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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

English Version

Industrial valves - Additional requirements for metallic valves for hydrogen application

Robinetterie industrielle - Exigences supplémentaires pour les appareils de robinetterie métalliques pour application hydrogène

Industriearmaturen - Zusätzliche Anforderungen an metallische Armaturen für Wasserstoffanwendungen

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 69.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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European foreword

This document (prEN 18191:2025) has been prepared by Technical Committee CEN/TC 69 “Industrial valves”, the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

Introduction

Metallic industrial valves are considered as essential pressure accessories in hydrogen applications. They are used in various hydrogen technologies applications, for example production, processing, storage, transportation, distribution, and usage.

Metallic industrial valves are integral pressure accessories of industrial piping, gas transportation and distribution systems.

CEN/TC 69 worked in cooperation with the following other technical committees: CEN/TC 267, CEN/TC 54, CEN/TC 234 and CEN/TC 235.

This document defines additional requirements for metallic industrial valves for hydrogen application published in EN standards and establishes the relationship to harmonized EN standards covering material, design considerations, specific manufacturing processes and final assessment (testing and inspection).

The document is an application standard to provide consolidation of requirements on known and proven solutions for hydrogen applications. Furthermore, it is intended to describe or exclude specific technical matters.

For this purpose, the standard addresses damage mechanisms of hydrogen services, which might exist in combinations.

1 Scope

This document applies to industrial metallic valves for hydrogen use. It contains recommendations and additional requirements applicable to material selection, design, manufacture, and final assessment.

This document addresses the following four services/damage mechanisms, which might exist in combinations:

- low temperature applications;
- hydrogen environmental embrittlement (HEE) or hydrogen-induced cracking (HIC);
- high temperature hydrogen attack (HTHA);
- hydrogen service with cyclic loads (fatigue).

The document considers the difference between gaseous hydrogen (GH₂) and liquid hydrogen (LH₂), where necessary.

The additional provisions set out in this document do not cover corrosion such as electro-chemical corrosion of metals under participation of hydrogen (e.g. sour gas).

This document is based on the requirements contained in the standards specified below:

- applications with a maximum allowable pressure PS greater than 0,5 bar in accordance with the European legislation for pressure equipment, the applicable provisions of EN 16668 apply;
- additional requirements for valves in chemical and petrochemical applications are specified in EN 12569;
- additional requirements for valves in gas distribution systems are specified in EN 13774;
- additional requirements for valves in gas transportation systems are specified in EN 14141.

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.

EN 19:2023, *Industrial valves — Marking of metallic valves*

EN 736-1, *Valves — Terminology — Part 1: Definition of types of valves*

EN 736-2, *Valves — Terminology — Part 2: Definition of components of valves*

EN 736-3, *Valves — Terminology — Part 3: Definition of terms*

EN 1708-1, *Welding — Basic welded joint details in steel — Part 1: Pressurized components*

EN 1976, *Copper and copper alloys — Cast unwrought copper products*

EN ISO 3651-2:1998, *Determination of resistance to intergranular corrosion of stainless steels — Part 2: Ferritic, austenitic and ferritic-austenitic (duplex) stainless steels — Corrosion test in media containing sulfuric acid (ISO 3651-2:1998)*

EN 10213+A1, *Steel castings for pressure purposes*

EN 12074, *Welding consumables — Quality requirements for manufacture, supply and distribution of consumables for welding and allied processes*

EN 12266-1, *Industrial valves — Testing of metallic valves — Part 1: Pressure tests, test procedures and acceptance criteria — Mandatory requirements*

EN 12266-2, *Industrial valves — Testing of metallic valves — Part 2: Tests, test procedures and acceptance criteria - Supplementary requirements*

EN 13479, *Welding consumables — General product standard for filler metals and fluxes for fusion welding of metallic materials*

EN ISO 15792-1, *Welding consumables — Test methods — Part 1: Preparation of all-weld metal test pieces and specimens in steel, nickel and nickel alloys (ISO 15792-1)*

EN ISO 15848-1, *Industrial valves — Measurement, test and qualification procedures for fugitive emissions — Part 1: Classification system and qualification procedures for type testing of valves (ISO 15848-1)*

EN ISO 15848-2, *Industrial valves — Measurement, test and qualification procedures for fugitive emissions — Part 2: Production acceptance test of valves (ISO 15848-2:2015)*

