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Determination of the resistance to cryogenic spillage of insulation materials —

Part 3: Jet release

Détermination de la résistance des matériaux d'isolation thermique suite à un refroidissement cryogénique —

Partie 3: Émission sous forme de jet

Reference number
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Foreword

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

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

This document was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 9, *Liquefied natural gas installations and equipment*.

A list of all parts in the ISO 20088 series can be found on the ISO website.

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

Introduction

The test is intended to be, as far as practicable, representative of a potential accidental pressurized release of cryogenic liquid natural gas (LNG) manufactured in industrial plants. The test includes:

a) an initial enhanced cooling effect due to the momentum driven liquid contact with the substrate;

b) a localized force that may be expected in a cryogenic jet release.

This test is designed to give an indication of how cryogenic spill protection systems will perform when subjected to a sudden cryogenic jet release.

The dimensions of the test specimen might be smaller than typical items of structure and plant. The liquid cryogenic jet mass flow rates can be substantially less than that which might occur in a credible event. However, the thermal and mechanical loads imparted to the cryogenic spill protection systems from the cryogenic jet release, described in this document, are representative of a cryogenic LNG jet release with hole size 20 mm or less and release pressure less than or equal to 6 barg.

Determination of the resistance to cryogenic spillage of insulation materials —

Part 3:
Jet release

CAUTION — The attention of all persons concerned with managing and carrying out cryogenic spill tests is drawn to the fact that liquid nitrogen testing can be hazardous and that there is a danger of condensing liquid oxygen (fire/explosion), receiving a 'cold burn' and/or the possibility that harmful gases (risk of anoxia) can be evolved during the test. Mechanical and operational hazards can also arise during the construction of the test elements or structures, their testing and disposal of test residues. An assessment of all potential hazards and risks to health shall be made and safety precautions identified and provided. Appropriate training and Personal Protection Equipment shall be given to relevant personnel. The test laboratory is responsible for conducting an appropriate risk assessment in order to consider the impact of liquid and gaseous nitrogen exposure to equipment, personnel and the environment.

1 Scope

This document describes a method for determining the resistance of a cryogenic spill protection (CSP) system to a cryogenic jet as a result of a pressurized release which does not result in immersion conditions. It is applicable where CSP systems are installed on carbon steel and will be in contact with cryogenic fluids.

A cryogenic jet can be formed upon release from process equipment operating at pressure (e.g. some liquefaction processes utilize 40 to 60 bar operating pressure). Due to high pressure discharge, the cryogenic spillage protection can be compromised by the large momentum combined with extreme cryogenic temperature.

Although the test uses liquid nitrogen as the cryogenic liquid, the test described in this document is representative of a release of LNG, through a 20 mm orifice or less, at a release pressure of 6 barg or less, based upon simulated parameters 1 m from the release point. Confidence in this test being representative is based upon a comparison of the expected dynamic pressure of the simulated release in comparison with dynamic pressure from releases in accordance with this document.

It is not practical in this test to cover the whole range of cryogenic process conditions found in real plant conditions; in particular the test does not cover high pressure cryogenic jet releases that might be found in refrigeration circuits and in LNG streams immediately post-liquefaction.

Liquid nitrogen is used as the cryogenic medium due to the ability to safely handle the material at the pressures described in this document. The test condition is run at nominally 8 barg pressure.

ISO 20088-1 covers cryogenic release scenarios which can lead to pooling conditions for steel work protected by cryogenic spill protection as a result of a jet release or low pressure release of LNG or liquid nitrogen. ISO 20088-2 covers vapour phase exposure conditions as a result of a jet release or low pressure release of LNG or liquid nitrogen.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

3.1
cryogenic jet release
unintended exposure to cryogenic liquid as a result of a pressurized release

3.2
cryogenic spill protection
CSP
coating or cladding arrangement, or free-standing system which, in the event of a cryogenic jet release, will provide insulation to restrict the heat transfer rate from the substrate

