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Installation and equipment for liquefied natural gas — Design and testing of marine transfer systems —

Part 2:
Design and testing of transfer hoses

Installations et équipements de gaz naturel liquéfié — Conception et essais des systèmes de transfert marins —

Partie 2: Conception et essais des flexibles de transfert

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Foreword

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This document was prepared by the European Committee for Standardization (CEN) (as EN 1474-2:2020+AC:2023) and drafted in accordance with its editorial rules. It was assigned to Technical Committee ISO/TC 67, *Oil and gas industries including lower carbon energy*, Subcommittee SC 9, *Production, transport and storage facilities for cryogenic liquefied gases* and adopted without modification.

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.

Installation and equipment for liquefied natural gas — Design and testing of marine transfer systems —

Part 2: Design and testing of transfer hoses

1 Scope

This document gives general guidelines for the design, material selection, qualification, certification, and testing details of hose assemblies for Liquefied Natural Gas (LNG) marine transfer applications.

The transfer hose assemblies are part of transfer systems (it means that they may be fitted with ERS, QCDC, handling systems, hydraulic and electric components etc.) To avoid unnecessary repetition, cross-references to EN ISO 16904 and EN 1474-3 are made for all compatible items, and for references, definitions and abbreviations. Where additional references, definitions and abbreviations are required specifically for LNG hose assemblies, they are listed in this document.

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 1474-1:2008, *Installation and equipment for liquefied natural gas — Design and testing of marine transfer systems — Part 1: Design and testing of transfer arms*

EN 1474-3:2008, *Installation and equipment for liquefied natural gas - Design and testing of marine transfer systems - Part 3: Offshore transfer systems*

EN ISO 7369:2004, *Pipework - Metal hoses and hose assemblies - Vocabulary (ISO 7369:2004)*

EN ISO 8330:2014, *Rubber and plastics hoses and hose assemblies - Vocabulary (ISO 8330:2014)*

EN ISO 10012:2003, *Measurement management systems - Requirements for measurement processes and measuring equipment (ISO 10012:2003)*

EN ISO 10619-1:2018, *Rubber and plastics hoses and tubing - Measurement of flexibility and stiffness - Part 1: Bending tests at ambient temperature (ISO 10619-1:2017)*

EN ISO 16904:2016, *Petroleum and natural gas industries - Design and testing of LNG marine transfer arms for conventional onshore terminals (ISO 16904:2016)*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 7369:2004 and EN ISO 8330:2014 and the following apply.

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

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

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

3.1.1
annular space
space between the inner fluid carrying layer and a second layer which can be used for insulation and/or safety purposes

3.1.2
armour layer
either a braid made of wires (see braid) or strips of metal or plastic used to provide pressure strength and/or external protection

3.1.3
axial stiffness
extent to which a hose assembly resists tensile deformation in response to an applied axial force

3.1.4
bend stiffness
ability of a flexible pipe to resist deflection when subjected to bending loads at constant tension, pressure and temperature

3.1.5
bend restrictor
device for limiting the bend radius by mechanical means

Note 1 to entry: A bend restrictor typically comprises a series of interlocking metallic or moulded rings, applied over the outer surface.

3.1.6
bending stiffener
ancillary conical shaped component, which locally supports the pipe to limit bending stresses and curvature of the pipe to acceptance levels

Note 1 to entry: Bend stiffeners may be either attached to an end fitting or a support structure where the flexible pipe passes through the bend stiffener.

3.1.7
boil-off gas
BOG
natural evaporation from liquefied natural gas due to vaporization

3.1.8
burst test
test conducted on a hose sample until it failed by internal pressurization

3.1.9
buoyancy
degree, to which the hose assembly has buoyancy capabilities calculated according to 7.3.2.6

3.1.10
connector
part of the end fitting used to provide a leak-tight structural connection between the end fitting and adjacent piping

3.1.11
crush test
application of a vertical load through a beam placed laterally across the hose assembly

3.1.12
double-envelope
layer or set of layers effecting the enclosure, and thus the isolation from the environment, of those structures, systems and components whose failure can lead to an unacceptable release of LNG

3.1.13
dynamic load
loads to flexible hose assembly or hose assembly configuration which vary in time, or whose deflections or boundary conditions vary in time, while hose is connected

3.1.14
emergency release system
ERS
system that provides a positive means of quick release of transfer system and safe isolation of LNG carrier and transfer system

Note 1 to entry: The ERS consists of an emergency release coupling (ERC) and interlocked isolating valves which automatically close on both sides, thereby containing the LNG or vapour in the lines (dry disconnect), and, if applicable, associated control system.

3.1.15
end termination
mechanical device which forms the transition between the flexible pipe body and the connector whose different pipe layers are terminated in the end fitting in such a way as to transfer the load between the flexible hose assembly and the connector

3.1.16
end fitting
assembly of connector and end termination

3.1.17
emergency release coupler
ERC
device to provide a means of quick release of the transfer system when such actions is required only as an emergency measure

3.1.18
fatigue life
number of cycles of a specified character that a given specimen sustains before failure of a specified nature occurs

3.1.19
hose assembly
hose and its fittings

3.1.20
impact test
test for determining the impact strength of a material

3.1.21
leak detection system
system able to detect a failure / leak from the fluid carrying part of the hose assembly

3.1.22
liquefied natural gas
LNG
natural gas that has been cooled and condensed into liquid form

3.1.23
maximum allowable impact energy
MAIE
maximum impact energy which can be applied to the hose assembly without bringing permanent damage to the hose assembly structure and performances

3.1.24
maximum allowable crush load
MACL
maximum allowable crush load which can be applied to the hose assembly without bringing permanent damage to the hose assembly structure and performances

3.1.25
maximum allowable working pressure
MAWP
maximum pressure (gauge) across the entire specified temperature range to which the hose may be exposed and operated

Note 1 to entry: It is commonly used by terminals to define their cargo system pressure capabilities (i.e. pump shut-in plus any static head or cargo system safety valve relief setting.

Note 2 to entry: This pressure rating is not expected to account for dynamic surge pressures, but does include nominal pressure variations during cargo transfer operations).

3.1.26
maximum working load
MWL
maximum allowable tensile force of the hose assembly in axial direction, applied to the end-fittings

3.1.27
minimum Bend Radius
MBR
minimum radius at which the hose assembly is designed to operate

3.1.28
non-destructive test
ND
test that is not expected to cause permanent damage to the hose assembly, so that the hose assembly can be used in subsequent tests and for operation as well

3.1.29
owner
business entity who has the legal or rightful title to the asset intended for LNG transfer

3.1.30
proof pressure
pressure to which the hose assembly is tested (i.e. during a Factory Acceptance Test) to demonstrate its structural integrity when subject to internal pressure

Note 1 to entry: According to the IMO IGC Code this pressure test at ambient temperature shall be not less than 1,5 x MAWP and not more than two-fifths of its burst pressure.

3.1.31
pumping port
connection to attach a vacuum pump for vacuum insulated hose assemblies

3.1.32
quick connect disconnect coupler
QCDC
manual or hydraulic mechanical device used to connect a transfer arm or hose to the cargo manifold without employing bolts

3.1.33
service life
period of time during which the hose assembly fulfils all performance requirements for the specified or less severe condition in the same Hose Qualification Category

3.1.34
static load
flexible hose assemblies not exposed to significant cyclically varying loads or deflections during normal operations

3.1.35
storage bend radius
minimum radius at which the hose assembly is designed to be stored or handled. SBR may be lower than MBR

3.1.36
super-insulation
several high reflecting foils to reduce heat transfer via radiation as part of a vacuum insulation system

3.1.37
type approval certificate
certificate issued by an IVA confirming the suitability and appropriate limits on the manufacturer's design methodologies, manufacturing processes and materials

Note 1 to entry: The name of this certificate can differ according to the IVA.

3.1.38
visual inspection
examination of parts and equipment for visible defects in material and workmanship

3.2 Abbreviations

D	internal bore diameter of the hose assembly
FAT	factory acceptance test
FSRU	floating Storage Regasification Unit
HQC	hose qualification category
IVA	Independent verification agency
L	Length of flexible part of the hose assembly
LNGC	liquefied natural gas carrier
MAAT	Maximum allowable applied twist

4 Applications and qualification categories

4.1 Applications

This subclause describes the main application using LNG transfer hose assemblies.

As industry and technology is developing, other type of application may consider using LNG transfer hose assemblies and shall be covered in this standard.

List of applications (not exhaustive):

— Offshore tandem FLNG offloading / loading aerial or floating;

— Ship-To-Ship transfer such as LNGC to FSRU, LNG Bunkering;

— Shore-To-Ship such as LNG bunkering;

— Ship-To-Shore such as offloading / loading.

Based on the application and use of the hose assembly, there are different categories of hose assembly qualification required. Main difference are the dynamic loads on the hose assembly. The following subclause introduces Hose assembly Qualification Categories (HQC).

NOTE Guidelines for the owners regarding applications and relevant HQC are available in Annex C. Selection of HQC remains the owner's responsibility.

4.2 Qualification categories

This subclause establishes criteria for definition of Hose Qualification Categories for the hose assemblies covered by this standard. The Hose Qualification Categories specified below define different design verification requirements as per subclause 7.2.2.

The test scope within all Qualification Categories define the basis for the hose assemblies qualification but are independent of each project specific data (metocean data, waves & current data,). During the design for a project the required HQC should be checked by the owner and / or IVA.

The owner / IVA can require executing additional tests in order to determine if the proposed hose assembly is "Fit for Purpose" (For fatigue test for example, specific attention should be paid on bending loads adjacent to end terminations)

— Hose Qualification Category A

  This HQC is intended to be used for quasi-static applications (i.e. application only driven by handling and/or thermal and pressure fatigue).

  This category is including the performance requirements applicable to all aerial transfer hose assembly, typically transfer hose assemblies used in protected environment for intermittent usage without contact with water and with negligible dynamic motions.

— Hose Qualification Category B

  This HQC is intended to be used for dynamic applications driven by aerial transfer fatigue including significant tensile and bending fatigue loads (e.g. by vessel motions or wind loads).

  This Category is including the performance requirements applicable to all aerial transfer hose assemblies and typically applicable for the hose assemblies used in combination of weather exposed environment and/or permanent usage and used in configurations with contact with floating structures.

— Hose Qualification Category C

  This HQC is intended to be used for dynamic applications for submerged or floating hose assemblies.

  Qualification tests for this category includes representative tests of contact with water such as insulation, water tightness properties and permanent connection potential issues.

The hose assemblies manufacturer shall propose a fatigue assessment methodology, to be applied at project phase, verifying that the hose assembly is fit for purpose for the intended application.

The methodology shall be validated by an IVA.

5 Description of typical LNG transfer hose assembly designs and accessories

5.1 General

This standard is addressing hose assemblies as a flange-to-flange component.

It means that all statements and requirements based on the hose assemblies shall be considered between conveyed fluid tightening surfaces at both ends.

5.2 Mandatory components

An LNG Transfer Hose assembly shall consist of the following:

— flexible part of the hose assembly

— associated end fittings

Hose extremity end fittings can permit the mounting of a QCDC or a spool piece or permit direct connection to LNGC or LNG terminal or another hose assembly.

NOTE A description of QCDC is given in EN ISO 16904:2016, for transfer system reference is made to EN 1474-3:2008.

Hose extremity end fittings can permit the mounting of an emergency release system with valves and ERC (Emergency Release Coupler).

(A description of emergency release system is given in EN ISO 16904:2016 and EN 1474-3:2008).