EN 16668:2025, *Industrial valves — Requirements and testing for metallic valves as pressure accessories*

EN ISO 28921-1:2022, *Industrial valves — Isolating valves for low-temperature applications — Part 1: Design, manufacturing and production testing (ISO 28921-1:2022)*

EN ISO 28921-2, *Industrial valves — Isolating valves for low-temperature applications — Part 2: Type testing (ISO 28921-2)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 736-1, EN 736-2, EN 736-3 and the following apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp/>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

diffusion

flux of a fluid through another fluid or material due to concentration gradient

Note 1 to entry: The diffusion coefficient is the mass of material diffusing across a unit of area in a unit of time at a unit concentration gradient.

EXAMPLE The motion of hydrogen gas through air, or the movement of hydrogen gas through the wall of a rubber hose.

3.2

gas permeability coefficient

number of moles of test gas passing through a test piece of unit thickness, per unit area, per unit time, with unit partial-pressure difference between the two sides of the test piece

[SOURCE: ISO 2782-1:2022, 3.2]

3.3

gas solubility coefficient

test gas concentration inside a test piece divided by the partial pressure of the test gas at the surface of the test piece

[SOURCE: ISO 2782-1:2022, 3.4]

3.4

gaseous hydrogen

hydrogen under gaseous form

[SOURCE: ISO 14687:2019, 3.10]

3.5

glass transition

reversible change in an amorphous polymer or in amorphous regions of a partially crystalline polymer from (or to) a viscous or rubbery condition to (or from) a hard and relatively brittle one

[SOURCE: EN ISO 472:2013, 2.440]

3.6

glass transition temperature

T_g

approximate midpoint of the temperature range over which the glass transition takes place

Note 1 to entry: The glass transition temperature varies significantly, depending upon the specific property and the test method and conditions selected to measure it.

Note 2 to entry: The glass transition temperatures of polymers and elastomers describe the temperature ranges at which polymers and elastomers turn from a hard, brittle material (below T_g) to a ductile or elastic material (above or equal T_g).

[SOURCE: EN ISO 472:2013, 2.441, modified— Symbol “T_g” added, NOTE 2 to entry added]

3.7

hardness

property of a material involving resistance to indentation, deformation, and/or abrasion

Note 1 to entry: It is measured as yield strength, work hardening, true tensile strength, modulus of elasticity, and other material characteristics.

3.8

high-temperature hydrogen attack (HTHA)

damage mechanism which results from exposure of steels to hydrogen gas at elevated temperatures and pressures; dissociated hydrogen atoms react with carbon and carbides in the steel to form CH₄

3.9

hydrogen

colourless, odourless, tasteless, flammable substance that is the simplest chemical element in the periodic table. It is virtually non-existent in its free form on earth and requires energy to liberate it from the material forms in which it is found. Hydrogen can be produced either by electrolysis of water, or by a chemical process

3.10**hydrogen applications**

wide range of industrial processes handling hydrogen in the physical state gaseous or liquified and gas mixtures with H₂ in various concentrations

3.11**hydrogen compatibility**

ability of a material to exhibit and maintain reliable mechanical integrity and low probability of failure, or leakage, in hydrogen applications within accepted risk parameters

Note 1 to entry: Hydrogen compatibility is a function of material susceptibility, application, applied stress and environment.

3.12**hydrogen environmental embrittlement (HEE) / hydrogen induced cracking (HIC)**

loss in strength, ductility, and/or fracture toughness of susceptible materials due to the penetration and diffusion of atomic hydrogen resulting from gaseous environment that can lead to brittle cracking

3.13**hydrogen partial pressure**

total operating pressure multiplied by mol.- % or vol.- % of hydrogen

3.14**liquid hydrogen**

hydrogen that has been liquefied, i.e. brought to a liquid state

[SOURCE: ISO 14687:2019, 3.1.15]

3.15**permeability**

rate of transmission of a pressurized gas through a material

3.16**permeation**

flow of a media through another (usually solid) material by diffusion without a defect or opening of the latter

Note 1 to entry: To be distinguished from leak flow which is not based on diffusion

3.17**rapid gas decompression****RGD**

Depressurization or explosive decompression

Rapid pressure-drop in a high pressure gas-containing system which disrupts the equilibrium between external gas pressure and the concentration of gas dissolved inside any polymer, with the result that excess gas tries to escape from the solution at points throughout the material, causing expansion

