G3 Liquefied gas cargo and process piping

(1974) (Rev.1 1979) (Rev.2 1997) (Rev.3 Dec 2008)

G3.1 General

G3.1.1 The present texts give the general principles which are applied by Classification Societies for approval and survey of the relevant items of liquefied gas tankers for classification purposes. They do not intend to cover full details of such approval and survey procedures which are to be found in the individual rules of Classification Society.

G3.1.2 Consideration of future technical advances may warrant modifications to the principles and details set forth in the text. IACS will accordingly review continuously these requirements.

G3.1.3 When reference is made in this Requirement to 'Classification Society', only members or associates of IACS are considered.

G3.2 Scope

The requirements here below apply to liquefied gas cargo and process piping including cargo gas piping and exhaust lines of safety valves or similar piping.

Note:

1. The requirements of G3.6 Rev.3 are to be uniformly implemented by IACS Societies for piping components and pumps:

   i) when an application for testing is dated on or after 1 January 2010; or

   ii) which are installed in new ships for which the date of contract for construction is on or after 1 January 2010.

2. The “contract for construction” date means the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder. For further details regarding the date of “contract for construction”, refer to IACS Procedural Requirement (PR) No. 29.

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G3.3 Scantlings for internal pressure

G3.3.1 General

Subject to the conditions stated in G3.3.4, the wall thickness of pipes is not to be less than that determined from the following formula:

$$t = (t_0 + b + c) \Big/ \left(1 - \frac{a}{100}\right) \quad (1)$$

where t = minimum thickness (mm)

t_0 = theoretical thickness (mm)

$t_0 = PD/(2Ke + P)$ when P (N/mm^2)

$t_0 = PD/(20Ke + P)$ when P bar } (2)

P = design pressure (N/mm^2 (bar))

D = outside diameter (mm)

K = allowable stress (N/mm^2) (see G3.3.2)

e = efficiency factor

(i) $e = 1$ for seamless pipes and for longitudinally or spirally welded pipes, delivered by manufactures approved for making welded pipes which are considered equivalent to seamless pipes when nondestructive testing on welds is carried out in accordance with the Rules of the Classification Society.

(ii) in other cases an efficiency factor of less than 1.0 may be required by the Classification Society depending on the manufacturing process.

b = allowance for bending (mm). The value of b is to be chosen so that the calculated stress in the bend, due to internal pressure only, does not exceed the allowable stress. Where such justification is not given, b is to be determined from the following formula:

$$b = \frac{1}{2{,}5}\frac{D}{r}t_0 \quad (3)$$

with r = mean radius of the bend (mm)

c = corrosion allowance (mm). When corrosion or erosion is expected, an increase in wall thickness of the piping is to be provided over that required by other design requirements.
This allowance is to be consistent with the expected life of the piping.

a = negative manufacturing tolerance for thickness (%).

G3.3.2 Design pressure

(a) The design pressure P in the formula (2) of G3.3.1 is the maximum pressure to which the system may be subjected in service.

(b) The greatest of the following design conditions is to be used for piping, piping systems and components as appropriate:

(i) for vapour piping systems or components which may be separated from their relief valves and which may which contain some liquid, the saturated vapour pressure at 45°C, or higher or lower if agreed upon by the Classification Society (see G1.2.5).

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(ii) for systems or components which may be separated from their relief valves and which contain only vapour at times, the superheated vapour pressure at 45°C or higher or lower if agreed upon by the Classification Society (see G1.2.5), assuming an initial condition of saturated vapour in the system operating pressure and temperature; or
(iii) the MARVS of the cargo tanks and cargo processing systems; or
(iv) the pressure setting or the associated pump or compressor discharge relief valve; or
(v) the maximum total discharge or loading head of the cargo piping system; or
(vi) the relief valve setting on a pipe line system.

(c) The design pressure is not to be less than 1 N/mm^2 (10 bar), except for open-ended lines where it is to be not less than 0,5 N/mm^2 (5 bar).

G3.3.3 Allowable stress

For pipes made of steel including stainless steel, the permissible stress to be considered in the formula (2) of G3.3.1 is the lower of the following values:

σ_B /2,7 or σ_F /1,8 *

where σ_B = specified minimum tensile strength at room temperature (N/mm^2)
σ_F = specified lower minimum yield stress or 0,2% proof at room temperature (N/mm^2).

For pipes made of materials other than steel, the allowable stress is to be specially considered by the Classification Society.

G3.3.4 Minimum wall thickness

(a) The minimum thickness is to be in accordance with the Rules of the Classification Society.

(b) Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of piping due to superimposed loads from supports, ship deflection or other causes, the wall thickness is to be increased over that required by G3.3.1, or, if this is impracticable or would cause excessive local stresses, these loads are to be reduced, protected against or eliminated by other design methods.

G3.3.5 Flanges, valves, fittings etc.

(a) For selection of flanges, valves, fittings etc., a recognised Standard is to used taking into account the design pressure defined under G3.3.1.

(b) For flanges not complying with a recognised Standard the dimension of flanges and relative bolts are to be to the satisfaction of the Classification Society.