— permanent identification marks

— hose handling device(s) (pad eye or lifting lugs, lifting collar, ...).

Hose assembly shall include necessary fittings for safe handling, coupling and uncoupling either from the LNGC or the onshore or offshore LNG terminal system as required by the system design according to EN 1474-3:2008.

5.3 Optional components

An LNG Transfer Hose assembly can consist of the following:

— leak detection system

If required by the owner, the hose assembly shall incorporate leak detection system e.

— insulation system (to minimize build-up of external ice)

— intermediate leak barrier(s)

— bending stiffeners or restrictors

— buoyancy

— weight elements

— specific supporting equipment

Hose assembly can support (e.g. piggy back mounted) hydraulic or pneumatic hoses, electric cables for the powering of the ERS and QCDC systems according to EN ISO 16904:2016, Clause 6.

5.4 Typical construction of LNG transfer hose assemblies

5.4.1 Main hose categories

At present LNG transfer hose assemblies are categorized in three types according to their method of construction:

— those based on a reinforced corrugated metal hose construction, hereafter called corrugated metal hose;

— those based on a construction in which polymeric films and fabrics are entrapped between a pair of close wound helical wires, hereafter called composite hose;

— those based on a hose-in-hose construction with annular space and which can derivate from one of the above technologies.

— as the technology develops, other types of hose assemblies can become available and are also to be considered covered by this document.

5.4.2 Corrugated metal hose assemblies

A corrugated metal hose assembly consists of a core layer made of a stainless-steel corrugations, and several other layers, metallic or non-metallic, reinforcing mechanical strength of the flexible part of the hose assembly.

In sequence, starting from the bore, typical construction is as follow:

a) Inner layer, made of stainless-steel corrugations (parallel of helical corrugated sometimes called bellows), parallel or helicoidal construction. Ensures the inner leakproofness of the structure, as well as sustaining the radial pressure.

b) Armours layers, made of steel or textile, supporting the axial loads and reinforcing inner radial pressure resistance.

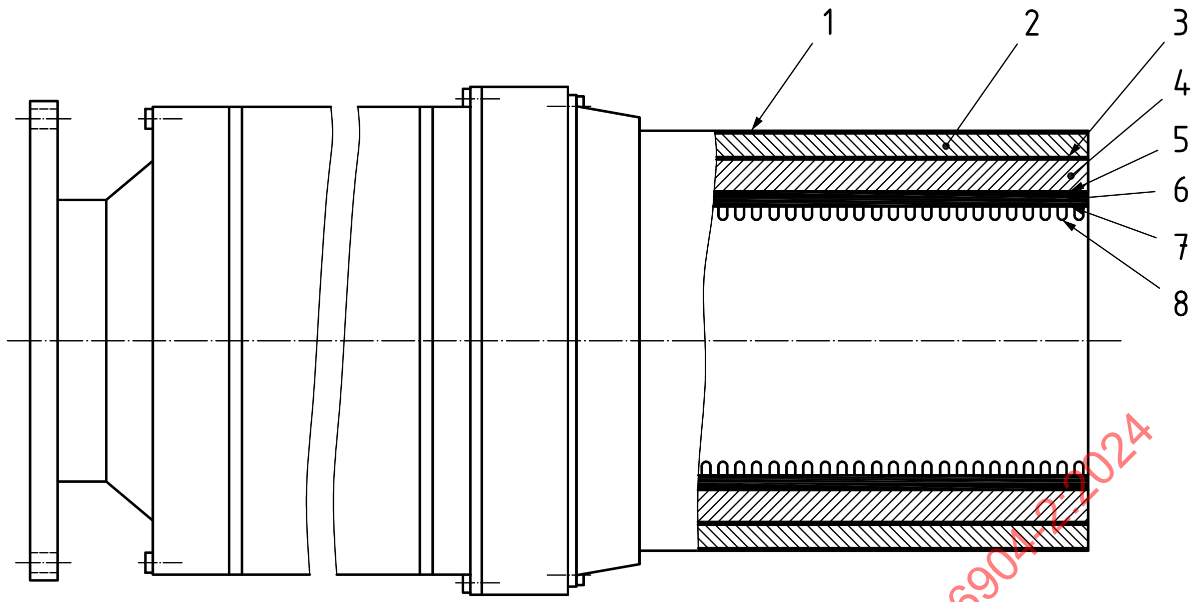
c) Optionally, thermal insulation layers, ensuring that the inner temperature is conserved whilst preventing any build-up of ice on the exterior of the hose assembly.

d) Optionally, Outer layers, protecting the hose assembly from external mechanical damages. These layers might be leak-proof, giving the hose assembly a double envelope (with an annulus between) thus permitting the detection of any leak of LNG as soon as it can occur. In case of a leak in the inner layer, the outer layer can be able to withstand some pressure at some temperature during certain amount of time.

The external layer, if leak-proof, prevents any ingress of water and air from the exterior.

The number, arrangement and sequence of the layers in steps b) to d) is specific to the hose assembly size and application and can vary based on metallic hose assembly technology.

The hose assembly construction shall ensure that all materials are used within their individual range of temperature.

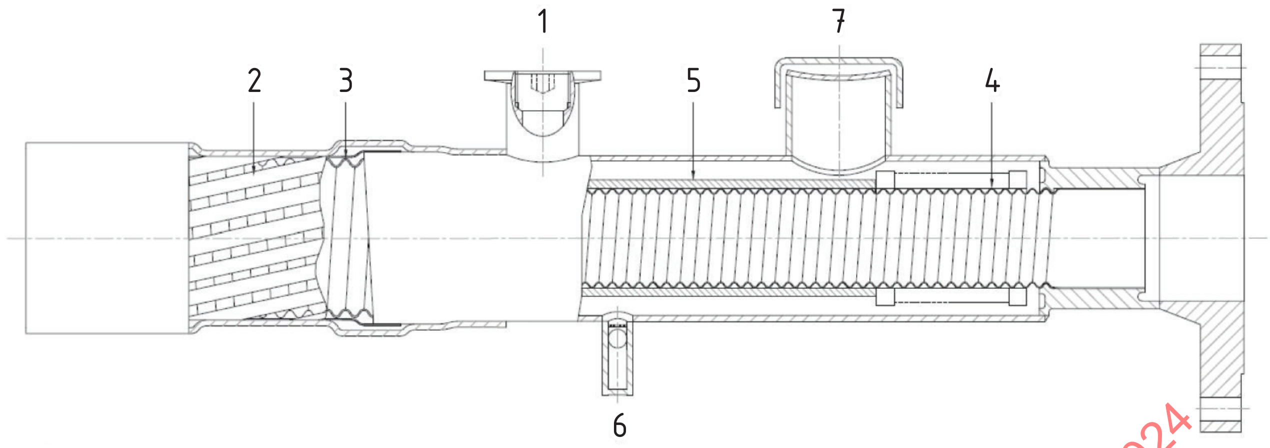


Key

1 leakproof layer
2 insulation
3 leakproof layer
4 insulation
5 supporting layer
6 armouring
7 leakproof layer
8 corrugated inner pipe

Figure 1 — Typical hose assembly - reinforced corrugated metal hose family

Depending on the design, the outer leak proof layer can be a corrugated stainless-steel pipe similar to the inner pipe. In this case the annular gap between inner and outer pipe can be evacuated. The pressure supervision of this annular gap results in a leak detection of inner and outer pipe. The thermal insulation can be maintained by layers of super insulation inside the evacuated annular gap.



Key

1 pumping port
2 armouring
3 corrugated outer pipe
4 corrugated inner pipe
5 vacuum superinsulation
6 vacuum supervision leak detection
7 burst disc

Figure 2 — Typical hose assembly – Sketch of an LNG flexible hose with vacuum insulation option

5.4.3 Thermoplastic multi-layer (non-vulcanized) hose assemblies (Composite hose assemblies)

A composite hose assembly consists of un-bonded, multiple polymeric film and fabric layers bounded between two wire helices which give the flexible part of the hose assembly its shape, one being internal and one being external. Broadly, the film layers provide a fluid-tight barrier to the conveyed product and the fabric layers provide the mechanical strength of the flexible part of the hose assembly. Additional layers for insulation may be added

In sequence, starting from the bore, the construction typically consists of:

a) inner metallic wire helix applied at a pre-determined close pitch;

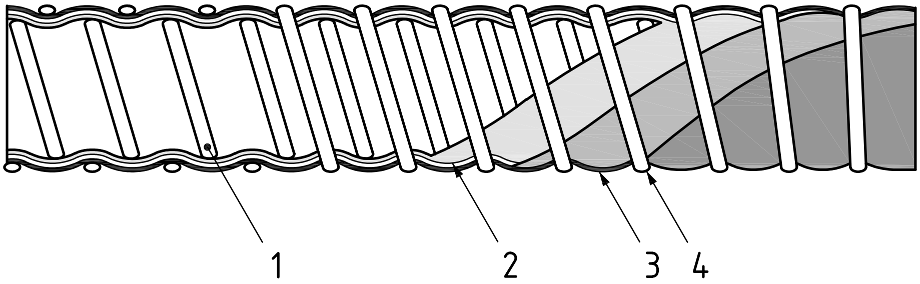
b) polymeric fabric layers forming the bore material;

c) pack of many polymeric film layers. The complete film pack achieves a tubular form and provides the fluid tight barrier to the conveyed product;

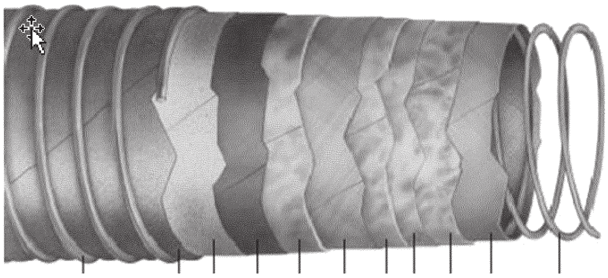
d) pack of many polymeric fabric layers which reinforce the flexible part of the hose assembly;

e) outer metallic wire helix applied at half a pitch offset to the inner wire under tension. This forms the flexible part of the hose assembly into the required convoluted structure.

The number and arrangement of the layers in steps c) and d) is specific to the hose assembly size and application. The polymeric film and fabric materials are selected to be compatible with the conveyed product and the extremes of operating temperature.



a)



b)

Key

1 inner wire

2 film

3 fabric

4 outer wire

Figure 3 — Typical hose assembly – composite hose family

5.4.4 Hose-in-hose with annular space

Hose assembly of this category shall comprise:

— An inner hose, based on composite hose or stainless-steel corrugated hose technologies, able to withstand cryogenic temperatures and MAWP without limit of time.

— An annular space that can ensure one of or all the following functions:

  — Thermal insulation.

    Thermal insulation is achieved by filling the annulus with material of low thermal conductivity, or by vacuuming the annulus, filled with an arrangement of metalized films and spacers (super-insulation).

  — Buoyancy

  — Leak detection

— An outer hose that can ensure one of or all the following functions:

  — Tightness in order to protect the inner hose from the external environment, to prevent from water and air ingress into the annular space.

  — Protection of the inner hose from impacts and crush loads.

  — Protection of the inner hose from excessive loads or bending.

  - Prevention of leakage or spillage in case of loss of primary containment. Proving this feature is not addressed by this standard.

- A leak detection system able to detect a failure of the inner hose

6 Design features of the LNG transfer hoses assemblies

6.1 General

The hose assembly forms part of an overall system for the transfer of LNG – for the requirements which will dictate the exact design of the hose assembly (e.g. static load and dynamic movements, ...) refer to EN 1474-3:2008. The design process and required information is outlined below.