Note 1 to entry: If large enough, and if the pressure drop rate is faster than the natural gas diffusion rate, blistering or rupturing can occur

[SOURCE: ISO 23936-2:2011, 3.1.10, modified — NOTE 1 to entry added]

3.18

sour gas

gas containing significant amount of acid gases such as carbon dioxide and sulphur compounds

Note 1 to entry: Sour gas is failing the qualification as pipeline quality natural gas due to the inclusion of undesirable components such as hydrogen sulfide (H₂S) or carbon dioxide in significantly greater amounts than those quoted for pipeline quality natural gas.

[SOURCE: EN ISO 14532:2017, 2.1.1.8, modified — NOTES to entry removed and new NOTE 1 to entry added]

3.19

trim

functional components of a valve excluding the shell components which are in contact with the fluid inside the valve

Note 1 to entry: The components are specified in the relevant product standards. Annex B, Table B.1 provides an overview

Note 1 to entry: Metallic trim components are categorized into two subgroups, based on the requirement that the component is under an applied stress for the effect of hydrogen degradation of metallic materials to occur:

- loaded: trim components that are under tension or torsion, that is either constant or cyclic;
- other: all other trim components, either with no applied load or in compression.

The valve manufacturer determines which trim components are loaded or not

[SOURCE: EN 736-2:2016, 3.2, modified — NOTE 1 and NOTE 2 to entry added]

3.20

wetted sub-components

components fitted inside a valve exposed to or in direct contact with the medium, that do not fall under the definition of trim nor shell

Note 1 to entry: Components that are neither pressure-bearing nor pressure-retaining components

Note 2 to entry: In the absence of standard requirements or unless otherwise agreed, the sub-components are to be specified by the manufacturer

4 General

This document does not claim to define or restrict hydrogen applications as intended use in detail. It considers hydrogen use applications as wide range of industrial processes handling hydrogen.

In the sense of an intended use, awareness should be given to the applicability of the specifications in this document with regard to the selection of material, specific design considerations, specific manufacturing processes and final assessment (testing and inspection).

Furthermore, the requirements of EN 16668 and, in addition, those of the respective application standard as well as the relevant harmonized European valve standards listed in Annex A are considered.

The performance and life of valves that are exposed to hydrogen for long periods may be i.a. limited by material characteristics that increase the susceptibility of metals to absorption and permeation of hydrogen. To achieve an optimum between design life and service life of hydrogen-exposed valve components, a careful analysis of operating conditions, proper selection of material, suitable valve design

and effective quality control during all stages of engineering, processing and manufacturing are therefore recommended. Proper maintenance and care are further factors to consider.

Material groups used in this document are according to CEN ISO/TR 15608, EN 12516-1:2014+A1:2018, Annex B, and EN 1092-1:2018 (Annex B).

NOTE Further information on material groups and corresponding materials are provided in CEN ISO/TR 20172:2021.

5 Hydrogen service (damage mechanisms)

5.1 Metallic materials

Table 1 summarizes the services considered in this document. It contains damage mechanisms caused by hydrogen (HEE, HTHA) or applications in combination with hydrogen which require additional measures.

NOTE In Table 1 the temperature of 170 °C as lower limit of HTHA considers a safety margin of 30 °C.

Table 1 — Summary of services

Service/damage mechanism	Hydrogen in low temperature application	Hydrogen Environmental Embrittlement (HEE) ^a	High Temperature Hydrogen Attack (HTHA)	Hydrogen service with cyclic loads ^b (fatigue)
Temperature	$-253\text{ °C} \leq TS < -150\text{ °C}$	$-150\text{ °C} \leq TS < 170\text{ °C}$	$TS \geq 170\text{ °C}$	all
Hydrogen partial pressure	All pressures	$p(\text{H}_2) > 1\text{ bar}$	$p(\text{H}_2) > 3,5\text{ bar}$	$p(\text{H}_2) > 1\text{ bar}$
^a HE E typically occurs up to a temperature of 150 °C. The temperature of 170 °C is specified to close the gap between HE E and HTHA.				
^b in accordance with EN 13480-3, Clause 10, resp. in accordance with EN 13445-3:2021, Clause 17 and 18				

5.2 Non-metallic materials

Non-metallic materials exhibit varying behaviour in the presence of hydrogen. The damaging mechanisms in the presence of hydrogen are different from those for metallic materials.

