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

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 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