Two design features categories shall be considered:

- Transfer Hose technology design parameters (listed in subclause 6.2)

  These are parameters which are intrinsically related to the product and constitute the minimum requirements to be defined for the certification of the LNG transfer hoses assemblies

- Project Specific Design Parameters (listed in subclause 6.3)

  These are project related parameters that define optional additional requirements to ensure the transfer hose assembly is fit for purpose. These parameters do not impact the certification which is based on Transfer Hose Assembly technology design parameters.

6.2 Transfer hose assembly technology design parameters

Following parameters are directly related to the hose assembly design and technology and shall be established by the manufacturer:

- Hose inner diameter for the flexible part of the hose assembly.
- Connector internal diameter, if different from flexible part of the hose assembly.
- Temperature range.
- Maximum Allowable Velocity - This parameter shall be comprised in a range from 7 to 12 m/s maximum for liquid.
- Maximum Allowable Working Pressure.
- Material compatibility:
  - With conveyed fluid
  - With external environment
- Maximum Allowable Twist.
- Maximum Allowable Axial Load.
- Minimum Bending Radius.
- Storage Bending Radius.
- Maximum allowable impact load for regular service conditions.
- Maximum allowable crush load for regular service conditions.

These parameters shall be mentioned in the Type Approval Certificate.

6.3 Project specific design parameters

6.3.1 Selection of hose assembly length

The overall hose assembly length will be dictated by the system design and shall be sufficient to meet both storage and operational conditions including motion envelopes as defined in EN 1474-3:2008

Depending on the length, system design and type, and other factors such as shipping requirements, the hose assembly shall be either supplied as a continuous length or as a string of discrete sections.

The hose assembly length used in the system shall be such that the motion envelopes as defined in EN 1474-3:2008 are met

Hose assembly length shall take into account the elongation of the hose assembly under pressure and its own weight. This elongation shall be consistent with the transfer system design.

6.3.2 Service life

The required service life shall be agreed between the owner and the manufacturer based on system requirements (see EN 1474-3:2008).

The calculation of the hose assembly service life will take into account the cumulative effects of the number and amplitude of flexure, tensile, pressure and temperature cycles in operation, environmental ageing and the consequences of emergency disconnections and internal pressure surge in service.

The safety ratio between service life, fatigue life and fatigue test duration shall be agreed by the owner and the manufacturer and shall be documented.

6.3.3 Selection of buoyancy and submersion

The transfer system shall be such that the hose assembly is either floating, aerial, or the owner will specify the degree of buoyancy if it is required

If buoyancy or submersion are required, it shall be agreed between the owner and the manufacturer based on system requirements (see EN 1474-3:2008).

6.3.4 Selection of insulation

If required, the hose assembly shall have sufficient insulation to minimize build-up of ice on the exterior of the hose assembly itself and to limit heat leak.

If thermal insulation is required, the maximum heat loss shall be agreed between the owner and the manufacturer based on system requirements (see EN 1474-3:2008).

6.3.5 Selection of external protection

The hose assembly shall have sufficient external mechanical protection against accidental damages such as dropped objects for instance, and regular service constrains such as friction, abrasion and corrosion. If external protection is required for a higher resistance than substantiated by the manufacturer in the hose assembly qualification program, project specific Maximum Impact Energy or the Maximum Crush Load shall be agreed between the owner and the manufacturer.

It shall be clarified whether these parameters are related to accidental or regular service conditions based on system requirements (see EN 1474-3:2008).

6.3.6 Selection of leak detection

See Clause 6.6.

6.4 Component details – End fitting

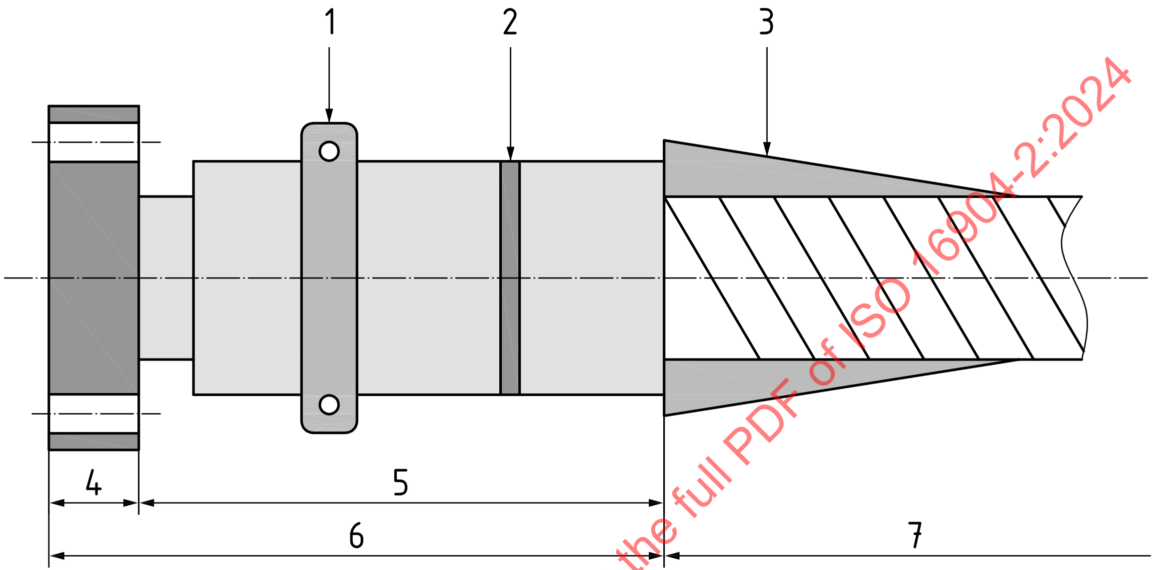
6.4.1 General

The end fittings of any hose assembly comprise of two main parts:

— termination;

— connector.

Illustration of an end fitting (typical, may vary depending on the hose assembly design):



Key

1 handling collar

2 identification collar

3 bending stiffener (optional)

4 connector

5 termination

6 end fitting

7 flexible part of the hose assembly

Figure 4 — Typical end fitting assembly – composite hose family

6.4.2 Termination

The termination shall ensure the following functions:

— mechanical attachment of all component layers of the hose assembly which resist against internal pressure, traction and torsion;

— provide a leak-proof seal against the transported fluid and/or gas;

— provide a leak-proof seal against ingress of humidity or water from the outer environment.

The end fitting shall comply with the system fatigue criteria.

6.4.3 Connector

The connector shall either be machined into the end termination or welded to it in accordance with a qualified procedure. The type of connector shall be specified by the owner and / or the system requirements.

6.4.4 Bending stiffener/restrictor (optional)

This is an optional item, either embedded into or mounted onto the hose assembly at either one or both terminations, if required. It has the function of providing a smooth transition of bending forces, if existing, from the end fitting to the hose assembly structure, and provides extra resistance to over bending.

The inclusion of a bend stiffener is at the manufacturer's discretion following review of the operational conditions.

6.5 Hose assembly handling / lifting device

Additional items such as the hose assembly handling device (pad eyes or collar etc.), QCDC and ERS shall be designed as part of the system and in accordance with EN ISO 16904:2016 and EN 1474-3:2008. Specific hose assembly handling instructions shall be issued as part of the system.

Appropriate hose handling instructions shall be supplied with each order to allow correct handling during transport and at other times prior to inclusion in the system.

A hose assembly handling/lifting device shall be designed, and proof tested to allow for safe handling of the complete hose assembly. When requested and upon mutual agreement between the manufacturer and owner, it can be designed to handle other equipment which could be attached to either end of the hose assembly.

Appropriate arrangements are to be provided to securely keep the hose assemblies in stored position when not in service or whilst being transported.

Chafing protection should be considered by owner and guidance for wear testing are available in Annex B Clause 8.

6.6 Safety systems

6.6.1 Leak detection (optional)

Hose assemblies with annulus:

Gas detection if fitted is to be provided as a warning of leakage of the hose assembly allowing appropriate action to be taken. The system can conform to one of the following:

— leak detection of only the inner pipe. In case of a break of the inner pipe, the supervision system gives alarm signal, but NG escapes to the environment;

— leak detection only at the end fitting to provide detection of seal failure;

— leak detection of only the inner pipe. In case of a break of the inner pipe, the supervision system gives alarm signal. For small leaks the escaping gas is exhausted from the annular gap. The annular gap is not able to withstand the MAWP of the hose assembly;

— leak detection of the inner pipe and an outer pipe if it is provided. In case of a leak in the outer pipe, the supervision gives a certain alarm to the terminal. In case of a leak in the inner pipe, the supervision gives alarm and the escaping gas is covered by the outer pipe. The outer pipe is able to withstand MAWP of Hose-in-hose with annular space;

— In case of inner hose leakage during an offloading operation, the hose in hose architecture combined with the leak detection system should prevent from any risk of LNG spillage into the atmosphere or sea water. The leak detection system allows to define when the offloading operation can continue safely, and when ESD1 shall be activated.

Hose assemblies without annulus:

Not all hose assemblies have an annulus running along their entire length. In these cases, a leak detection can be provided in the vicinity of the hose assembly (e.g. thermos camera, open path laser…).

6.6.2 Fire safety requirements

Fire safety requirements, if specified shall be mutually agreed between owner and manufacturer, see also EN 1474-3:2008, subclause 7.6.

6.6.3 Electrical safety requirements

Electrical continuity requirements shall be mutually agreed between the owner and the manufacturer, see also EN 1474-3:2008, subclause 7.6.

6.7 Connection to the ship

Connection to the ship by the manifold will be achieved by handling the LNG hose assemblies by the means of their dedicated connection on the hose assembly system, see also EN 1474-3:2008, Clause 8.

6.8 Hydraulic and electric control systems

Any requirements for hydraulic and electric control system affecting the hose assembly shall be specified by the owner

NOTE Refer to EN ISO 16904:2016, Clause 7.

7 Qualification requirements

7.1 Foreword

The manufacturer shall demonstrate that the hose assembly performs according to this standard. The owner can use the manufacturer's hose assembly qualification data to demonstrate that the transfer system that includes the hose assembly, is able to function safely under the operational and environmental conditions it is designed against within the frame of its application.

The IVA role is to assess through review of technical documentation and witness of testing, the potential risk held:

— By the owner developed transfer system solution.

— By the manufacturer on the performance of the hose assembly based on the herein standard and to release a type approval certificate.

The manufacturer shall demonstrate to the owner that the hose assembly passed the requirements from the herein standard through a type approval certificate and technical documentation

The type approval certificate of the IVA can be complemented by an IVA technical report and inspection reports.

Hose assembly qualifications performed before publication of this standard according to the EN1474 –2:2008, remain valid.

7.2 Qualification process

7.2.1 General principle

When a new hose assembly is to be designed / developed, its intended application(s) (see Annex C: Guidelines for Hose Qualification Categories (HQCs) Selection) should be defined. The testing program should then be developed. It is advised to request IVA support during this phase to establish a program and requirements acceptable to the IVA before starting the testing campaign. The manufacturer is free to determine the number of hose assembly samples required to cover the full qualification process and to use the same sample for different tests. The manufacturer is free to determine the sequence of the tests for the testing campaign.

Once the qualification programme definition is finalised, the vendor should approach an IVA in order to monitor the qualification campaign.

The vendor and IVA should agree on which tests require IVA witnessing. Testing procedures and acceptance criteria should be made available by the vendor before a test is performed.

Once the testing program has been completed as per requirements set in this standard in Clause 7.2.2, the IVA releases a type approval certificate which shall include information on the hose assembly tested such as geometrical characteristics, operational use, application, tests carried out, documentation provided, etc.