3.3
limiting temperature
minimum temperature that the equipment, assembly or structure to be protected may be allowed to reach

3.4
nozzle
assembly from which the cryogenic liquid is released as a jet

3.5
sponsor
person or organization that requests a test

3.6
specimen owner
person or company that holds/produces a material to test

4 Test configurations

4.1 General

The configuration under which the test is conducted is where the specimen is placed horizontally at height on suitable supports. The test piece is impacted at the mid-point by a horizontal liquid nitrogen cryogenic jet release. Due to safety concerns, it is proposed that the test should only be performed outside, unless there are sufficient safeguards implemented to mitigate the confined space and liquid nitrogen safety risks.

5 Construction of the test apparatus and substrates

5.1 General

The key items required for the test are:

— a nozzle and cryogenic liquid feeder assembly where the temperature and pressure of the liquid can be measured at the point the liquid enters the reducing diameter pipe to the nozzle;

— liquid nitrogen of sufficient volume for the test duration supplied from a tanker capable of offload via a pump to generate the required stable pressure at the nozzle;

— a carbon steel specimen protected with CSP;

— thermocouples to determine the temperature as a function of time in the steel specimen.

5.2 Material

The steel grade used for the test is to be recorded. Where welded plate girders are used, construction is to be representative of the as-built structure. All dimensions are in millimetres and, unless otherwise stated, the following tolerances shall be used:

— whole number ± 1,0 mm;

— decimal to point ,0 ± 0,4 mm;

— decimal to point ,00 ± 0,02 mm;

— angles ± 0’ 30”;

— radius ± 0,4 mm.

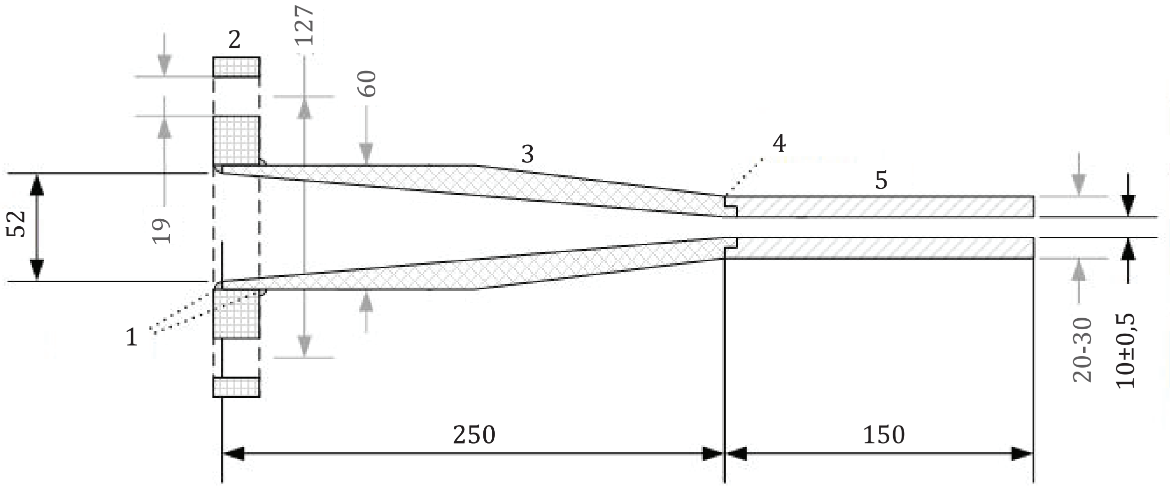
Test specimens shall include as a minimum a beam of designation 406 mm × 178 mm × 60 kg/m or tubular specimen of wall thickness 6,3 mm and outer diameter between 270 mm and 350 mm (including the cryogenic spill protection material). All test specimens are to be 2,5 m in length unless otherwise agreed by the sponsor.

