INTERNATIONAL STANDARD

ISO 13984

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Liquid hydrogen — Land vehicle fuelling system interface

Hydrogène liquide — Interface des systèmes de remplissage pour véhicules terrestres

Contents

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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 the member bodies casting a vote.

International Standard ISO 13984 was prepared by Technical Committee ISO/TC 197, *Hydrogen technologies.*

Introduction

The fuelling system interface described in this International Standard is intended to be used in conjunction with fuel tanks constructed in accordance with ISO 13985.

NOTE Pursuant to the agreement reached during the sixth plenary meeting of ISO/TC 197, the basic allowable stresses shown in Table 1 of this International Standard have been changed.

Liquid hydrogen — Land vehicle fuelling system interface

1 Scope

This International Standard specifies the characteristics of liquid hydrogen refuelling and dispensing systems on land vehicles of all types in order to reduce the risk of fire and explosion during the refuelling procedure and thus to provide a reasonable level of protection from loss of life and property.

This International Standard is applicable to the design and installation of liquid hydrogen (LH_2) fuelling and dispensing systems. It describes the system intended for the dispensing of liquid hydrogen to a vehicle, including that portion of the system that handles cold gaseous hydrogen coming from the vehicle tank, that is, the system located between the land vehicle and the storage tank.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 1106-3:1984, *Recommended practice for radiographic examination of fusion welded joints — Part 3: Fusion welded circumferential joints in steel pipes of up to 50 mm wall thickness.*

ISO 1182:—[1)], *Reaction to fire tests for building products — Non-combustibility test.*

ISO 9303:1989, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Full peripheral ultrasonic testing for the detection of longitudinal imperfections.*

ISO 10286:1996, *Gas cylinders — Terminology.*

ISO 11484:1994, *Steel tubes for pressure purposes — Qualification and certification of non-destructive testing (NDT) personnel.*

ISO 12095:1994, *Seamless and welded steel tubes for pressure purposes — Liquid penetrant testing.*

ISO 13663:1995, *Welded steel tubes for pressure purposes — Ultrasonic testing of the area adjacent to the weld seam for the detection of laminar imperfections.*

ISO 13664:1997, *Seamless and welded steel tubes for pressure purposes — Magnetic particle inspection of the tube ends for the detection of laminar imperfections.*

ISO 13665:1997, *Seamless and welded steel tubes for pressure purposes — Magnetic particle inspection of the tube body for the detection of surface imperfections.*

[1)] To be published. (Revision of ISO 1182:1990)

ASTM A240/A240M-97a, *Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.*

3 Terms and definitions

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

3.1
design pressure
pressure used in the formula for the calculation of the minimum wall thickness for each component in the piping system

NOTE The design pressure should be not less than the pressure at the most severe condition of coincident internal or external pressure and temperature (minimum or maximum) expected during service.

3.2
fuel tank
liquid hydrogen reservoir, installed on a vehicle, with appurtenances for connecting to a refuelling station

3.3
inspector
qualified person employed by a recognized independent national or international agency

3.4
liquid hydrogen
LH_2
hydrogen that has been liquefied, i.e. brought to a liquid state

NOTE Liquefaction may be achieved by chilling and compression or other means, such as the magnetocaloric effect.

3.5
maximum permissible operating pressure
MPOP
maximum effective gauge pressure allowable in the piping system in its operating condition

3.6
noncombustible material
material that does not ignite, burn, support combustion or release flammable vapours when subjected to fire or heat in accordance with ISO 1182

3.7
operating pressure
gauge pressure at which the piping system operates

NOTE Operating pressure should not exceed the maximum permissible operating pressure.

3.8
service temperature range
temperature ranging from that of liquid hydrogen (– 253 °C) to an assumed ambient temperature of 54 °C

3.9
storage tank
liquid hydrogen reservoir, located at the refuelling station, to supply the land vehicle with liquid hydrogen

4 Requirements

4.1 Applicability

The provisions of this clause apply only to system components which handle liquid hydrogen and cold gaseous hydrogen.

4.2 Refuelling system

4.2.1 Compatibility with hydrogen and cold temperatures

All components of the refuelling system which come in contact with liquid hydrogen and cold gaseous hydrogen shall be compatible with and suitable for liquid hydrogen service and cold gas flows such as those associated with the handling of cold gaseous hydrogen returning from the vehicle fuel tank.

Consideration shall be given to the thermal expansion and contraction of piping systems when exposed to the temperature fluctuations over the service temperature range. Consideration shall be given to the possible condensation of air.

4.2.2 Material specifications

Material used in the manufacture of piping for liquid hydrogen service shall be austenitic stainless steel, or any other material provided it is proven to be equivalent in performance.

4.2.3 Piping

4.2.3.1 Design

Piping, valves, fittings, gaskets and sealants shall be suitable for hydrogen service at the temperatures and pressures involved.

Permanent joints in piping shall be made by welding or brazing; flanged, threaded or screwed joints shall not be used. Compression fittings may be used only to connect instrumentation and pressure-relief devices to the gas lines. The materials used in valves and fittings shall be suitable for liquid hydrogen service over the service temperature range. Bayonet joints shall be used for transfer operations of liquid hydrogen.