The vendor should make the certificate and all its appendices available upon request to the Owner.

When certain tests have not been performed as per the present standard, the vendor shall provide the IVA sufficient documentation to demonstrate the hose assembly would pass the requirements of the standard herein and that not carrying out these tests is acceptable. The certification documentation shall refer to any technical evidence provided by vendor allowing non-execution of any given tests and to current edition of this standard; refer to Clause 7.2.3 for further details.

From a full qualification of a hose assembly, it may be possible to define a range of certifications with the guidance given in Clause 7.2.3 ‘certification range definition from a tested prototype’.

For the qualification of a new technology, it is recommended to follow internationally recognized guidelines (e.g. standards, recommended practices…)

7.2.2 Qualification levels specific requirements

As a minimum, the following tests shall be performed with regards to the category selected by the manufacturer.

Table 1 — Tests for Hose Qualification Categories

Test	Subclause n°	HQC A	HQC B	HQC C
		Y/N	Y/N	Y/N
Tensile Stiffness	7.3.2.1	Y	Y	Y
Torsion Stiffness	7.3.2.2	Y	Y	Y
Bending Stiffness	7.3.2.3	Y	Y	Y
Hose Assembly Damping	7.3.2.4	N	Y	Y
Thermal Insulation Test	7.3.2.5	N	Y	Y
Buoyancy / Submersion Test	7.3.2.6	N	N	Y
Collapse Resistance to external pressure	7.3.2.7	N	N	Y
Pressure Leak Test	7.3.3.1	Y	Y	Y
Pressure and Temperature Cycle Test	7.3.3.2	Y	Y	Y
Burst Test	7.3.3.3	Y	Y	Y
Impact and Crush Load Tests	7.3.3.4	Y	Y	Y
Creep Test	7.3.3.5	N	Y	Y
Tensile and torsional axial operational load test	7.3.3.6	Y	Y	Y
Bending Radius Test	7.3.3.7	Y	Y	Y

Table 1 *(continued)*

Test	Subclause n°	HQC A	HQC B	HQC C
		Y/N	Y/N	Y/N
Fatigue Test	7.3.3.8	Y	Y	Y
Flow Rate Test	7.3.3.9	Y	Y	Y
Electrical properties Test	7.3.3.10	Y	Y	Y

The selection of all materials and associated equipment for cryogenic hose assemblies shall be validated by IVA during qualification process.

Qualification category will be mentioned in the type approval certificate established by IVA.

Multiple qualifications can be granted for the same product.

7.2.3 Certification range definition from a tested hose assembly

From a full qualification of a hose assembly, it may be possible to extend it to a range of certifications for related products or hose assembly performances. Extension of any given certification requires the support of the IVA from which the certificate was issued.

The extension philosophy is based on the concept of hose assembly family. A hose family is a group of hose assemblies being a range of sizes and pressure ratings manufactured with the same material types, production processes and process controls, hose assembly construction for a given HQC. A hose assembly family is made of one or several hose assembly family representative(s) and hose assembly variant(s). A family representative is typically the hose assembly that has undergone the full qualification program. A hose assembly variant is a hose assembly whose design slightly differs from the hose assembly family representative, but still complies with the given hose assembly family definition.

First it should be established by the vendor what is / are the hose assembly family representative(s) for the existing certification. Such a hose assembly will have undergone the full qualification program as per herein standard. Once identified, the new hose(s) assembly(ies) intended to be part of the certification extension fall under a hose assembly variant category. As such they are also part of the hose assembly family but will not necessarily undergo the full qualification campaign. If they do not fall under a hose variant category, they are considered part of another hose assembly family and shall undergo the full qualification program.

The extension philosophy is to use the lessons learnt from a hose assembly family representative, among other data, in terms of behaviour and limit state considerations to establish the testing program requirements for the hose assembly variant. The dedicated testing program intended for the hose assembly variant should be agreed between vendor and IVA considering the below paragraphs. Refer to subclause 7.2.1 for qualification process.

Below are important aspects listed that the IVA and vendor should consider before classifying a range of hose assemblies as hose assembly variant(s):

— How far it deviates from the hose assembly family representative(s) in terms of size and other characteristics such as pressure ratings.

— Possibility that new failure mechanisms are triggered by the identified design difference(s).

— Existence of a vendor's methodology for predicting hose assembly behaviour under extreme and/or fatigue operational condition. In the latter case, correlation with (full scale) tests and theory needs to be reviewed and validated by the IVA.

— Difference in category of specification.

— Difference in operating conditions.

Some additional requirements are available in Clause 8.

Once the testing program is determined for the hose assembly variant, it shall be executed. Upon success, the certification range associated to the hose assembly family would be extended to include the hose assembly variant.

7.2.4 Certification extension and update

From a general perspective, an existing range of certification may be extended to one or all hoses assemblies families subject to the assessment by the IVA of new evidence provided by the manufacturer. Such evidence may be new results (corresponding to all or part of the original qualification program) or new justifications. The assessment of this new evidence shall comply with subclause 7.2.2 to 7.2.3.

The manufacturer shall update the certification documentation and the IVA shall update the type approval certificates.

7.3 Hose assembly tests

7.3.1 General

7.3.1.1 Safety considerations

In addition of tests set up described here after, specific risk evaluation should be performed based on actual set up at manufacturer's or laboratory's facility.

Redundancy on pressure measurement equipment is advised to avoid any over pressurization

7.3.1.2 Test liquids

This standard specifies to pressurize hose assemblies at both ambient and cryogenic temperature. For reasons of safety it is assumed that this will be executed with liquids. Commonly water is used to test at ambient temperature and liquid nitrogen for test at cryogenic temperature. However, alternative liquids may be acceptable. Subject to the purpose of the test and safety in testing, some tests may be executed with gas. In the remainder of this standard it is assumed that the tests will be executed with water and liquid nitrogen. If a vendor wants to deviate from this, this shall be validated by the IVA.

7.3.1.3 Pressure and temperature requirements

The requirements for pressures and temperatures are:

— The test pressure shall be equal or above the specified test pressure.

— Test temperature requirements:

  — For ambient test temperature:

  — For the hose assembly outer surface: no specific requirement; the outer surface temperature shall be recorded

  — For the external air temperature: no specific requirement; the air temperature shall be recorded

  — For the testing fluid: no specific requirement; the test fluid temperature shall be recorded

  — The difference between above recorded temperatures shall not been more than 25 °C.

  — For cryogenic test:

  — For the hose assembly outer surface: no specific requirement; the outer surface temperature shall be recorded

  — For the testing fluid temperature: lower than −160 °C, except for flow test and burst test.

  — For the external air temperature: no specific requirement; the air temperature shall be recorded.

The test can commence when the sample is thermally stable as assessed by temperature sensors on the hose assembly outer surface and end fittings.

When the hose assembly is thermally insulated, the test can commence when the insulated hose is thermally stable. This should be preferably assessed by temperature sensors on the insulated hose assembly outer surface and end fittings.

Hose assembly is considered as thermally stable when:

Recorded temperatures decrease less than 5 *°C* during 10 *min*.

Alternatively, when a reasonable measurement of temperature stability with temperature sensors is not possible, the hose assembly is considered as thermally stable when boil off generation of liquid nitrogen or LNG has dropped significantly after cooling down process and low boil off generation rate is stable on low level for minimum 10 *min*.

If the temperature stability is assessed by other means, the method shall be validated by the IVA.

7.3.1.4 Requirements for measurement equipment accuracy

Equipment used to inspect, test, or examine material or other equipment shall be identified, controlled, calibrated, and adjusted at specified intervals in accordance with documented manufacturer instructions and consistent with a recognized industry standard (e.g. EN ISO 10012:2003 or equivalent), to maintain the required level of accuracy.

The controlling and recording instruments shall possess an inaccuracy lower than 5 % in the appropriate full-scale range.

Calibration certificates shall be made available to IVA.

7.3.2 Hose assembly property characterization tests

7.3.2.1 Tensile stiffness

The purpose of the test is to measure the axial tensile stiffness of the hose assembly for the following load conditions:

Table 2 — Tensile stiffness test load conditions

Test number	Test temperature	Constant Pressure	Axial load (varying)	Comment, further requirement
1	Ambient	0; 5; 10,5 *barg*; (0; 0,5; 1,05 *Mpa*); MAWP	From 0 to MWL and From MWL to 0	Rotation-z not restrained
2	Cryogenic			

The test principle is shown in Figure 5.

Minimum length of test sample shall be 4 times Internal Diameter

The boundary conditions are specified in Table 3.

For each test, the varying load shall be applied minimum 3 times up and down to account for hysteresis.

The test speed in mm/min shall be constant and a load cycle shall take at least 2 min from 0 to MWL and from MWL to 0.

As a minimum the following parameters shall be measured and recorded:

— Internal hose condition: pressure; temperature (2 locations minimum)

— Primary test data: Initial length of flexible part of the hose assembly, axial load, elongation of the flexible part of the hose assembly body and rotation of the flexible part of the hose assembly

— Secondary test data: hose assembly surface and end fitting temperature

Table 3 — Boundary conditions for the axial tests

Location	X	y	Z	rot x	rot y	rot z
Flange A	Fixed	fixed	fixed	Fixed	fixed	fixed
Flange B	Fixed	fixed	driven	“fixed”	“fixed”	free
“fixed” = no specific measures required free/driven = the hose assembly is free to move or load is applied into that direction subject to the test						

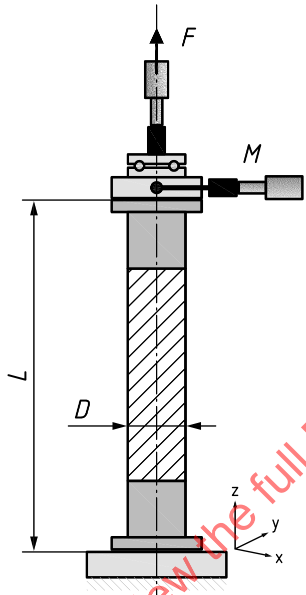


Figure 5 — Principle of the axial tension and torsion test set up

Alternative equivalent test set up shall be agreed with IVA.

Report for each of the tests the primary data as function of the pressure and axial load for following axial load levels at 0, 0,2xMWL; 0,4xMWL; 0,6xMWL; 0,8xMWL and MWL

Average values from third cycle (up and down) will be reported separately.

The stiffness is related to hose assembly elongation due to the external force to the end fittings.

The test is non-destructive.

No permanent damage shall be noticed after completion of this test

NOTE This test can be combined with test of subclause 7.3.3.6 “Tensile and torsional axial operational load test”.

7.3.2.2 Torsion stiffness

The purpose of the test is to measure the torsion stiffness of the hose for the following load conditions:

Table 4 — Torsion stiffness test load conditions

Test number	Test temperature	Pressure	Twist cycle (varying)	Comment, further requirement
3	Ambient	0; 5; 10,5 *barg*; (0; 0,5; 1,05 *Mpa*); MAWP	From 0 to MAAT and From MAAT to 0	1st cycle: Anti clockwise 2nd cycle: Clockwise
4	Cryogenic			

The *L*/*D* of the specimen shall be > = 4.

The boundary conditions are specified in Table 5.

For each test, the varying twist shall be applied minimum 3 times to eliminated effects of hysteresis.

The stiffness is related to hose assembly twist due to the external moment to the end fittings.

The test speed in mm/min shall be constant and a load cycle shall take at least 2 min from 0 to MAAT and from MAAT to 0.