5.3 Release nozzle

5.3.1 Nozzle construction

Liquid nitrogen is released towards the specimen from a nozzle as shown in Figure 1. The nozzle shall be of length (150 ± 1,0) mm, constructed from 10 mm nominal diameter stainless steel pipe with outside diameter of 20 mm to 30 mm, -0,5/+0,5 mm giving a wall thickness between 5 mm and 10 mm. The nozzle shall not be tapered and the end shall be clean cut with no chamfering of pipe walls. The nozzle is fed with liquid nitrogen from a 52,5 mm diameter schedule 40 stainless steel pipe gradually reducing in internal diameter to 10 mm over a length of 200 mm to 250 mm.

Dimensions in millimetres



Key

1 welds
2 slip-on flange
3 reducing section
4 butt weld
5 straight-sided nozzle

Figure 1 — Feed pipe and nozzle construction with a nozzle of 10 mm wall thickness

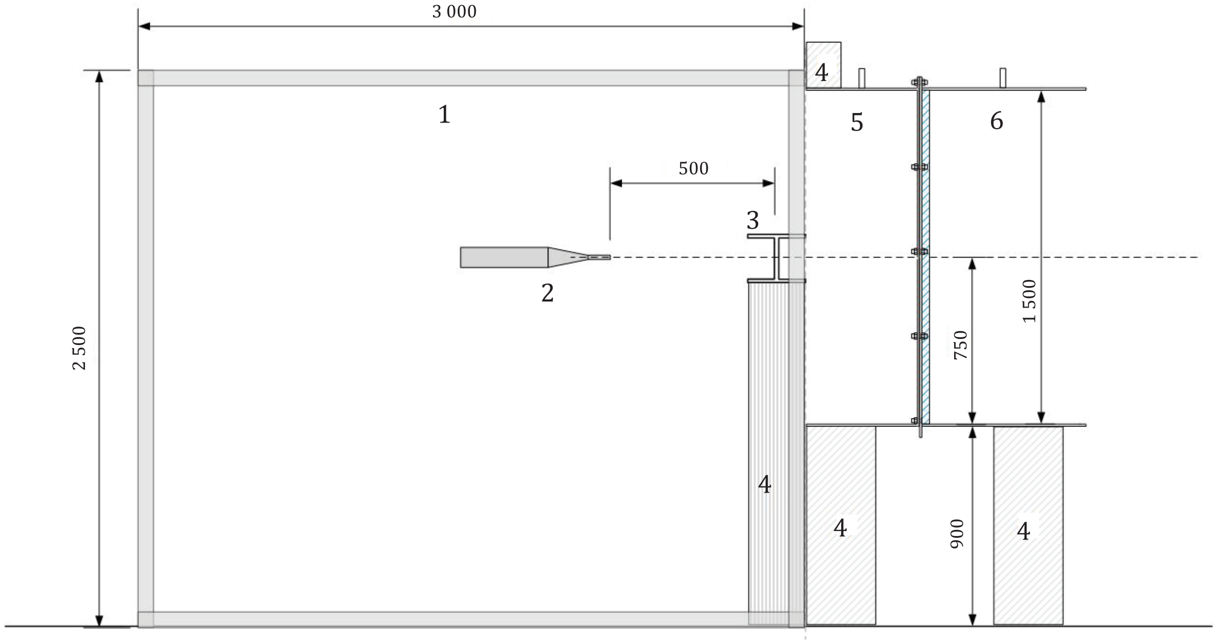
5.3.2 Nozzle position

The nozzle shall be positioned horizontally in front of the test specimen, focussed at the centre point such that the cryogenic jet release impacts normal to the web of the beam [dry film thickness (DFT) measurement point 7] or normal to a tangent drawn where the radius of the tube intersects the centre point of the tubular (DFT measurement point 3) as shown in Figure 4. The tip of the nozzle shall be located (500 ± 10) mm from the protected surface of the test specimen as shown in Figure 2.

