

# G3 Liquefied gas cargo and process piping

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## G3.1 General

G3.1.1 The present texts give general principles 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 rules of each 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.

## G3.2 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 July 2010; and
  - ii) which are installed in new ships for which the date of contract for construction is on or after 1 July 2010.
2. The requirements of G3.6 Rev.4 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 2012; and
  - ii) which are installed in new ships for which the date of contract for construction is on or after 1 January 2012.
3. The requirements of G3.6 Rev.5 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 2014; and
  - ii) which are installed in new ships for which the date of contract for construction is on or after 1 January 2014.
4. The requirements of G3.6 Rev.6 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 2017; and
  - ii) which are installed in new ships for which the date of contract for construction is on or after 1 January 2017.
5. The “contracted 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.
6. Rev.7 of this UR is 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 2021; or
  - ii) which are installed in new ships for which the date of contract for construction is on or after 1 January 2021.

## G3 (cont)

### G3.3 Scantlings for internal pressure

#### G3.3.1 Piping Scantlings

Piping systems are to be designed in accordance with recognized standards acceptable to the Classification Society.

#### G3.3.2 Design pressure

- (a) The design pressure  $P$  in the formula in G3.3.4 (a) 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, based on the cargoes being carried:
  - (i) for vapour piping systems or components which may be separated from their relief valves and which may contain some liquid, the saturated vapour pressure at 45°C, or higher or lower values, if agreed upon by the Classification Society, may be used (see 4.13.2.2 of the IGC Code).
  - (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 values, if agreed upon by the Classification Society, may be used (see 4.13.2.2 of the IGC Code), assuming an initial condition of saturated vapour in the system operating pressure and temperature; or
  - (iii) design conditions defined in 5.4.2.3 to 5.4.2.5 of the IGC Code (Resolution MSC.370(93)).
- (c) The minimum design pressure is not to be less than the value defined in 5.4.1 of the IGC Code (Resolution MSC.370(93)).
- (d) The additional requirements regarding surge pressures defined in 5.4.3 of the IGC Code (Resolution MSC.370(93)) are to be complied with.
- (e) The design pressure of the outer pipe or duct of gas fuel systems are not to be less than the value defined in 5.4.4 of the IGC Code (Resolution MSC.370(93)).

#### G3.3.3 Allowable stress

For pipes, the allowable stress  $K$  referred to in the formula in G3.3.4 (a) is the lower of the values defined in 5.11.3.1 of the IGC Code (Resolution MSC.370(93)).

#### G3.3.4 Minimum wall thickness

- (a) The wall thickness of pipes is not to be less than that determined from the following formula:

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

- where
- $t$  = minimum thickness (mm)
  - $t_0$  = theoretical thickness (mm)
  - $t_0 = PD/(2Ke + P)$

## G3 (cont)

$P$  = design pressure (MPa)  
 $D$  = outside diameter (mm)  
 $K$  = allowable stress (N/mm<sup>2</sup>) (see G3.3.3)  
 $e$  = 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 non destructive 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:

$$b = \frac{1}{2,5} \frac{D}{r} t_0$$

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 (%).

- (b) The minimum thickness is to be in accordance with recognized standards acceptable to the Classification Society.
- (c) The additional requirements in 5.11.2.4 of the IGC Code (Resolution MSC.370(93)) are to be complied with.
- (d) In fuel gas piping systems of design pressure greater than the critical pressure, the tangential membrane stress of straight section of pipe or ducting shall be according to 5.11.4 of the IGC Code (Resolution MSC.370(93)).

### 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 5.4 of the IGC Code (Resolution MSC.370(93)).
- (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.
- (c) The design and installation of expansion bellows shall be in accordance with recognized standards acceptable to the Classification Society and to be fitted with means to prevent damage due to over-extension or compression.

**G3**  
(cont)**G3.4 Stress analysis**

G3.4.1 When design temperature is  $-110^{\circ}\text{C}$  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  $-110^{\circ}\text{C}$ , 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 5.12.1 and 5.12.2 of the IGC Code (Resolution MSC.370(93), Corr.1) and with W1 taking into account the minimum design temperature.

G3.5.2 For an outer pipe or duct equipped with mechanical exhaust ventilation having a capacity of at least 30 air changes per hour, the effects of both pressure and possible low temperature in the event of a high pressure line failure shall be taking into account

G3.5.3 Where the cargo piping system is of a material susceptible to stress corrosion cracking in the presence of a salt-laden atmosphere, requirements of 5.12.4 of the IGC Code (Resolution MSC.370(93)) are to be complied with.