As a minimum the following parameters shall be measured and recorded:

— Internal hose assembly condition: pressure; temperature (2 locations minimum)

— Primary test data: Initial length of the flexible part of the hose assembly; pressure, torsion load, elongation and rotation of the flexible part of the hose assembly

— Secondary test data: hose surface and end fitting temperature

Table 5 — Boundary conditions for the torsion tests

Location	**x**	**y**	**z**	**rot x**	**rot y**	**rot z**
bottom flange	fixed	fixed	fixed	fixed	fixed	fixed
top flange	fixed	fixed	free	“fixed”	“fixed”	driven
“fixed” = no specific measures required free/driven = the hose assembly is free to move or load is applied into that direction subject to the test						

Report for each of the tests the primary data as function of the pressure and torsion load for following torsion load levels 0, 0,25xMAAT; 0,5xMAA, MAAT, 0,25-MAAT, 0,5x-MAAT and -MAAT

Average values from third cycle (up and down) will be reported separately.

The test is non-destructive.

No permanent damage shall be noticed after completion of this test

NOTE This test can be combined with the tests of the subclause 7.3.3.6 “Tensile and torsional axial operational load test”.

7.3.2.3 Bending stiffness

The purpose of the test is to measure the bending stiffness of the hose assembly for the following load conditions:

Table 6 — Bending stiffness test load conditions

	Test temperature	Pressure	Bend radius (varying)	Comment
5	Ambient	0; 5; 10,5 *barg*; (0; 0,5; 1,05 *Mpa*); MAWP	From 0 to MBR & From MBR to 0	
6	Cryogenic			

Alternative tests set-up agreed between manufacturer and IVA shall not be excluded.

The most appropriate set-up shall be selected regarding suitability versus hose assembly technology. It is acceptable to apply bending only on specific areas of the hose assembly depending on the effect of bending efforts on the product.

It is understood that the bending moment may not be constant all along the hose assembly structure due to effect of end fittings, test set-up design, and other factors. Relevance of the reported bending stiffness measurement shall be ensured by the IVA.

The *L*/*D* of the specimen shall be > = 4.

The boundary conditions are specified in Table 7.

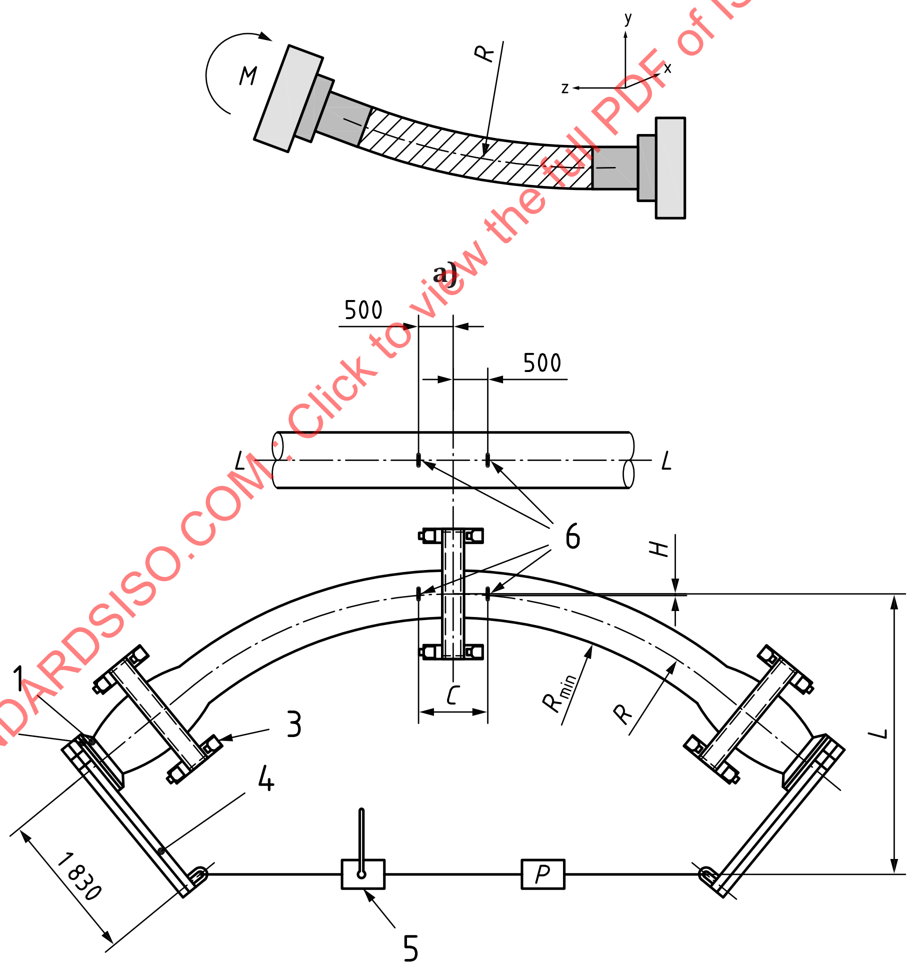
For each test, the varying load shall be applied minimum 3 times to eliminated effects of hysteresis.

As a minimum the following parameters shall be measured and recorded:

— Internal hose assembly condition: pressure; temperature (2 locations minimum)

— Primary test data: pressure, bending moment, curvature of the flexible part of the hose assembly

— Secondary test data: hose assembly surface and end fitting temperature



b)

Figure 6 — Principle of the bending stiffness test set up

Table 7 — Boundary conditions for the bending tests

location	x	y	Z	rot x	rot y	rot z
Right flange	fixed	fixed	fixed	fixed	fixed	fixed
Left flange	fixed	free	free	driven	free	free
"fixed" = no specific measures required free/driven = the hose assembly is free to move or load is applied into that direction subject to the test						

Report for each of the tests the primary data as function of the pressure and curvature for following curvature levels at 0, 5xMBR; 4xMBR; 3xMBR; 2xMBR and MBR

Average values from third cycle (up and down) will be reported separately.

The test is non-destructive.

No permanent damage shall be noticed after completion of this test

NOTE In this test, considerations about other bend radius at 0 *barg* (0 *Mpa*) can be used as optional characterization data in order to gain better understanding of properties for hose assemblies intended to be used in permanently connected applications.

7.3.2.4 Hose assembly damping

Damping information is an important input for system design and without any available information coming from previous tests and / or field proven experience, this test shall be performed

The purpose of the test is to determine the damping of the hose assembly in bending for the following load conditions:

Table 8 — Hose damping test load conditions

	Test temperature	Pressure	Comment
7	Ambient	0; 5; 10,5 *barg*; (0; 0,5; 1,05 *Mpa*); MAWP	Suspended hose assembly
8	Cryogenic		

A hose assembly is suspended, and the bottom is free to swing as a pendulum.

Several configurations are possible to allow using the test set up for other tests, see Figure 7:

— a straight hose assembly, using the axial stiffness or heat ingress test set up

— a hose assembly in U-shape having two vertical sections.

The requirement is that the main displacement in swinging is caused by shallow bending deformation. For that reasons the L/D of the specimen shall be > = 10.

The boundary conditions for the flange(s) from which the hose assembly is suspended fixed in the 6 degrees of freedom.

With the hose assembly at the required test temperature and pressure, the lower part of the hose assembly is moved out of plane and subsequently released to let the hose assembly swing in the lowest eigen-frequency, unrestraint along its length.

The exponential decay of the swing amplitude shall be measured. The test shall be repeated 3 times for each temperature-pressure condition.

NOTE Damping of higher eigen-frequencies can be determined using an impulse hammer.

As a minimum the following parameters shall be measured and recorded:

— Internal hose assembly condition: pressure; temperature

— Primary test data: out of plane displacement or acceleration

Report the average damping ratio for each of the temperature-pressure conditions. The test is non-destructive.

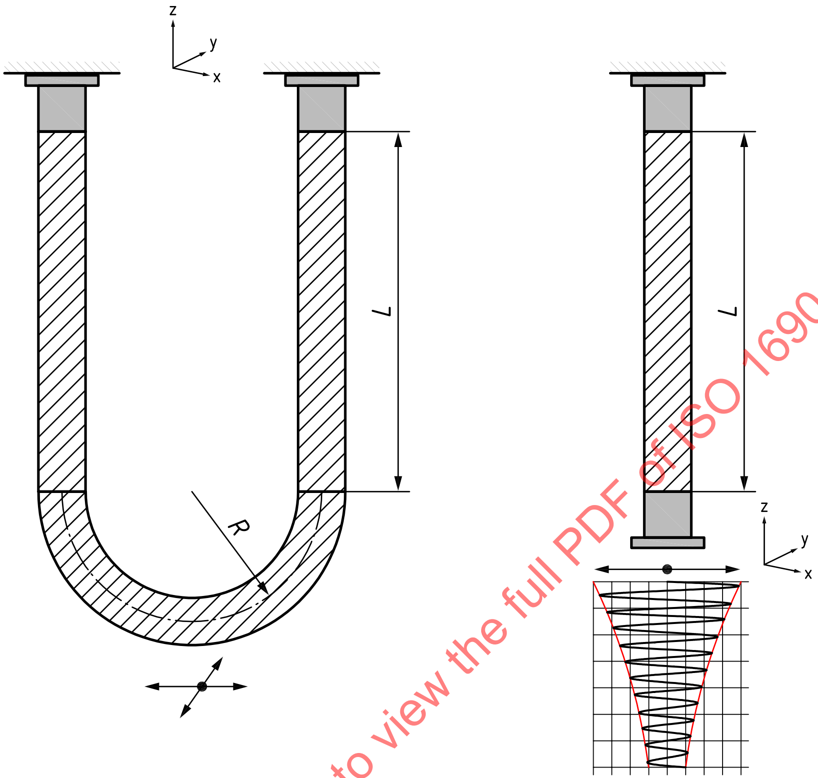


Figure 7 — Two possible principles of the hose assembly damping test set up

7.3.2.5 Thermal insulation test

The purpose of the test is to measure the heat loss of the hose assembly per meter length, excluding the end fittings, under several known internal and external temperature conditions of:

— The entire, full length, hose assembly including end fittings or

— the flexible part of the hose assembly per meter length, excluding the end fittings, when the hose can be supplied in different lengths

Table 9 — Insulation test load conditions

	Test temperature	Pressure	Outside condition	Comment
9	Cryogenic	0 *barg* (0 *Mpa*)	Ambient air	

The test principle is shown in Figure 8.

When partial hose assembly length samples are used the end fittings need to be thermally insulated to minimize their influence on the test result.

As the boiling temperature and evaporation heat of LN2 is known, the GN2 flow is a measure for the thermal properties.

The GN2 temperature before the gas flow meter need to be either measured except when this can be assumed to be ambient temperature due to the test layout.

The *L*/*D* of the specimen shall be > = 10.

The hose assembly sample shall be thermally stable before commencing the test as per subclause 7.3.1.2

The gas flow shall be measured over a 5 *min* period.

Measurement is based on middle area of the hose assembly and effect on the end fitting shall be minimized.

Thermal Insulation Properties of materials of end fittings components shall be made available to IVA.

Effect of end fittings and potential further tests must be addressed by this test or separately.

