A	A	A	A	A	A	A	A	A	NW	NW	NC	NC	A
131 (2198)	PHOSPHORUS PENTAFLUORIDE	PF_5		A	-	A	A	-	-	A	A	A	A	-	-	-	A	-	-	A	-	-	-	-	A
86 (2200)	PROPADIENE	C_3H_4		A	A	A	A	AW	A	A	A	A	A	A	NS	NS	A	VS	NS	A	NS	NS	NW,I	A	A
85 (1978)	PROPANE	C_3H_8		A	A	A	A	A	A	A	A	A	NS	NS	A	NS	A	NS,M	NS,M	NS	A	NS	NW	A	A
87 (1077)	PROPYLENE	C_3H_6		A	A	A	A	A	A	A	A	A	NS	NS	NS	NS	A	NS	NS	NS	NS	NS	NW	A	A

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Table 1 (*continued*)

				Plastics										Elastomers									Fluid lubricant		MoS2
N° (UN-No)	**Name**	**Formula**	**R #**	**PTFE**	**PI**	**PCTFE**	**PVDF**	**PA**	**PP**	**POM**	**PEEK**	**PPS**	**PVC**	**IIR**	**NBR**	**CR**	**FKM**	**VMQ**	**EPDM**	**FVMQ**	**ACM**	**PUR**	**HC**	**FC**	
88 (1280)	PROPYLENE OXIDE	C_3H_6O		A	-	A	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NW	NW	A
132 (2194)	SELENIUM HEXAFLUORIDE	SeF_6		A	-	A	A	NW	A	A	A	A	A	Nw	NW	NW	A	NW	NW	NW	NW	NW	-	-	A
89 (2203)	SILANE	SiH_4		A	A	A	A	-	-	A	A	A	-	-	-	-	-	-	A	A	A	A	NC	NC	A
90 (1818)	SILICON TETRACHLORIDE	$SiCl_4$		A	-	A	A	NW	A	NW	NW	NW	NW	NW	NW	NW	A	NW	A	NW	NW	NW	NC	NC	A
91 (1859)	SILICON TETRAFLUORIDE	SiF_4		A	-	A	A	NW	A	NW	NW	NW	NW	NW	NW	NW	NW	NW	A	NW	NW	NW	NC	NC	A
106 (2676)	**STIBINE**	SbH_3		A	A	A	A	A	A	A	A	A	A	A	NW	A	A	A	A	A	A	a	a	a	A
133 (2191)	SULFURYL FLUORIDE	SO_2F_2		A	-	A	NW	NW	NW	NW	NW	NW	NW	NW	NW	-	A	NW	A	NW	NW	NW	-	-	A
92 (1079)	SULPHUR DIOXIDE	SO_2		A	A	A	A	NW	A	NW	A		NW	A	NW	NW	NW	NW	A	NW	NW	A	NW,C	NC	A
93 (1080)	SULPHUR HEXAFLUORIDE	SF_6		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	NW	A	A	A	A
94 (2418)	SULPHUR TETRAFLUORIDE	SF_4		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	NW	A	A	A	A
134 (2195)	TELLURIUM HEXAFLUORIDE	TeF_6		A	A	A	A	NW	A	A	A	A	A	NW	NW	NW	A	NW	NW	NW	NW	NW	-	-	A
95 (1081)	TETRAFLUOROETHYLENE	C_2F_4	R114	A	-	A	A	A	NS	A	A	A	NS	A	A	A	A	NS	A	AS	NS	A	NW	NW	A
18 (1982)	TETRAFLUOROMETHANE	CF_4	R14	A	A	AS,W	A	A	A	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	NS,W	A	NS,W	NS,W	NS,W	NS,W	NS,W	NW	A	A
96 (1295)	TRICHLOROSILANE	$SiHCl_3$		A	-	A	A	NW	NW	NW	NW	NW	NW	NW	NW	NW	A	NW	A	NW	NW	NW	NC	NC	A
26 (1082)	**TRIFLUOROCHLOROETHY LENE**	C_2ClF_3	R1113	A	-	NS	A	A	NS	NS	NS	NS	NS	-	-	-	A	NS	NS	NS	-	NS	NW	NW	A
52 (1984)	TRIFLUOROMETHANE	CHF_3	R23	A	-	NS,W	A	A	A	A	A	A	NS,W	A	A	A	A	A	A	A	NS	NS	NW	A	A
99 (1083)	TRIMETHYLAMINE	C_3H_9N		A	-	NG	NG,W	NW	A	A	A	NW	A	A	AW	NW	NW	NW	A	NW	NW	NW	NW	NRA	A
100 (2196)	TUNGSTEN HEXAFLUORIDE	WF_6		A	A	A	A	-	A	A	A	A	A	NW	NW	NW	A	NW	A	NW	NW	NW	NC	NC	A
101 (1085)	VINYL BROMIDE	C_2H_3Br	R140B1	A	-	AS	A	-	NS	NS	NS	NS	NS	NS	NS	NS	A	NS	NS	NS	NS	NS	NW	NW	A
102 (1086)	VINYL CHLORIDE	C_2H_3Cl	R140	A	-	AS	A	-	NS	NS	NS	NS	NS	NS	NS	NS	A	NS	NS	NS	NS	NS	NW	NW	A
103 (1860)	VINYL FLUORIDE	C_2H_3F	R141	A	-	AS	A	-	NS	NS	NS	NS	NS	NS	NS	NS	A	NS	NS	NS	NS	NS	NW	NW	A
135 (1087)	VINYL METHYL ETHER	C_3H_6O		A	-	A	A	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-	-	A
104 (2036)	XENON	Xe		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

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