Some general information has been included in Annex B.

6 General information on material selection for each hydrogen service (damage mechanism)

6.1 Hydrogen in low temperature applications

The proneness to brittle fracture of the selected materials shall be considered for the respective application.

For multiple process operation modes (e.g. H₂ purging, cool-down, warm-up...), other requirements linked to HE E, HTHA damage mechanism that may apply shall be considered.

NOTE Hydrogen plants to low temperature covered by EN 13445, EN 13480, Annex B method 2 are in safe operation for years. The influence of hydrogen to the transition temperature is investigated in separate scientific project.

Unless there is any other information available, a limitation to minus 40 °C (NL1) and to minus 50 °C (NL2) is considered sound engineering practice.

6.2 Hydrogen Environmental Embrittlement (HEE)

6.2.1 General

Materials shall be selected for industrial valves intended for hydrogen applications.

In the following clauses, materials according to harmonized European material standards are considered.

6.2.2 Ferritic steels except austenitic ferritic stainless steels

Here are listed the main metallic materials:

a) Materials of group 1.1, 1.2 (3E0, 7E0) and 1.2 (3E1, 8E2, 8E3):

- The nominal minimum yield strength shall be less than or equal to 360 MPa with a nominal minimum tensile strength less than or equal to 620 MPa as defined within the applicable material standard.
- Materials of group 1.1, 1.2 (3E0, 7E0) and 1.2 (3E1, 8E2, 8E3) are suitable for hydrogen applications.

NOTE 1 Values for yield strength or tensile strength are nominal values as per material standard at room temperature

b) Materials of group 5.1 (5E0), 5.2 (6E0) and 9.1 (7E2, 7E3): Materials belonging to these groups are suitable for hydrogen applications.

c) Material of group 6.3 (-) 20CrMoV13-5-5 (1.7779): Materials belonging to this group are slightly susceptible to hydrogen embrittlement under certain conditions. A case-by-case verification is therefore considered appropriate.

NOTE 2 More information can be found in Annex B, Table B.2.

d) Material of group 9.2 (7E3) 12Ni14 (1.5637, 1.5638) only 12Ni14 may be considered, provided the application temperatures do not exceed 50°C and no welding takes place on the parent material.

NOTE 3 The advice can also be found in Annex B, Table B.2.

6.2.3 Austenitic stainless steels

Materials of group 8.1 (11E0, 12E0, 13E0, 13E1, 14E0, 15E0) and 8.2 (13E0) are suitable for hydrogen applications.

All materials of group 8.1 and 8.2 shall satisfactorily pass intergranular corrosion test (ICC) according to EN ISO 3651-2:1998, Method A.

NOTE The intergranular corrosion test might be replaced by other methods to demonstrate a proper micro-structure.

6.2.4 Austenitic-ferritic steels

Austenitic-ferritic steels of group 10.1 such as 1.4462 (16E0) are suitable for hydrogen applications if cold forming is below 5 %. During processing, strain-hardening shall be avoided.

6.2.5 Aluminium and aluminium alloys

Aluminium alloys as specified in EN 12516-4+A1 are suitable for hydrogen dry environment applications otherwise additional provisions should be addressed. Aluminium alloy EN AW 6061 is susceptible to hydrogen embrittlement.

6.2.6 Cast irons

Cast irons are generally susceptible to hydrogen embrittlement.

Therefore, the use of cast iron containing lamellar graphite shall be avoided.

Ductile cast iron may be selected based on suitability evaluation if product and application standards provide for it.

6.2.7 Steel casting

Steel castings according to EN 10213+A1 are suitable for hydrogen applications, whereby the above-mentioned requirements for the corresponding material groups shall be considered.

Due to the nature of casting a higher porosity can be expected. Adverse effects of porosity (e.g. leakage) need to be considered. A sound casting design is crucial to enable foundries to achieve a high and reproducible casting quality, especially around large changes in thickness. Castings shall not be peened, plugged or impregnated.

NOTE Good manufacturing practice on casting quality and NDT can be found in EN 16668:2025, Annex E.