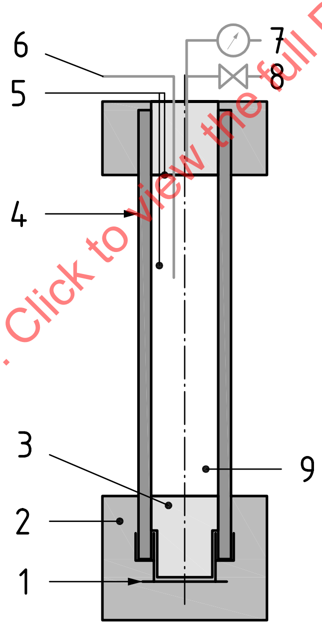
As a minimum the following parameters shall be measured and recorded:

— Internal hose assembly condition: pressure; temperature (3 locations minimum)

— Primary test data: gas flow, hose assembly outer surface temperature; air temperature and air speed

— External temperature

— External wind velocity



Key

1 end fitting
2 external insulation
3 insulation
4 Tc (6×)
5 Tc
6 LN2 inlet
7 flow meter
8 GN2 outlet
9 Tc

Figure 8 — Principle of the insulation test set up

Report for each of the tests the heat loss in *W* or *W/m* for respectively a full length or partial length hose assembly.

If the influence of end fittings to heat ingress is assessed by other means, the method shall be validated by the IVA

The test is non-destructive.

7.3.2.6 Buoyancy / submerged weight

Buoyancy calculation is intended to demonstrate that the buoyancy of the flexible part of the hose assembly or the hose assembly is adequate for a floating application and shall be specified by the manufacturer.

Submerged weight definition is intended to provide initial design basis.

This information can either be determined by testing or calculations. Preferably, the value of buoyancy should be deduced from measurements.

For hose assemblies with annulus, the manufacturer must assess the loss of buoyancy when the annulus is flooded with water.

Following formula shall be used:

$$Buoyancy\text{, }hose\ assembly\ full\,[\%] = 100 \times \frac{W_{displaced\ water} - W_{Hose\ assembly\text{, }full}}{W_{Hose\ assembly\text{, }full}}$$

$$Buoyancy\text{, }hose\ assembly\ empty\,[\%] = 100 \times \frac{W_{displaced\ water} - W_{Hose\ assembly\text{, }empty}}{W_{Hose\ assembly\text{, }empty}}$$

where

$W_{displaced\ water}$	is the weight of water displaced when the hose assembly is fully submerged;
	It corresponds to the external volume of the hose assembly multiplied by the water density;
	The manufacturer shall specify the water density taken into account;
$W_{hose\ assembly,\ full}$	is the weight of the hose assembly, full of LNG;
	The manufacturer shall specify the LNG density taken into account;
$W_{hose\ assembly,\ empty}$	is the weight of the hose assembly, empty.

7.3.2.7 Collapse resistance

Submersion (hydrostatic pressure for submarine hose assemblies only) is intended to demonstrate that the hose assembly can support the hydrostatic head of seawater at its maximum rated depth.

Submerge the empty, not pressurized, straight and blinded hose to 1,3 times its maximum rated depth associated hydrostatic pressure and hold for 1 *h*. The hose shall not collapse or be otherwise damaged.

Vacuum test is intended to demonstrate that the hose assembly can support temporary vacuum application.

Vacuum test shall be performed by applying vacuum up to −0,85 *barg* (−0,085 *Mpa*) for 10 min.

The hose assembly shall, when returned to normal conditions, be externally and internally inspected and found to be free from visible damage and permanent deformation such as ovalizing, kinking, collapsing and folding.

7.3.3 Qualification tests with acceptance criteria

7.3.3.1 Pressure leak test

The purpose of the test is to demonstrate that the hose assembly with end caps can support its proof pressure without leaking at ambient and cryogenic temperature:

Table 10 — Pressure leak test load conditions

	Test temperature	Minimum Proof Pressure	Time at test pressure	Comment
10	Ambient	PP = 1,5x MAWP	4 *h*	
11	Cryogenic	PP = 1,5x MAWP	4 *h*	

The test principle is shown in Figure 9.

The *L/D* of the specimen shall be > = 4.

Ambient test:

For the ambient test the hose assembly shall be pressurized with water.

First the hose assembly shall be pressurized two times up to a pressure defined by the design of the hose assembly to determine the initial length. The purpose of this is to condition the multi-layer structure regarding elongation hysteresis effect.

Next the Proof Pressure is applied as per manufacturer procedure. The pressure shall be stabilized. The stabilization requirement is set according manufacturer documented procedure.

After the stabilization the hose shall be isolated from the pressure source for 4 *h*.

During the 4 *h* period:

— No leakage of liquid shall be observed.

After the 4 *h* period

— No pressure drop larger than 4 % of MAWP *barg* unless this can be proven to be attributed to variation in temperature.

— End test pressure shall not be less than Minimum Proof Pressure.

Cryogenic test:

For the cryogenic test the hose assembly shall be pressurized with fluid liquid nitrogen

First the hose assembly shall be cooled down as per manufacturer procedure and when the hose assembly temperature is stabilized, the hose assembly shall be pressurized two times up to a pressure defined by the design of hose assembly to determine the initial length. The purpose of this is to condition the multi-layer structure regarding elongation hysteresis effect. Next the Proof Pressure is applied and maintained for 4 *h*.

Test set up shall ensure that sample remains filled with liquid during this period.

An appropriate device shall be used to detect leakage.

Test will be performed according the manufacturer test procedure.

The requirement is that, over the total length of the hose assembly sample, the permeability rate is maximum 0,5 *l/min* of nitrogen gas at ambient temperature and pressure per m^2 of wetted surface.

~For hose assemblies with annular space and insulation vacuum it is possible to mix gaseous Helium into the testing fluid and use a helium leak detector connected to the vacuum pumping port. If the permeability rate at the helium leak detector is better than 10^-7 mbar*l/s (10^-5 Pa*l/s) the leak test can be accepted.TM

NOTE See Annex E for justification about maximum allowed permeability rate and above leak detection value.

As a minimum the following parameters shall be measured and recorded:

— Internal assembly hose condition: pressure; temperature (2 locations minimum)

— Primary test data: pressure, elongation of the hose assembly, leakage

— Secondary test data: hose assembly surface and end fitting temperature; air temperature

Table 11 — Boundary conditions for the ambient and cryogenic pressure tests

location	X	Y	Z	rot x	rot y	rot z
right flange	fixed	fixed	Fixed	Fixed	Fixed	fixed
left flange	fixed	fixed	free	Free	Free	free
"fixed" = no specific measures required free/driven = the hose assembly is free to move or load is applied into that direction subject to the test						

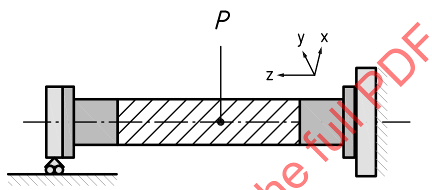


Figure 9 — Principle of ambient and cryogenic pressure tests

Following lengths measurements shall be performed in order to determine elongations:

— Just before pressurization at Proof Pressure (not pressurized)

  — L_0 = Initial Length

— Between 3h30 and 4h00 at Proof Pressure

  — L_1 = Length Under Pressure

— After 4 h, release pressure and hold 15 *min* not pressurized

  — L_2 = Final Length

Temporary Elongation = $(L_1 - L_0) / L_0$

Permanent Elongation = $(L_2 - L_0) / L_0$

The test is non-destructive.

7.3.3.2 Pressure and temperature cycle test

The purpose of the test is to demonstrate that the unrestrained hose assembly with end caps is capable of withstanding pressure cycle test:

Table 12 — Pressure and temperature cycle test load conditions

	Test temperature	Minimum Pressure Amplitude (varying)	Minimum Number of cycles	Comment
12	Ambient	1 *barg* (0,1 *Mpa*) - 2xMAWP	200	
13	Ambient-cryogenic	1 *barg* (0,1 *Mpa*)- MAWP	20	

The *L/D* of the specimen shall be > = 4.

Ambient test:

For the ambient test the hose shall be pressurized with water at 1 *barg* (0,1 *Mpa*). Then, 200 pressure cycles are applied. Each cycle shall last minimum 1 *min*. After the last cycle the hose assembly shall pass the FAT pressure Test (subclause 8.4.2.1)

Ambient to Cryogenic pressure cycle test:

For the cryogenic test the hose assembly shall be pressurized with fluid as per 7.3.1.2.

The purpose of this test is to simulate a thermal cool down.

A pressure cycle consists of the following steps:

— the cycle starts with the hose assembly at ambient temperature and atmospheric pressure.

— the hose assembly is cooled down with testing fluid at a pressure between 0 and1 *barg* (0,1 *Mpa*) as short as feasible and not exceeding the time specified by manufacturer cooling down procedure.

— the pressure is increased to MAWP and hold for 10 *min*

— the pressure is relieved and the testing fluid purged

— using air at ambient temperature, the hose assembly inside and outside temperature is raised to ambient temperature within a range of tolerance of 10 *°C*

Forced external ventilation may be used. In addition, the hose assembly may be purged with GN2 with a temperature not higher than the maximum operating temperature of the hose assembly.

As a minimum the following parameters shall be measured and recorded:

— Internal hose assembly condition: pressure; temperature (2 locations minimum)

— Primary test data: pressure, elongation of the hose assembly, leakage

— Secondary test data: air temperature

After the last pressure cycle, hose assembly shall pass the following cryogenic leak test

— The hose assembly shall be pressurized and stabilized at 1,5 times MAWP

— This pressure shall be maintained for 15 *min* and the hose assembly shall be inspected for leakage using an appropriate leak detection device

— The maximum allowable permeability rate is 0,5 *l/min* of nitrogen gas per m^2 of hose assembly wetted area

The test is non-destructive. Hose used for thermal and pressure cycle tests may be the same as used for fatigue testing.

7.3.3.3 Burst test

The purpose of the test is to demonstrate that the minimum burst pressure is at least 5 time MWAP:

Table 13 — Burst test load conditions

	Test temperature	Minimum Burst Pressure	Comment
14	Ambient	> 5x MAWP	
15	Cryogenic	> 5x MAWP	

The *L/D* of the specimen shall be > = 4.

Ambient test:

For the ambient test the hose assembly shall be pressurized with liquid (preferably with water). The pressure shall be steadily increased up to 5 times MAWP. In preference, the pressure shall be held at 5 times MAWP for 5 *min*.

Subsequently the pressure shall be increased to burst or leakage. The highest pressure recorded is the burst pressure to be reported.

A brief description of the failure mode shall also be reported.

Cryogenic test:

For the cryogenic test the hose assembly shall be pressurized with LN2. First the hose assembly shall be cooled down at a pressure between 0 and 1 *barg* (0,1 *Mpa*). When the hose assembly temperature is stabilized, the pressure shall be steadily increased up to 5 times MAWP. In preference the pressure shall be held at 5 times MAWP for 5 *min*.

Subsequently the pressure shall be increased to burst or leakage. The highest pressure recorded is the burst pressure to be reported.

A brief description of the failure mode shall also be reported.

As a minimum the following parameters shall be measured and recorded:

— Internal hose assembly condition: pressure; temperature (2 locations minimum)

— Primary test data: pressure, elongation of the hose assembly, leakage

— Secondary test data: air temperature

7.3.3.4 Impact load test and crush load test

7.3.3.4.1 General

In order to account for impact and crush event which could occur during normal operation, the manufacturer shall specify

Maximum Allowable impact energy (MAIE)

Maximum Allowable Crush load (MACL)

After each test, hose assembly shall pass the following cryogenic leak test

— The hose assembly shall be pressurized and stabilized at 1,5 times MAWP

— This pressure shall be maintained for 15 *min* and the hose assembly shall be inspected for leakage using an appropriate leak detection device

— The maximum allowable permeability rate is 0,5 *l/min* of nitrogen gas per m^2 of hose assembly wetted area

Further guidance and test set up examples are available in appendix B "guidelines for further testing considerations"

7.3.3.4.2 Impact load test

Impact Load Test shall be performed in cryogenic conditions according a documented test procedure agreed between IVA and manufacturer considering that maximum impact surface of the testing tool shall be $\frac{(\pi D^2)}{8}$.