The bursting strength of all pipes, valves, fittings and hoses shall be at least four times the design pressure of the storage tank and not less than four times the pressure to which they shall be subjected in normal service by the action of a pump or other device, the action of which shall subject portions of the piping to pressures greater than the storage tank's design pressure.

Each valve shall be designed and constructed for a rated pressure and service temperature not less than those used as the design values for the storage tank or the section of piping containing the valve, whichever set of values is higher. Each valve shall be compatible with liquid hydrogen or cold hydrogen gas service.

Means shall be provided to minimize exposure of personnel to piping and to prevent air condensate from contacting piping, structural members and surfaces not suitable for oxygen enrichment or cryogenic temperatures. During an emergency when exposed to fire, heat, cold or water as applicable, insulation shall maintain any system properties that are required by design. It shall be designed to have a vapour-tight seal in the outer covering to prevent the condensation of air and subsequent oxygen enrichment within the insulation. The insulation material and outer covering shall also be of adequate design to prevent attrition of the insulation due to normal operating conditions.

4.2.3.2 Thickness requirements

The required thickness of straight sections of pipe shall be determined in accordance with equation (1):

$$t_m = t + c \tag{1}$$

where

t_m is the nominal thickness, including mechanical, corrosion and erosion allowances, in millimetres;

t is the pressure design thickness, as calculated from equation (2), in millimetres;

c is the sum of the mechanical allowances (thread or groove depth) plus corrosion and erosion allowances, in millimetres.

The pressure design thickness t shall be calculated using equation (2):

$$t = \frac{PD_o}{2\,(S \cdot E + P \cdot Y)} \qquad (2)$$

where

P is the internal design gauge pressure, plus vacuum, if vacuum-insulated, in megapascals;

D_o is the outside diameter of pipe, in millimetres;

S is the basic allowable stress value for material from Table 1, in megapascals;

Y is a coefficient equal to 0,4 for austenitic steels;

E is the quality factor, which for stainless steel and seamless tubes is 1,0.

Table 1 — Basic allowable stresses (S) in tension for austenitic stainless steel tubes and pipes

Dimensions in megapascals

Designation	Specified minimum tensile strength	Specified minimum yield strength	Maximum basic allowable stress S at minimum temperature (2/3 of the yield strength)
ASTM A 240, type 304	517	207	138
ASTM A 240, type 304 L	482	172	115
ASTM A 240, type 316	517	207	138
ASTM A 240, type 316 L	482	172	115

4.2.3.3 Cyclic effects

4.2.3.31 Cyclic loadings

Piping and components shall be designed to accommodate the effects of metal fatigue resulting from the thermal cycling to which the system will be subjected. Particular consideration shall be given where changes in wall thickness occur between pipes, fittings, valves, components, and at areas of anchoring.

Cyclic design conditions shall include coincident pressure, temperature, imposed end-displacements and thermal expansion of the joint itself, for cycles during operation. Cycles due to transient conditions (startup, shutdown and abnormal operation) shall be stated separately.

4.2.3.3.2 Limits of calculated stress due to sustained loads and displacement strains

4.2.3.3.2.1 Internal pressure stresses

Stresses due to internal pressure shall be considered safe when the wall thickness of the piping component, including any reinforcements, meets the requirements of 4.2.3.2.

4.2.3.3.2.2 Longitudinal stresses S_L

The sum of longitudinal stresses S_L in any component in a piping system, due to pressure, weight and other sustained loadings, shall not exceed S_h in equation (4).

The thickness t of the pipe used in calculating the stress value S_L shall be the nominal thickness t_m minus mechanical corrosion and erosion allowance c [from equation (1)].

4.2.3.32.3 Computed displacement stress range S_E

The computed displacement stress range S_E in a piping system, given by equation (3), shall not exceed the allowable displacement stress S_A calculated by equation (4):

$$S_E = \sqrt{S_b{}^2 + 4\,S_t{}^2} \tag{3}$$

where

S_b is the resultant bending stress, in megapascals;

S_t is the torsional stress, in megapascals.

4.2.3.3.2.4 Allowable displacement stress range S_A

$$S_A = f(1{,}25\,S_c + 0{,}25\,S_h) \tag{4}$$

where

S_A is the allowable displacement stress, in megapascals;

S_c is the basic allowable stress at minimum metal temperature expected during the displacement cycle under analysis, in megapascals;

S_h is the basic allowable stress at maximum metal temperature expected during the displacement cycle under analysis, in megapascals.

When S_h is greater than S_L, the difference between them may be added to the term 0,25 S_h in equation (4). In this case, the allowable displacement stress is calculated by equation (5):

$$S_A = f[1{,}25\,(S_c + S_h) - S_L] \tag{5}$$

where

S_L is the sum of longitudinal stresses in any component in the piping system due to pressure, weight and other sustained loadings, in megapascals;

f is the stress range reduction factor from Table 2 or calculated by equation (6):

$$f = 6{,}0\,[N]^{-0{,}2} \leqslant 1 \tag{6}$$

where

N is the equivalent number of full displacement cycles during the expected service life of the piping system;

S_b is the resultant bending stress, in megapascals;

S_t is the torsional stress, in megapascals.