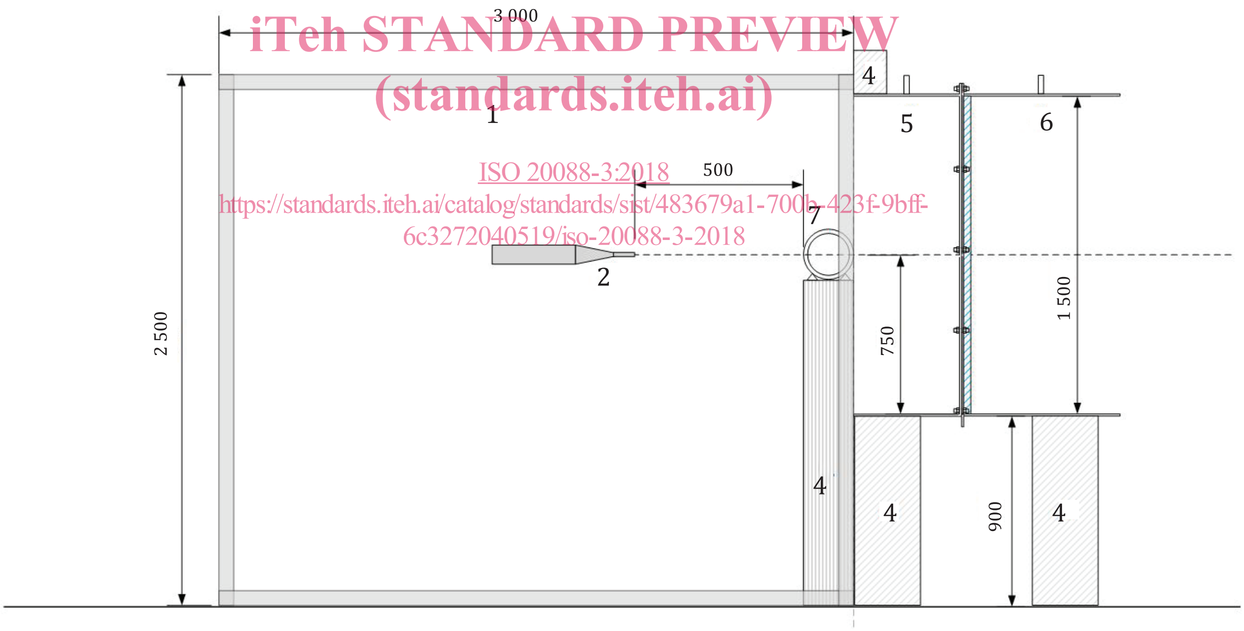
5.4 Specimen support

A generic support shall be used to hold and support the test specimen. The support shall be fabricated from a material resistant to cryogenic temperatures. It is the responsibility of the test laboratory to ensure proper design of such an item and to ensure that pool formation of cryogenic liquid cannot occur and come in contact with the sample (for tubular specimens, no liquid should be allowed to enter the inside of the specimen). An example is given in Figure 2 with more detailed figures showing the overall test configuration in Annex B.

Dimensions in millimetres



a) Beam configuration (side view — including environmental chamber)



b) Pipe configuration (side view — including environmental chamber)