Preliminary testing at ambient temperature should be performed in order to help to define the most accurately the MAIE in service conditions.

7.3.3.4.3 Crush load test

Crush Load Test shall be performed in cryogenic conditions according a documented test procedure agreed between IVA and manufacturer considering that minimum dimensions of the crush application tool shall be a square of *DxD*.

Preliminary testing at ambient temperature should be performed in order to help to define the most accurately the MACL in service conditions.

7.3.3.5 Creep test

For hose assemblies that are continuously stressed by pressure or axial or bending load, creep or relaxation can affect the hose assembly properties over service time.

This can also hold for hose assemblies that are not used continuously but are expected to a high number of accumulated hours under load.

Manufacturer shall liaise with IVA to assess if claimed applications require creeping qualification tests. Outputs of this assessment shall be documented and referenced in the certification documentation.

Guidance regarding creeping tests are provided in appendix B "guidelines for further testing considerations".

7.3.3.6 Tensile and torsional axial operational load test

The purpose of the test is to demonstrate that the hose assembly is capable to support its maximum working loads whilst at MAWP:

Table 14 — Tensile and torsional axial operational load test conditions

Test number	Test temperature	Pressure	Twist	Axial load (varying)	Comment, further requirement
16	Ambient	MAWP	-MAAT; MAAT	0 - MWL	
17	Cryogenic				

For test conditions, see subclauses 7.3.2.1 and 7.3.2.2 (characterization tests).

Ambient test:

For the ambient test the hose assembly shall be pressurized as per 7.3.1.2.

The pressure shall be steadily increased to MAWP.

The pressure shall be hold at MAWP for 1 *min*.

Subsequently the axial load is steadily increased to MWL and MAAT (clockwise) while maintaining the pressure at MAWP.

The MWL, MAAT and MAWP shall held for 15 *min* after which the hose assembly is visually inspected for leakage.

Same test shall be performed at –MAAT (anticlockwise).

No damage shall be observed after relieving the loads.

Cryogenic test:

For the cryogenic test the hose assembly shall be pressurized as per 7.3.1.2.

First the hose assembly shall be cooled down at a pressure between 0 and 1 *barg* (0,1 *Mpa*).

Next, when the hose assembly temperature is stabilized, the hose assembly shall be pressurized steadily to MAWP.

Subsequently the axial load is steadily increased to MWL and MAAT (clockwise) while maintaining the pressure at MAWP.

The MWL, MAAT and MAWP shall be held for 15 *min*. after which the hose assembly is inspected for leakage using a GN2 leak detection device.

The requirement is that, over the total length of the hose assembly sample, the permeability rate is maximum 0,5 *l/min* of nitrogen gas at ambient temperature and pressure per m^2 of wetted surface.

No damage shall be observed after relieving the loads.

As a minimum the following parameters shall be measured and recorded:

— Internal hose assembly condition: pressure; temperature (2 locations minimum)

— Primary test data: axial load, torsion load, permeability rate

— Secondary test data: hose assembly surface and end fitting temperature

The test is non-destructive.

After both tests, the hose assembly shall pass either:

1) FAT Ambient Pressure as per 1) of Clause 8.4.2

2) Cryogenic test:

 — The hose assembly shall be pressurised and stabilized at 1,5 times MAWP

 — This pressure shall be maintained for 15 *min* and the hose assembly shall be inspected for leakage using an appropriate leak detection device

 — The maximum allowable permeability rate is 0,5 *litre/min per* m^2 of hose assembly wetted area

7.3.3.7 Bend radius test

The purpose of Ambient and cryogenic bend tests to MBR (Minimum Bend Radius) is to confirm that the hose can support its MAWP at working MBR based on the principles given in EN ISO 10619-1:2018. However, the test set up for the subclause 7.3.2.3 "Bending Stiffness Test" may also be used.

The *L/D* of the specimen shall be > = 10. The boundary conditions are specified in Table 15.

The hose assembly is fitted in the test set up as per agreed procedure

For the cryogenic test only, the hose assembly is cooled down up to cryogenic conditions as per 7.2.1.3

MBR and pressurization sequence shall be performed as per manufacturer test procedure.

The hose assembly is examined for leaks whilst being held for 15 *min* at MBR and MWAP.

Hose assembly shall pass:

1) For the ambient MBR the FAT Ambient Pressure as per subclause 8.4.2, paragraph 1.

2) For the cryogenic test:

— The hose assembly shall be pressurized and stabilized at 1,5 times MAWP

— This pressure shall be maintained for 15 *min* and the hose assembly shall be inspected for leakage using an appropriate leak detection device

— The maximum allowable permeability rate is 0,5 *l/min per* m^2 of hose assembly wetted area

The hose assembly shall, when returned to ambient conditions, be externally and internally inspected and found to be free from visible damage and permanent deformation such as ovalizing, kinking, and folding.

Table 15 — Boundary conditions for the axial tests

Location	X	Y	Z	rot x	rot y	rot z
Left flange	fixed	Fixed	fixed	fixed	fixed	fixed
Right flange	free	Fixed	fixed	fixed	free	fixed
"fixed" = no specific measures required free/driven = the hose assembly is free to move or load is applied into that direction subject to the test						

Above test considers a single continuous hose assembly that somewhere along its length could be bent to MBR in service. If the hose assembly is not manufactured as a single length continuous hose assembly, the connection between hose assembly and coupling shall be tested under MBR load conditions:

— This may be accomplished by including the coupling mid length in the bent area of the test set up.

— Alternatively, the test shall induce the MBR in the flexible part of the hose assembly adjacent to the flange.

— If a bend stiffener is incorporated in the design, the bend stiffener does not have to be bent to MBR but the flexible area adjacent to the bend stiffener shall be submitted to MBR.

As a minimum the following parameters shall be measured and recorded:

— Internal hose assembly condition: pressure; temperature (2 locations minimum)

— Primary test data: curvature of the flexible part of the hose assembly, permeability rate

— Secondary test data: hose assembly surface and end fitting temperature

The test is non-destructive.

7.3.3.8 Fatigue test

Cryogenic bending cyclic fatigue testing is intended to demonstrate the fatigue resistance of the flexible part of the hose assembly to bending cycles.

Number of cycles have been defined to fit specifically claimed applications categories and shall be applied as per Table 16.

If hose assemblies are intended to be connected in hose assembly string, the end fitting of the hose assembly shall be tested under bending load conditions.

— This may be accomplished by including the coupling mid length in the bent area of the test set up.

— Alternatively, the test shall induce the bending moment in the flexible part of the hose assembly adjacent to the end fitting.

— If a bend stiffener is incorporated in the design, the flexible area adjacent to the bend stiffener shall be submitted to bending moment.

Table 16 — Fatigue test conditions

Hose Qualification Category	Temperature	Pressure	Minimum Number of cycles	Severity (loads /curvatures)
A	Cryogenic	0,5 MAWP	40 000	10 000 Straight to SBR 10 000 Straight to MBR 20 000 Straight to 2x MBR
B	Cryogenic	0,5 MAWP	400 000	10 000 Straight to SBR 10 000 Straight to MBR 380 000 Straight to 2x MBR
C	Cryogenic	0,5 MAWP	400 000	10 000 Straight to SBR 10 000 Straight to MBR 380 000 Straight to 3 MBR

User shall bear in mind that MBR is defined by manufacturer depending on design and technology and could be significantly different from one product to another.

Category C test curvatures reflect expected condition of floating hose assemblies where curvature below to 3 MBR are very unlikely to occur.

After this test, hose assembly shall pass the following cryogenic leak test

— The hose assembly shall be pressurized and stabilized at 1,5 times MAWP

— This pressure shall be maintained for 15 *min* and the hose assembly shall be inspected for leakage using an appropriate leak detection device

— The maximum allowable permeability rate is 0,5 l/min *per* m^2 of hose assembly section area

Burst pressure test may be done after fatigue.

7.3.3.9 Flow rate tests

Flow rate testing (ambient or cryogenic) is intended to demonstrate that the hose assembly can operate at its maximum flow rate and confirm the predicted head loss.

Table 17 — Flow test conditions

Parameter	Value or range	Comment
Bend radius	1- Straight; 2- Bent at MBR	
Flow velocity	From 0 to max flow velocity specified by the hose assembly manufacturer	Two phase flow shall be avoided
Pressure	5 *barg* (0,5 *Mpa*) minimum	At least in one area flexible part of the hose assembly during the test

The L/D of the specimen shall be > = 20

Test set up:

For the head loss measurement, a smooth straight pipe shall be installed upstream the prototype hose assembly with a length of at least 10 times the hose assembly inner diameter and downstream the hose assembly a straight smooth pipe of at least 5 times the hose assembly inner diameter. The inner diameter of these straight pipes should not deviate more than 5 % (with a maximum of 5 mm) from the inner diameter of the hose assembly -flange. The differential pressure sensor(s) should be installed as close as possible to the inlet and outlet of the hose assembly, but not closer than 50 *mm*. When the sensor cannot be installed close to the inlet and outlet of the hose assembly, the additional pressure loss across the system should be accounted for in the head loss assessment.

When the flow test is carried out with water, it should be prevented that air could interfere with the head loss measurement and that the tubing connected to the pressure differential sensor is always filled with liquid.

When the flow test is carried out with cryogenic liquid, consideration shall be given to the selection of the test fluid (single or multi-component) and the selected fluid shall be mentioned in the test report. The pressure differential sensor is likely to be installed some distance away from the test hose assembly, since the sensor cannot be able to withstand the cryogenic temperature. In this case, the sensor and tubing towards the sensor should be installed elevated from the hose assembly so that there is no liquid but only gas in the tubing.

Alternative test set up could be agreed between IVA and manufacturer.

Test sequences and duration:

1) For each test, the flow is increased from 0 to maximum flow rate by increment of 20 % of max flow rate. The flow rate is maintained 1 *min* minimum at each step.

   The flow is maintained at least 15 *min* at the maximum flow rate.

2) The flow is then decreased back to 0, by increment of 20 % of max flow rate.

   The flow rate is maintained 1 *min* minimum at each step.

As a minimum the following parameters shall be measured and recorded:

— Pressure upstream (static pressure);

— Differential pressure (pressure drop measurement);

— Pressure drop versus flow rate;

— Temperature (water temperature);

— Vibration (by acceleration method);

— Temporary hose assembly length (straight configuration);

— Bend radius.

For tests 1 and 2, the manufacturer shall provide a curve of pressure drop versus flow rate.

For tests 1 and 2, the manufacturer shall provide a curve of vibration level versus flow rate.

For the bent configurations, if the hose assembly is curved only on a part of the hose assembly length, it shall be considered for the calculation of the friction factor at the given curvature.

The hose assembly shall be externally and internally inspected and found to be free from visible damage and permanent deformation.

7.3.3.10 Electrical properties test

Electrical testing is intended to confirm that the hose assembly is either electrically continuous or discontinuous and that the resistance value is appropriate for the designation.

Hose assembly shall be drained and supported above ground by non-conductive means and the resistance measured between the two end fittings (connection face). Electrically continuous hose assemblies shall have a resistance of less than 100 *Ohms*.

Electrically discontinuous hose assemblies shall have a resistance of not less than 25 000 *Ohms*.