* At discretion of the Classification Society a safety factor less than 1,8 may be allowed provided a detailed stress analysis according to the method indicated under G3.4 is carried out.

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G3.4 Stress analysis

G3.4.1 When design temperature is -110°C or lower, a complete stress analysis, taking into account all the stresses due to weight of pipes (including acceleration if significant), internal pressure, thermal contraction and loads induced by hog and sag of the ship for each branch of the piping system is to be submitted to the Classification Society. For temperatures above -110°C, stress analysis may be required in relation to design or stiffness of the piping system, choice of materials, etc; in any case, consideration is to be given by the designer to thermal stresses, even though calculations are not submitted.

G3.4.2 This analysis is to take into account the various loads such as pressure, weight of piping with insulation and internal medium, loads due to the contraction, for the various operating conditions. The analysis may be carried out according to the Rules of the Classification Society or to a recognised code of practice.

G3.5 Materials

G3.5.1 Choice and testing of materials used in piping systems are to comply with W1 taking into account the minimum design temperature. However, some relaxation may be permitted in the quality of the material of the open ended vent piping, provided the temperature of the cargo at the pressure relief valve setting is -55°C or greater and provided no liquid discharge to the vent piping can occur. Similar relaxation may be permitted under the same temperature conditions for open ended piping inside cargo tanks, excluding discharge piping and all piping inside of membrane and semi-membrane tanks.

G3.5.2 Materials having a melting point below 925°C are not to be used for piping systems outside the cargo tanks, except for short lengths attached to the cargo tanks, in which case fire resisting insulation should be provided.

G3.6 Tests of piping components and pumps prior to installation on board

G3.6.1 Valves

G3.6.1.1 Prototype Testing

Each size and type of valve intended to be used at a working temperature below -55°C is to be approved through design assessment and prototype testing. Prototype testing to the minimum design temperature or lower and to a pressure not lower than the maximum design pressure foreseen for the valves is to be witnessed in the presence of the Society's representative. Prototype testing is to include hydrostatic test of the valve body at a pressure equal to 1.5 times the design pressure, seat and stem leakage test at a pressure equal to 1.1 times the design pressure, and cryogenic testing consisting of valve operation and leakage verification.

For valves intended to be used at a working temperature above -55°C, prototype testing is not required.

G3.6.1.2 Unit Production Testing

All valves are to be tested at the plant of manufacturer in the presence of the Society's representative. Testing is to include hydrostatic test of the valve body at a pressure equal to 1.5 times the design pressure, seat and stem leakage test at a pressure equal to 1.1 times the design pressure. In addition, cryogenic testing consisting of valve operation and leakage

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verification for a minimum of 10% of each type and size of valve for valves intended to be used at a working temperature below -55°C.

As an alternative to the above, the manufacturer may request the Society to certify a valve subject to the following:

- The valve has been prototype tested as required by 3.6.1.1 for valves intended to be used at a working temperature below -55°C, and
- The manufacturer has a recognized quality system that has been assessed and certified by the Society subject to periodic audits, and
- The quality control plan contains a provision to subject each valve to a hydrostatic test of the valve body at a pressure equal to 1.5 times the design pressure and seat and stem leakage test at a pressure equal to 1.1 times the design pressure. The manufacturer is to maintain records of such tests, and
- Cryogenic testing consisting of valve operation and leakage verification for a minimum of 10% of each type and size of valve for valves intended to be used at a working temperature below -55°C in the presence of the Society's representative.

G3.6.2 Bellows

The following prototype tests are to be performed on each type of expansion bellows intended for use on cargo piping, primarily on those used outside the cargo tank:

- An overpressure test. A type element of the bellows, not precompressed, is to be pressure tested to a pressure not less than five times the design pressure without bursting. The duration of the test is not to be less than 5 minutes.
- A pressure test on a type expansion joint complete with all the accessories (flanges, stays, articlations, etc) at twice the design pressure at the extreme displacement conditions recommended by the Manufacturer. No permanent deformations are allowed.

  Depending on materials it may be required that the test be performed at the minimum design temperature.
- A cycle test (thermal movements). The test is to be performed on a complete expansion joint, which is to successfully withstand at least as many cycles, under the conditions of pressure, temperature, axial movement, rotational movement and transverse movement, as it will encounter in actual service. Testing at room temperature, when conservative, is permitted.
- A cycle fatigue test (ship deformation): the test is to be performed on a complete expansion joint, without internal pressure, by simulating the bellows movement corresponding to a compensated pipe length for at least 2000000 cycles at a frequency not higher than 5 cycles/second. The test is only required when, owing to the piping arrangement, ship deformation loads are actually experienced. The Classification Society may waive performance of the above mentioned tests provided that complete documentation is supplied to establish the suitability of the expansion joints to withstand the expected working conditions.

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When the maximum internal pressure exceeds 0,1 N/mm^2 (1 bar) this documentation is to include sufficient test data to substantiate the design method used, with particular reference to correlation between calculation and test results.