6.2.8 Copper and its alloys

Copper (material group 31 according to CEN ISO/TR 15608), and its alloys (material group 32-38 according to CEN ISO/TR 15608) can be embrittled in hydrogen gas due to a reaction between dissolved hydrogen and oxygen (either in solution or from oxides) to form water, resulting in pores that promote material failure. For this reason, the use of copper and copper alloys shall be limited to oxygen-free grades only.

The oxygen content shall be controlled by the manufacturer so that the material conforms to the hydrogen embrittlement requirements in accordance with EN 1976.

Some copper and its alloys (i.e. bronze, brass) are specified in EN 12516-4+A1.

NOTE More information on copper and its alloys can be found in EIGA IGC Doc 121/14 and ISO/TR 15916.

6.2.9 Nickel, Nickel alloys, Titanium and Titanium alloys

Nickel and nickel alloys (material group 41-48 according to CEN ISO/TR 15608) are generally considered to be susceptible to hydrogen embrittlement. Nickel and Nickel alloys are neither covered by EN 12516-1+A1 nor EN 12516-4+A1.

NOTE For nickel and nickel alloys HEE could also occur at temperatures above 170 °C.

Titanium and Titanium alloys (material group 51-54 according to CEN ISO/TR 15608) are susceptible to hydrogen embrittlement. Titanium and Titanium alloys are neither covered by EN 12516-1+A1 nor EN 12516-4+A1.

6.2.10 Zirconium

Zirconium (material group 61 acc. to CEN ISO/TR 15608) are susceptible to hydrogen embrittlement. Zirconium and Zirconium alloys are neither covered by EN 12516-1+A1 nor EN 12516-4+A1.

6.2.11 Other metallic materials

The outlined selection and provisions reflect a somewhat conservative state of experience for avoidance of conventional hydrogen embrittlement within the existing hydrogen producing and processing industry at the time of writing this document.

Materials with higher yield and/or tensile values may be used if experience is available for the particular technical application or if further investigations have been made.

6.3 High temperature hydrogen attack (HTHA)

Austenitic stainless steel is generally not decarburised in hydrogen at any temperature or hydrogen pressure, therefore materials of group 8.1 (10E0, 11E0, 12E0) are suitable.

NOTE When selecting ferritic steels, information provided in API RP 941 is useful to take in consideration.

6.4 Hydrogen service with cyclic loads (fatigue)

6.4.1 General requirements

Fatigue is a material failure mode particular to cyclic loading. Fatigue is arguably the most important failure mechanism in structures subjected to cyclic stress, therefore this failure mechanism is worth to be considered in the design of industrial valves subjected to pressure cycling.

For the assessment of fatigue life EN 12516-2:2014+A1:2021, Clause 12 applies.

The service life shall be specified by the valve manufacturer in the accompanying documentation, i.e. operating instructions.

NOTE Provisions for determining whether cyclic loads are provided in EN 13480-3, Clause 10, respectively in accordance with EN 13445-3:2021, Clauses 17 and 18.

6.4.2 Fatigue in combination with the other hydrogen services (damage mechanisms)

6.4.2.1 Low temperature service

Only austenitic steels, copper alloys and aluminium are considered in this case. As hydrogen has no negative effects in this range of application, the materials mentioned in this document are suitable.

6.4.2.2 Hydrogen environmental embrittlement (HEE)

Shell of welded constructions should be avoided. If welded seams cannot be avoided, the welds shall be designed as full-penetration seams and be designed in areas with low loads. Permanent backing strips shall not be used.

6.4.2.3 High temperature hydrogen attack (HTHA)

Materials shall be selected in accordance with 6.3 considering high temperature embrittlement. The rules for fatigue verification shall be fulfilled as a minimum.

Any additional requirements other than standard requirements should be agreed.

6.5 Non metallic materials

Material behaviour for selection of polymer and elastomer in gaseous hydrogen environment, obtained from scientific literature data, are given in Annex B.

7 Additional specifications

7.1 Design

7.1.1 General

The design requirements of EN 16668 and the relevant harmonized European valve standards listed in Annex A shall apply.

Depend on the application, further design-related requirements, as specified in the application standards, should be considered. Information on some commonly used materials for metallic industrial valves according to EN valve product standards, for use with hydrogen is provided in Annex B.

The design verification for the intended hydrogen use application and for the reasonably foreseeable conditions should be done.

7.1.2 Design temperature

When selecting the materials, the entire temperature range shall be considered, not only those applicable according to Table 1 of this document.