Key

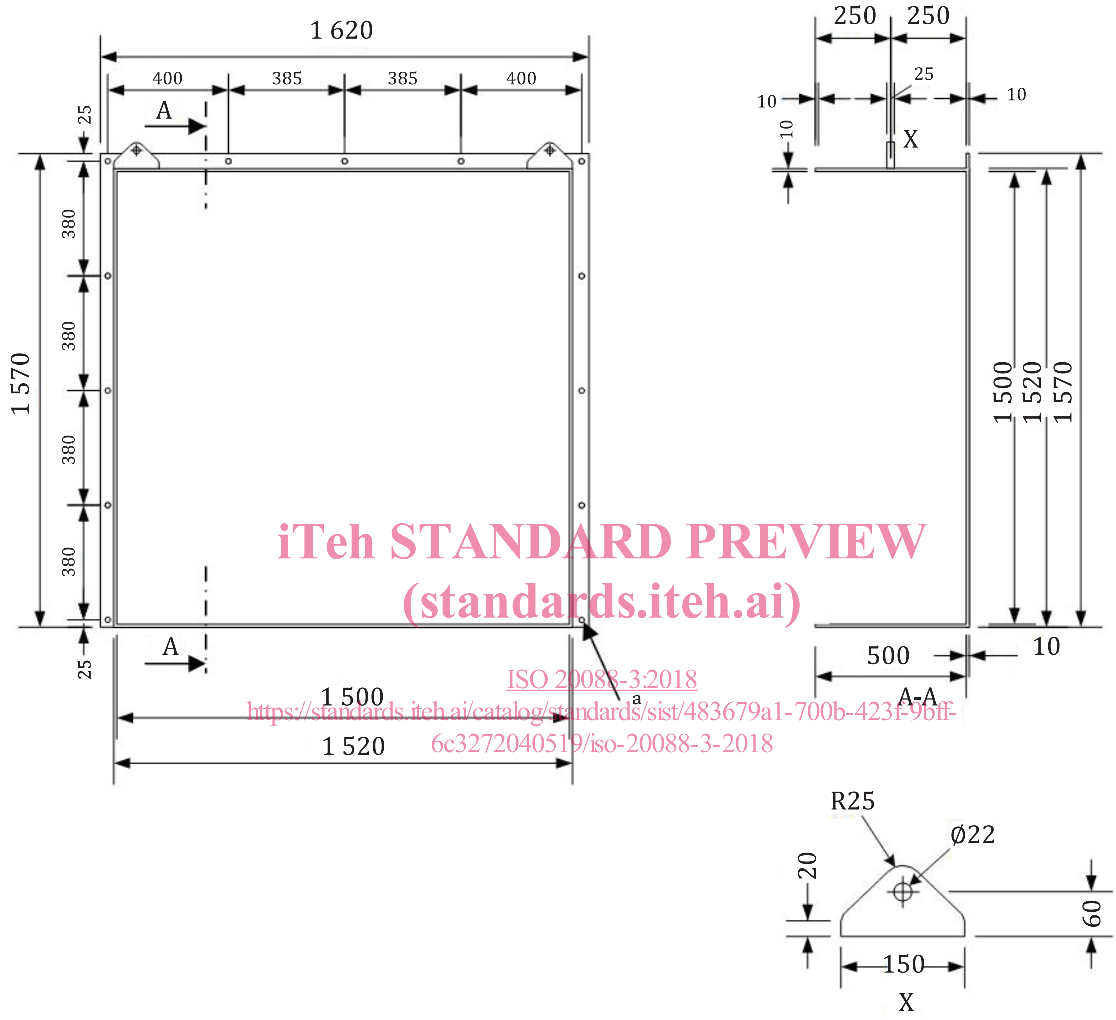
1	environmental chamber
2	release nozzle (8 ± 0,8) barg (average pressure ±standard deviation)
3	specimen (beam shown)
4	specimen (and recirculation and protective chambers) supports
5	recirculation chamber (insulated on back surface)
6	protective chamber (support and stability)
7	specimen (tubular shown)

Figure 2 — Example of specimen support and side view configuration

5.5 Recirculation chamber

A recirculation chamber as shown in Figure 3 shall be placed behind the specimen to provide the means to standardize the atmospheric test environment. Insulation board (U Value maximum 1,25 W/m^2.K) is to be affixed to the rear of the recirculation chamber. To provide extra support and stability, a steel box is to be attached to the rear of the recirculation chamber as shown in Figure 2 (refer to ISO 22899-1).

Dimensions in millimetres



a Thirteen holes drilled Ø18.

Figure 3 — Recirculation chamber

6 Cryogenic spill protection materials

6.1 General

CSP systems generally come in two forms; wet applied materials/coatings and preformed systems. Preformed systems include boards, tiles, blankets, sandwich panels, etc., and are characterized by systems that include joints and fixings. Preformed systems may be used in conjunction with wet applied materials.