**G3.6 Tests of piping components and pumps prior to installation on board****G3.6.1 Valves****G3.6.1.1 Prototype Testing**

Each type of valve intended to be used at a working temperature below  $-55^{\circ}\text{C}$  shall be subject to the type tests defined in 5.13.1.1.1 to 5.13.1.1.3 of the IGC Code (Resolution MSC.370(93)).

For emergency shutdown valves, with materials having melting temperatures lower than  $925^{\circ}\text{C}$ , the type testing shall include a fire test to a standard acceptable to the Classification Society.

**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 for all valves, seat and stem leakage test at a pressure equal to 1.1 times the design pressure for valves other than safety valves. In addition, cryogenic testing consisting of valve operation and leakage verification for a minimum of 10% of each type and size of valve for valves other than safety valves intended to be used at a working temperature below  $-55^{\circ}\text{C}$ . The set pressure of safety valves is to be tested at ambient temperature.

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For valves used for isolation of instrumentation in piping not greater than 25mm, unit production testing need not be witnessed by the surveyor. Records of testing are to be available for review.

As an alternative to the above, if so requested by the relevant Manufacturer, the certification of a valve may be issued subject to the following:

- The valve has been approved 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 for all valves and seat and stem leakage test at a pressure equal to 1.1 times the design pressure for valves other than safety valves. The set pressure of safety valves is to be tested at ambient temperature. 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 other than safety 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 prototype tests defined in 5.13.1.2.1 to 5.13.1.2.4 of the IGC Code (Resolution MSC.370(93)) are to be performed on each type of expansion bellows intended for use on cargo piping outside the cargo tank and where required by the Administration or recognized organization acting on its behalf, on those installed within the cargo tanks.

**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.

In lieu of prototype testing, satisfactory in-service experience, of an existing pump design approved by a Society submitted by the manufacturer may be considered.

Prototype testing is to include hydrostatic test of the pump body equal to 1.5 times the design pressure and a capacity test. For submerged electric motor driven pumps, the capacity test is to be carried out with the design medium or with a medium below the minimum working temperature. For shaft driven deep well pumps, the capacity test may be carried out with water. In addition, for shaft driven deep well pumps, a spin test to demonstrate satisfactory operation of bearing clearances, wear rings and sealing arrangements is to be carried out at the minimum design temperature. The full length of shafting is not required for the spin test, but must be of sufficient length to include at least one bearing and sealing arrangements. After completion of tests, the pump is to be opened out for examination.

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(cont)**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 submerged electric motor driven pumps, the capacity test is to be carried out with the design medium or with a medium below the minimum working temperature. For shaft driven deep well pumps, the capacity test may be carried out with water.

As an alternative to the above, if so requested by the relevant Manufacturer, the certification of a pump may be issued subject to the following:

- The pump has been approved 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 types of connections defined in 5.8.2.1 to 5.8.2.3 of the IGC Code (Resolution MSC.370(93)) may be considered.

**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. For all piping (except open end lines) the restrictions defined in 5.8.3.2.1 and 5.8.3.2.2 of the IGC Code (Resolution MSC.370(93)) apply.

**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**

Where bellows and expansion joints are provided, requirements in 5.8.4 of the IGC Code (Resolution MSC.370(93)) are to be complied with.

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(cont)**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, 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 or ultrasonic inspection testing of butt welded joints for piping systems with service temperatures lower than  $-10^{\circ}\text{C}$ , 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 Society depending upon service, position and materials. In general at least 10% of butt welded joints of pipe are to be subjected to radiographic or ultrasonic inspection.

**G3.8 Tests onboard****G3.8.1 General**

The requirements of this section apply to piping inside and outside the cargo tanks.

**G3.8.2 Pressure tests (strength and leak test)**

- (a) After assembly, all cargo and process piping should be subjected to a strength test with a suitable fluid in accordance with 5.13.2.2 of the IGC Code (Resolution MSC.370(93)).
- (b) The additional requirements regarding leak tests defined in 5.13.2.3 of the IGC Code (Resolution MSC.370(93)) are to be complied with.
- (c) The additional requirements regarding double wall gas-fuel piping system defined in 5.13.2.4 of the IGC Code (Resolution MSC.370(93)) are to be complied with.

**G3.8.3 Functional tests**

All piping systems including all 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, in accordance with recognized standards acceptable to the Classification Society.

**G3.9 Cargo piping insulation system**

G3.9.1 Requirements regarding cargo piping insulation in 5.12.3.1 and 5.12.3.2 of the IGC Code (Resolution MSC.370(93)) are to be complied with.

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