NOTE 1 With regard to austenitic stainless steels and their lowest minimum metal temperature T_M , for additional information are contained in EN 13480-2:2024, Table B.2-11, EN 13445, Table B.2-11.

NOTE 2 Further details related to toughness requirements of materials at cryogenic temperatures can be found in EN ISO 21028-1.

7.1.3 Hydrogen partial pressure

Hydrogen partial pressure, according to 3.12, is total operating pressure multiplied by mol. - % or vol. - % of hydrogen. The limit value of partial pressure for each damage mechanisms is specified in Table 1.

7.1.4 Tightness aspects

Positive sealing of packing glands is important in hydrogen service. It is therefore vital that aspects affecting tightness shall be considered. The operating frequency and wear as well as material ageing of sealing materials have an influence on the service life of the sealing device and therefore ultimately on the tightness of a valve.

Any foreseeable internal or external leakages (i.e. leakages into the atmosphere/environment) that could pose a hazard due to pressure shall be identified as part of the analyses of hazards and risks.

Sealing devices shall be selected that provide long-term tightness.

NOTE The term “fugitive emissions” covers all losses of (usually volatile) substances due to unforeseen or unintentional leaks.

Requirements for testing and maintenance of the sealing systems shall be specified in the accompanying documentation, i.e. operating instructions.

The use of live loaded (energised) packing system is a preferred technique for fugitive emissions control.

Bellow seals shall not be used as the sole sealing element against atmosphere.

The tightness and additional testing are given in Annex C.

7.2 Materials

7.2.1 General

A valve consists of various components which are made of different metallic and non-metallic materials. Each material that is used (for example, seats, seals, adhesives, lubricants, electrical insulation, springs, bolts, and piping) shall be evaluated for its use in the design and foreseeable operating conditions to which it is exposed.

Shell parts (pressure-bearing parts), within this document, are always made of metallic materials. Internals can be made of both metallic and non-metallic materials.

A material should be evaluated carefully before it is used for hydrogen use application. The provisions in this document focus on the main topic of avoiding damage caused by physically induced hydrogen cracking (hydrogen embrittlement). Hydrogen embrittlement is counteracted by suitable design and selection of materials. Materials that have been used successfully with hydrogen should be preferred over materials with little or no history of use with hydrogen.

For components of valves that are continuously exposed to hydrogen or may become exposed in case of failure of seals, only materials suitable for hydrogen applications shall be selected.

Information on materials are provided in Annex B.

Where the behaviour of a material can be affected by manufacturing processes or operating conditions, to an extent that would adversely affect the safety or service life of the metallic industrial valve, this shall be taken into consideration when specifying material.

Adverse effects may arise from:

- manufacturing processes: e.g. degree of cold forming and heat treatment, reticulation or crystallization degree, for thermoset and elastomer, or thermoplastics;
- operating conditions: e.g. hydrogen embrittlement, RGD.

When selecting materials and manufacturing methods the following subjects shall be considered:

- degradation effects of hydrogen on the mechanical performance of a material;
- material's corrosion and wear resistance;
- electrical conductivity;
- impact strength;
- ductile behaviour;
- aging resistance;
- effects of temperature variations;
- effects arising when materials are combined (for example, galvanic corrosion).

NOTE Guidance to account for the degradation effects of hydrogen on the mechanical performance of a material can be found in ISO/TR 15916.

Non-metallic materials shall retain their mechanical stability with respect to strength for the full range of service conditions and design lifetime

7.2.2 Metallic and non metallic materials

7.2.2.1 Metallic materials

EN 16668 contains provisions to be observed when selecting shell materials.

Reference to materials for trim components are provided in the valve product standards.

NOTE EN 16668 provides an informative overview of European harmonized standards for materials for shell parts.

7.2.2.2 Non metallic materials

In the selection of non-metallic materials, application standards and harmonized European valve standards apply.

Hydrogen effect on non-metallic materials should be considered, this includes:

- diffusion;
- permeability;
- rapid gas decompression (RGD);
- low/elevated temperatures;
- thermal cycling;
- chemical compatibility;
- stress cracking;
- effects of tribology on H₂-emissions (tightness).

7.2.2.3 Fasteners

Hydrogen embrittlement properties shall be considered where appropriate.