G3.6.3 Cargo Pumps

G3.6.3.1 Prototype Testing

Each size and type of pump is to be approved through design assessment and prototype testing. Prototype testing is to be witnessed in the presence of the Society's representative. Prototype testing is to include hydrostatic test of the pump body equal to 1.5 times the design pressure and a capacity test. For pumps intended to be used at a working temperature below -55°C, the capacity test is to be carried out at the minimum working temperature. After completion of tests, the pump is to be opened out for examination.

G3.6.3.2 Unit Production Testing

All pumps are to be tested at the plant of manufacturer in the presence of the Society's representative. Testing is to include hydrostatic test of the pump body equal to 1.5 times the design pressure and a capacity test. For pumps intended to be used at a working temperature below -55°C, the capacity test is to be carried out at the minimum working temperature.

As an alternative to the above, the manufacturer may request the Society to certify a pump subject to the following:

- The pump has been prototype tested as required by 3.6.3.1, and
- The manufacturer has a recognised quality system that has been assessed and certified by the Society subject to periodic audits, and
- The quality control plan contains a provision to subject each pump to a hydrostatic test of the pump body equal to 1.5 times the design pressure and a capacity test. The manufacturer is to maintain records of such tests.

G3.7 Piping fabrication and joining details

G3.7.1 General

The requirements of this section apply to piping inside and outside the cargo tanks. However, the Classification Society may accept relaxations from these requirements for piping inside cargo tanks and open ended piping.

G3.7.2 Direct connection of pipe lengths (without flanges)

The following types of connections may be considered:

(i) Butt welded joints with complete penetration at the root. For design temperature below -10°C, butt welds are to be either double welded or equivalent to a double welded butt joint. This may be accomplished by use of a backing ring, consumable insert or inert gas back-up on the first pass.
For design pressures in excess of 1 N/mm^2 (10 bar) and design temperatures ≤ -10°C backing rings are to be removed.

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(ii) Slip-on welded joints with sleeves and related welding having suitable dimensions in accordance with the rules of the Classification Society.

(iii) Screwed couplings in accordance with the rules of the Classification Society.
The above mentioned types of connections are allowed dependent upon the diameter of pipes and service, as follows;
joints (i) : all applications
joints (ii) : for open end lines for design temperature down to -55°C for external diameters ≤ 50 mm
joints (iii) : for accessory lines and instrumentation lines with external diameters ≤ 25 mm.

G3.7.3 Flange connections

(a) Flanges are to be of the welding neck, slip-on or socket welding type.

(b) Flanges are to be selected as to type, made and tested in accordance with the Rules of the Classification Society. In particular, for all piping (except open end lines) the following restrictions apply:
(i) For design temperatures < -55°C: only welding neck flanges are to be used.
(ii) For design temperatures < -10°C: slip-on flanges are not to be used in nominal sizes above 100 mm and socket welding flanges are not to be used in nominal sizes above 50 mm.

G3.7.4 Other types of pipes connections

Acceptance of types of piping connections other than those mentioned in G3.7.2 and G3.7.3 may be considered by the Classification Society in each particular case.

G3.7.5 Bellows and expansion joints

(a) If necessary, bellows are to be protected against icing.

(b) Slip joints are not to be used except within the cargo tanks.

G3.7.6 Welding, post-weld heat treatments and nondestructive tests

(a) Welding is to be carried out in accordance with W1.

(b) Post-weld heat treatments are required for all butt welds of pipes made with carbon-manganese and low alloy steels.
The Classification Society may waive the requirement for thermal stress relieving for pipes having a wall thickness less than 10 mm in relation to the design temperature and pressure of the concerned piping system.

(c) In addition to normal procedures before and during the welding and also visual inspection of the finished welds, as necessary for proving that the manufacture has been carried out in a correct way according to the requirements, the following inspections are required:
(i) 100% radiographic testing of butt welded joints for piping systems with service temperatures lower than -10°C and with inside diameters of more than 75 mm or wall thickness greater than 10 mm.
(ii) For butt welded joints of pipes not included in (i), spot radiographic controls or other non-destructive controls are to be carried out at the discretion of the Classification

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Society depending upon service, position and materials. In general at least 10% of butt welded joints of pipe are to be radiographed.

G3.8 Tests onboard

G3.8.1 General

The requirements of this section apply to piping inside and outside the cargo tanks. However, the Classification Society may accept relaxations from these requirements for piping inside cargo tanks and open ended piping.

G3.8.2 Pressure tests (strength and leak test)

(a) After assembly, all cargo and process piping should be subjected to a hydrostatic test to at least 1,5 times the design pressure. However, when piping systems or parts of systems are completely manufactured and equipped with all fittings, the hydrostatic test may be conducted prior to installation aboard ship. Joints welded on board should be hydrostatically tested to at least 1,5 times the design pressure. Where water cannot be tolerated and the piping cannot be dried prior to putting the system into service, proposals for alternative testing fluids or testing means should be submitted to the Classification Society for approval.

(b) After assembly on board each cargo and process piping system is to be subjected to a leak test (by air, halides, etc.) to a pressure depending on the leak detection method applied.

G3.8.3 Functional tests

All piping systems including valves, fittings and associated equipment for handling cargo or vapours are to be tested under normal operating conditions not later than at the first loading operation.

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