7.3.3.11 Leak detection system qualification test

If hose assembly claims a qualification including a leak detection system, a documented qualification test procedure agreed with IVA shall be established in order to demonstrate the ability of the leak detection system to perform efficient detection.

8 Quality assurance and control

8.1 General

The quality system of the facilities involved in design and manufacturing should conform to EN ISO 9001.

Validation of design shall be established by an Independent Verification Authority based on the requirements included in Clause 7 of this standard

8.2 Material selection

For each component part of the finished product (including auxiliary materials as nuts, bolts, seals, weld rods…), the manufacturer shall define and provide as a minimum:

— Material Specification / Data Sheet:

  This document shall clearly establish unique identification of the product versus its physical characteristics and acceptance criteria.

  Updates shall be approved by IVA.

— Approved Manufacturer List

  This list shall be established in accordance with the Quality Management Systems dispositions and updates shall be made available for possible review by IVA.

  Updates don't need to be approved by IVA.

— Quality Control Plan

  As part of the manufacturer Quality Management Systems, a dedicated Quality Control plan shall be established for components which are part of the finished product. This Quality Control Plan shall include description of quality control activity, sampling rules, responsibilities, applicable references and acceptance criteria.

Updates shall be approved by IVA.

8.3 Manufacturing

8.3.1 Manufacturing basics

Manufacturing facility shall be included into the scope of the Quality Management Systems (see EN ISO 9001).

Any major change of manufacturing site shall require an approval from IVA as per certification extension philosophy (see Clause 7.2.4)

A documented manufacturing specification shall be available and will be reviewed by IVA as part of the qualification file.

This manufacturing specification shall describe as a minimum:

— Sequence of manufacturing operations

— Manufacturing parameters and related acceptance criteria

8.3.2 Traceability

Manufacturer shall implement a system to ensure traceability of:

— components in contact with conveyed fluid / gas

— pressure containing components

— components in contact with external environment

— components withstanding design load as per qualification categories requirements

When possible, traceability will be ensured by permanent marking on components.

For hose-in-hose design, manufacturer shall ensure independent traceability of both hoses intended for building of the finished hose assembly.

8.3.3 Marking

Each hose assembly shall bear a permanent marking at both ends and diametrically opposed including as a minimum:

— name of manufacturer;

— EN1474-2:2020+AC:2023 and the appropriate HQC;

— hose assembly unique serial number;

— internal diameter of the hose assembly;

— specified MAWP;

— maximum and minimum service temperature;

NOTE This is in accordance with IMO IGC Code (complete reference is given in Bibliography).

— overall weight of the hose assembly.

This marking shall be clearly visible and shall remain visible throughout the whole lifetime of the hose assembly.

8.3.4 Packing and preservation

Hose assembly shall be packed after Factory Acceptance Test activities in order to prevent any damage on the product.

Packing of end terminations shall be sufficient enough to prevent damages on sealing surfaces and shall be performed immediately after FATs completion.

Preservation method for end fitting shall be part of design qualification.

8.4 Factory acceptance tests

8.4.1 General

Factory acceptance tests are non-destructive and tests results shall be recorded in a written report.

8.4.2 Tests to be performed on every hose assembly

1) Ambient pressure leak test including approved drying procedure.

   For the ambient test the hose assembly shall be pressurized with liquid (preferably with water). Then the Proof Pressure is applied as per manufacturer procedure. The pressure shall be stabilized. The stabilization requirement is set according manufacturer documented procedure. After the stabilization the hose assembly shall be isolated from the pressure source for 15 *min*.

   During the 15 *min* period, no leakage of liquid shall be observed.

   In factory environment, pressure test with gas is allowed provided that all necessary safety precautions are implemented, and that leakage can be monitored.

2) Electrical testing (for electrical continuity). (See 7.3.3.10)

3) Dimensional checks (length, diameter (OD and ID) connectors etc.).

4) Internal and external visual inspection.

5) Inspection of marking and identification plate (marking requirements defined elsewhere).

9 Documentation

9.1 Purchasing guidelines

Guidance for purchasers is available in Annex A.

9.2 Design, qualification and manufacturing documentation

As part of an approved quality system, the Manufacturer shall be able to provide the following documents:

— quality manual;

— manufacturing quality plan;

— inspection and test plan;

— IVA approved certification;

— manufacturing data book.

9.3 As-built documentation/manufacturing Data Book

The as-built documentation shall include, as a minimum the following:

— purchase order reference number;

— references to design specifications and drawings;

— material certificates;

— factory acceptance test results;

— welding procedure specifications and qualifications (if applicable);

— welder qualification records (if applicable);

— weld map (if applicable);

— NDE operator qualifications and NDE test records (if applicable);

— heat treatment records (if applicable).

9.4 Operation manual

An operation manual shall be prepared for the hose assembly and shall address all maintenance tasks and restrictions, and emergency procedures, including repair procedures to be used, as specified by the manufacturer or owner. The manual shall include the following as a minimum:

— Hose qualification category including intended application / operational limitations (e.g. SBR, MBR, MWL, MAAT, Buoyancy, MAIE, MACL...);

— hose assembly description;

— diameters (internal and external);

— weight per meter and weight of end fittings, accessories;

— MAWP and test pressures, allowable vacuum if applicable;

— design minimum and maximum temperatures;

— design water depth if applicable;

— installation requirements;

— interface requirements;

— Service life;

— Replacement recommendations after incident above operational limitations. The hose assembly shall be replaced or the fitness for further service shall be assessed by specific inspection techniques.

— inspection procedures including damage or ageing identification methodologies (elongation monitoring, ...);

  The manufacturer should describe which inspection techniques can be used and demonstrate which damage can be detected and which damage cannot be detected in case of incident above operational limitations.

  After such incident the hose assembly should be replaced or at the minimum the fitness for further service shall be assessed which can require special inspections.

  When the owners opt inspections to assess the fitness for service, the manufacturer should specify what inspection techniques can be used and demonstrate what damage can be detected and what damage cannot be detected.

  The manufacturer should demonstrate by tests and/or an engineering assessment that the risk of an LNG/NG spill is low for non-detectable damage. In this assessment both the probability of occurrence and the consequences shall be considered as in EN1474-3:2008. Examples of such assessments are given in Annex D.

— repair procedures (if applicable);

— general maintenance procedure (for day-to-day and/or periodic maintenance as applicable/required, e.g. interval for bolt tensioning, marine growth cleaning etc.);

— handling, storage, winding/unwinding procedures;

— reference for as-built documentation.

If specified by the owner, a separate installation manual shall be supplied, and this shall document the installation procedures.

Annex A
(informative)

Purchasing guidelines table

The first table gives data to be provided by Purchase when specifying a hose assembly, when the second table gives data to be provided by the hose manufacturer

Table A.1 — General purchasing specification parameters

Hose assembly Application		
Hose assembly intermittent / permanent operation (if intermittent specify frequency of use		
Exposed or Protected environment (specify dynamic conditions if applicable)		
Configuration drawings with envelope of motions provided and dynamic loads if applicable		
Intended storage area / conditions		
Internal diameter (mm):		*mm / in*
Length (m):		*m / fr*
Operating pressure (min and max)		*barg / psi*
Fluid density		*kg/m*^{3}
Fluid temperature (mix and max)		*°C*
External temperature (min and max)		*°C*
Transfer flowrate per hose assembly		*m*^{3}*/h*
Maximum allowable pressure drop at maximum flowrate		*barg / psi*
Need for external protection		YES / NO
Need for electrical continuity		YES / NO
End-Fitting connector type		
EN1474–2 Hose Qualification Category requested (A, B or C)		
Type Approval required, if so, to be specified		YES / NO
FAT Witness by 3rd Party required		YES / NO

Table A.2 — General hose assembly parameters from manufacturer

Hose Assembly Technology type		
Hose Assembly Model Name:		
Qualification as per Hose Qualification Category (A, B or C)		
Hose Assembly ID		*mm / In*
Length		*m / ft*
Length tolerances		*mm / in*
End-Fitting termination type		
Hose assembly design temperature (min and max)		*°C*
Weight in air empty		*kg/m*
Weight in air full of LNG		*kg/m*
MAWP (Maximum Allowable Working Pressure)		*barg*
FAT (Factory Acceptance Test) Pressure		*barg*

Table A.2 *(continued)*

Axial Stiffness at atmospheric pressure and ambient temperature		*kN*
Axial Stiffness at atmospheric pressure and cryogenic temperature		*kN*
Axial Stiffness at MAWP and cryogenic temperature		*kN*
Maximum Working Load (under MAWP)		*kN*
Maximum Working Load (without pressure)		*kN*
Breaking Load		*kN*
Torsional Stiffness at atmospheric pressure and ambient temperature		$kN.m^2$
Torsional Stiffness at atmospheric pressure and cryogenic temperature		$kN.m^2$
Torsional Stiffness at MAWP and cryogenic temperature		$kN.m^2$
Maximum Twist		°/*m*
Bending Stiffness at atmospheric pressure and ambient temperature		$kN.m^2$
Bending Stiffness at atmospheric pressure and cryogenic temperature		$kN.m^2$
Bending Stiffness at MAWP and cryogenic temperature		$kN.m^2$
Thermal insulation type		
Heat Ingress		*W/m*
Cooling-down / Warming-up limitations		
Buoyancy Value Empty (if applicable)		%
Buoyancy Value Full of LNG (if applicable)		%
Collapse Resistance (if applicable)		*m*
Leak detection device type and performances		
External protection type if applicable		
Impact Resistance		*J*
Crushing Resistance		*kN*
Storage Bend Radius		*m*
Minimum Bend Radius (for operation)		*m*
Pressure drop at maximum flowrate		*bar / m*
Electrical resistance value between flanges		*Ω*

Annex B
(informative)

Guidelines for additional testing program

B.1 Introduction

EN 1474-2 specifies mandatory hose assembly qualification tests. This is not meant to cover all potential applications. In particularly the hose assembly response over service time and combinations of loads can require additional testing. This appendix therefor contains information that the manufacturer can consider in defining tests in addition to the mandatory tests. Clause B.2 provides some guidelines on combined loads. Clause B.3 provides a damage tolerance philosophy that is applied to impact and crush loads. This philosophy can also be applied to wear, surge pressure, and other events during service life. Clause B.6 through B.8 provide more some guidelines on respectively impact/crush tests, creep and wear.

B.2 Combined loads and in-service conditions to be considered

The mandatory tests cover the effect of pressure, static loads (tension, bending, torsion), bending- fatigue, and normal in-service impact and crush loads. The simultaneously occurrence of combinations of is only partially considered in these tests. As an example, tension in combination with pressure and torsion is included but bending in combination with torsion is not included.

There are several other circumstances that can affect service life and hose assembly performance, such as:

— Effects of ambient climate exposure

— Effects of marine environment

— Incidental loads (such as extreme impact loads and surge pressure)

— Creep (that is the effect of long lasting/continuous loads or deformations)

— Wear (damage to the hose assembly outer surface due to friction).

Above mentioned combined loads and in-service aspects shall be considered in system qualification per EN 1474-3:2008 and can lead to tests in addition to the mandatory hose assembly qualification program. It is recommended that the manufacturer, in view of his market perspective, considers adding some of these aspects to the hose assembly qualification program.

B.3 Damage tolerance philosophy applied to impact and crush loads

A hose assembly can be (partially) made resistant against handling damage and incidents by designing the hose assembly with a certain robustness. Four aspects play a role:

— the magnitude of the “load”,

— the response of the hose assembly to that load,

— the detectability of damage, and

— the consequences for safety.

Each aspect will be introduced below.