7.2.2.4 Springs

Springs providing the sealing and/or closing force for any closure member shall be made of corrosion-resistant materials and shall be designed considering static and dynamic loads that are expected. Information in this regard are contained in EN 13906-1 and EN 13906-2.

7.2.2.5 Non-pressure parts and weld attachments

For non-pressure parts and weld attachments on shell components such as lifting lugs, trunnions and similar parts, materials are to be used that are supplied according to material specifications covering at least requirements for the chemical composition and the tensile properties. These materials shall not limit the operating conditions of the material to which they are attached.

7.2.3 Delivery conditions of finished valve components

The finished valve components from which a valve is comprised shall be cleaned to remove all scale and processing compounds prior to the final surface examination. The cleaning process shall not injure the surface finish, material properties, or the metallurgical structure. The surface finish shall allow the detection of imperfections that can be disclosed by visual inspection. Selected typical surface discontinuities shall be explored for depth.

The following imperfections shall be removed by means of a mechanical surface finishing, like smooth grinding:

- surface imperfections such as cracks, lamination, tears and notches;
- mechanical marks, abrasions, and pits;
- visual imperfections commonly referred to as scabs, seams, laps, tears, or slivers found by exploration to be deeper than 5 % of the nominal wall thickness.

The components surface in contact with hydrogen environment shall be free from:

- corrosion;
- contamination (e.g. carbon deposits);
- injurious imperfections that can be detected by visual inspection.

7.3 Manufacture

7.3.1 Welding

Welding related requirements as outlined in EN 16668 shall apply. When there is no application standard requirement, the additional welding recommendations for welding of metallic materials of EN 1011 series shall be considered.

NOTE 1 For additional information about welding of steel, see CEN/TR 17797:2022, 5.2.2.3.

Filler materials shall match the chemical analysis and the mechanical properties of the base material.

In order to reduce the diffusible hydrogen in weld metal of martensitic, bainitic and ferritic steel, which is generated during welding of these steels (parent/ base materials) using arc welding processes with filler metal, only low hydrogen contents type electrodes shall be used.

When diffusible hydrogen removal treatment is specified by the manufacturer, it shall be carried out in accordance with EN ISO 15792-1.

NOTE 2 For additional information about diffusible hydrogen, see EN ISO 2560:2020, Annex D (informative).

All pressure bearing welds shall be in accordance with EN 1708-1 and shall be welded full penetration, unless another weld design is qualified for the specific application.

The use of socket welds is not permitted unless this weld design is allowed for the specific application and the size is limited to DN 25. This document is not providing any details on fabrication and/ or testing of such welds.

Dissimilar pressure bearing welds are not permitted.

Welds between material groups 9 and 8 are not permitted.

Austenitic stainless steel and nickel alloy filler material shall not be used for welding of material group 9, unless the suitability is demonstrated for this specific application.

Intermittent pressure bearing welds are not permitted.

Welding work or cold forming operations after final heat treatment of the shell parts shall not be carried out.

Welding on stems and shafts in the sections that are in contact with the medium is not permitted.

7.3.2 Welding consumables

Technical delivery conditions for welding consumables used of pressure parts and attachments to pressure parts shall be in accordance with EN 13479 and EN 12074.

7.3.3 Cold forming

Cold forming without subsequent heat treatment of austenitic stainless steels may be used if experience is available for the intended application or if further investigations have been made.

7.3.4 Strain hardening

For applications in the range of HEE, where strain hardening is applied to enhance mechanical properties of austenitic stainless steels, the suitability for hydrogen application shall be demonstrated with mechanical test at the lowest operating temperature lower than $-50\text{ }^{\circ}\text{C}$.

7.3.5 Hardness

For welded constructions of valve shells/components made of materials of group 1.1, 1.2, 5.1, 5.2 and 9.1 in particular, the manufacturer is expected to spot-check on the production welds that the hardness values measured do not exceed the values recorded as part of the qualification of welding procedures.

7.3.6 Mechanical properties of welds

Welding processes and operators' qualification shall verify that weld sample meet the same strength and toughness requirement as the parent metal.

7.4 Final assessment

Each valve shall be finally assessed (inspected and tested) by the manufacturer prior to despatch in accordance with the requirements of EN 16668, the relevant harmonized European valve standards, and the relevant application standards, as applicable.

Additional requirements for testing specified in Annex C shall apply.

7.5 Marking

With regard to additional markings, the requirements specified in Annex C shall apply.