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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

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 58, *Gas cylinders*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 23, *Transportable gas cylinders,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 11114-2:2013), which has been technically revised. The main changes compared with the previous edition are as follows:

— new materials were added in Table 1;

— Table 2, dedicated to the compatibility for liners, was added.

A list of all parts in the ISO 11114 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document provides guidance on 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 covered 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 document.

This document 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 document has been written so that it is suitable to be referenced in the UN Model Regulations[7].

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

Part 2: Non-metallic materials

1 Scope

This document gives guidance on the selection and evaluation of compatibility between non-metallic materials for gas cylinders and valves and the gas contents. It is also applicable to tubes, pressure drums and bundles of cylinders.

This document covers composite and laminated materials used for gas cylinders. It does not include ceramics, glasses and adhesives.

This document considers the influence of the gas in changing the material and mechanical properties (e.g. chemical reaction or change in physical state). The basic properties of the materials, such as mechanical properties required for design purposes (normally available from the materials supplier), are not considered. Other aspects, such as quality of delivered gas, are not considered.

The compatibility data given are related to single component gases but can be applicable to gas mixtures.

This document does not apply to cryogenic fluids (this is covered in ISO 21010).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10286, *Gas cylinders — Vocabulary*

ISO 10297, *Gas cylinders — Cylinder valves — Specification and type testing*

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10286 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

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

[SOURCE: ISO 11114-1:2020, 3.1, modified — "qualification" has been added to the definition.]

3.2
acceptable
satisfactory material/gas combination, under normal conditions of use, provided that any indicated non-compatibility risks are taken into account

Note 1 to entry: Normal conditions of use are defined in Clause 5.

Note 2 to entry: Non-compatibility risks are provided in Table 1.

3.3
not acceptable
unsafe material/single gas combination, under normal conditions of use

Note 1 to entry: For gas mixtures, special conditions can apply.

Note 2 to entry: Normal conditions of use are defined in Clause 5.

3.4
dynamic sealing
non-metallic material used, in normal operation, to provide a pressure seal between two surfaces that have 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, and Table 2 for the cylinder liners, or the necessary properties have been proved by tests or long and safe experience to the satisfaction of a competent person.

NOTE When plastic liner materials are used, it is necessary to use metallic bosses. For compatibility of metallic bosses, see ISO 11114-1.

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 Type of materials

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

— plastics;

— elastomers;

— fluid lubricants.

NOTE 1 Solid lubricants are sometimes used, e.g. MoS_2.

Materials considered in this document are as follows:

a) plastics:

- polytetrafluoroethylene (PTFE);
- polychlorotrifluoroethylene (PCTFE);
- polyvinylidenefluoride (PVDF);
- polyamide (PA);
- polypropylene (PP);
- polyethylene (PE);

  NOTE 2 PE covers grades such as HDPE (high density polyethylene), MDPE (medium density polyethylene), LDPE (low density polyethylene), PEX (cross-linked), etc.

- polyethylene terephthalate (PET);
- polyetheretherketone (PEEK);
- polypropylene sulfide (PPS);
- polyvinyl chloride (PVC);
- polyimide (PI);
- polyoxymethylene (POM);

b) elastomers (rubber):

- butyl rubber (IIR);
- nitrile butadiene rubber (NBR);
- chloroprene rubber (CR);
- fluorocarbon rubber (FKM);
- methyl-vinyl-silicone rubber (VMQ);
- ethylene propylene diene rubber (EPDM);
- polyacrylate rubber (ACM);
- polyurethane rubber (PUR);
- epichlorohydrin rubber (ECO);
- methyl-fluoro-silicone rubber (FVMQ);

c) fluid lubricants:

- hydrocarbon (HC);
- fluorocarbon (FC).

5 General consideration

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 (e.g. 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.

Where the lubricant is listed as "not acceptable" in Table 1 for reasons other than violent reaction (oxidation/burning) (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 (oxidation/burning) (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 be 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 is intended to 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. carbon dioxide).

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 defined in 6.2.

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 or an oxygen enriched atmosphere, or both, 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 (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);

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

These general factors should be viewed in the context of the entire system design so that the following specific factors will assume the proper relative significance:

— 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 or oxidizing gas concentrations in a gas mixture, or both, 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);

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

— the 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 authorization 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 test methods for polymeric materials and fluid lubricants that result in conservative value. Some non-metallic materials can be safely used at higher pressure if they are satisfactorily tested in the final design configuration, e.g. in gas cylinder valves and regulators. Cylinder valves intended to be used for oxidizing gas service shall be tested in accordance with ISO 10297.