
G2 Liquefied gas cargo tanks and process pressure vessels

G2.1 General

(1974)
(Rev. 1 1979)

G2.1.1 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 purpose. 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 Societies.

G2.1.2 Where appropriate, these Rules refer to the basic tank types which are defined under G1.2. Tanks differing from these definitions will be the subject of special consideration.

G2.1.3 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.

G2.1.4 When reference is made in this Requirement to 'Classification Society', only members or associates of IACS are considered. ◀

G2.2 Scope

(1974)
(Rev. 1 1979)

The requirements here below apply to independent cargo tanks type C (pressure cargo tanks) such as defined in G1. They may also apply to process pressure vessels if required by the Classification Society. The words 'pressure vessels' are used in this text to cover the two above-mentioned categories. These requirements apply to tanks and vessels made of materials defined in W1. ◀

G2.3 Calculation of thickness under internal pressure

(1974)
(Rev. 1 1979)

G2.3.1 General

The thickness and form of pressure containing parts of pressure vessels under internal pressure, including flanges, are to be determined according to Rules of the Classification Society. These calculations are to be based in all cases on generally accepted pressure vessel design theory. Openings in pressure containing parts of pressure vessels are to be reinforced in accordance with the Rules of the Classification Society.

G2.3.2 Design pressure

For calculation according to G2.3.1, the design liquid pressure defined under G1.3.2 is to be taken into account.

G2.3.3 Efficiency factor for welded joints ▶

The welded joint efficiency factor to be used in calculation according to G2.3.1 is to be 0,95 when the inspection and nondestructive examination stated under G2.8.2 (i) are carried out.

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This figure may be increased up to 1,0 taking into account other considerations, such as materials used, type of joints, welding procedure, type of loading, etc. For process pressure vessels, the Classification Society may accept partial nondestructive examinations, but not less than those under G2.8.2 (ii) may be allowed depending on the material used, the design temperature, the nil ductility temperature of the material as fabricated, the type of joint, welding procedure, etc., but in this case the efficiency factor 0,85 is to be adopted.

For special materials, the above mentioned factors are to be reduced depending on the specified mechanical properties of the welded joint.

G2.3.4 Maximum allowable membrane stress

The maximum allowable membrane stress to be used in calculation according to G2.3.1 is to be the lower of the following values:

$$\frac{\sigma_B}{A} \text{ or } \frac{\sigma_F}{B}$$

where A and B are defined in G1.5.1(d) σ_B and σ_F are defined in G1.5.1(h).

The above properties are to correspond to the minimum specified mechanical properties of the material, including the weld material in the as fabricated condition. Subject to special condition by the Classification Society, advantage may be taken of enhanced yield stress and tensile strength at a low temperature.

G2.3.5 Corrosion allowance

No corrosion allowance is generally required if the contents of the pressure vessel are judged to be non-corrosive and the external surface is also protected by inert atmosphere or by an appropriate insulation with an approved vapour barrier, etc. Paint or other thin coatings exposed to weather or mechanical damage are not to be credited as external protection. Also in the case of use of special alloys with acceptable corrosion resistance, no corrosion allowance is required. If the above conditions are not satisfied, the thickness calculated according to G2.3.1 is to be increased as appropriate for the product carried.

G2.3.6 Manufacturing plate tolerance

The thickness calculated according to G2.3.1 or the thickness required by G2.4 plus the corrosion allowance, if any, is to be considered as a minimum, without any negative tolerance.

G2.3.7 Minimum thickness of shell and heads

The thickness, including corrosion allowance, after forming of any shell and head is not to be less than 5mm for C-Mn steels and Ni steels, 3 mm for austenitic steel or 7 mm for aluminium alloy. ◀

G2.4 Buckling criteria

(1974)
(Rev. 1979)

G2.4.1 General

The thickness and form of pressure vessels subject to external pressure and other loads causing compressive stresses are to be calculated according to the Rules of the Classification Society. These calculations in all cases are to be based on generally accepted pressure vessel buckling theory and are to adequately account for the difference in theoretical and actual buckling stress as a result of plate edge misalignment, ovality and deviation from true circular form over a specified arc or chord length.

G2.4.2 Design external pressure

The design external pressure P_e to be used for verifying the buckling of the pressure vessels is given by the following formula:

$$P_e = P_1 + P_2 + P_3 + P_4 \quad (\text{N/mm}^2) \text{ (bar)} \quad \blacktriangleright$$

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- where P_1 = setting value of vacuum relief valves. For vessels not fitted with vacuum relief valves, P_1 is to be specially considered, but is, in general, not to be taken less than 0,025 N/mm² (0.25 bar).
- P_2 = for pressure vessels or parts of pressure vessels in completely closed spaces: the set pressure of the pressure relief valves for these spaces.
Elsewhere $P_2 = 0$.
- P_3 = compressive actions in the shell due to the weight and contraction of insulation, weight of shell, including corrosion allowance, and other miscellaneous external pressure loads to which the pressure vessel may be subjected. These include but are not limited to weight of domes, weight of towers and piping, effect of product in the partially filled condition, accelerations and hull deflection. The local effect of external and/or internal pressure is also to be taken into account.
- P_4 = external pressure due to head of water for pressure vessels or part of pressure vessels on exposed decks.
Elsewhere $P_4 = 0$. ◀

G2.5 Stress analysis in respect of static and dynamic loads(1974)
(Rev. 1979)

G2.5.1 Pressure vessel scantlings are to be determined in accordance with G2.3 and G2.4.

G2.5.2 Calculations of the loads and stresses in way of the supports and the shell attachment of the support are to be made. Loads as applicable, from G1.3, are to be used. Stresses in way of the supports are to be in accordance with the Rules of the Classification Society.

In special cases, a fatigue analysis may be required by the Classification Society.

G2.5.3 Furthermore, when required by the Classification Society, secondary stresses and thermal stresses are to be specially considered. ◀

G2.6 Welding joints details(1974)
(Rev. 1979)

G2.6.1 All longitudinal and circumferential joints of pressure vessels are to be of butt welded, full penetration, double vee or single vee type. Full penetration butt welds are to be obtained by double welding or by the use of backing rings. If used, backing rings are to be removed, unless specifically approved by the Classification Society for very small process pressure vessels. Other edge preparations may be allowed by the Classification Society depending on the results of the tests carried out at the approval of the welding procedure.

G2.6.2 The bevel preparation of the joints between the pressure vessel body and domes and between domes and relevant fittings are to be designed according to the Rules of the Classification Society for pressure vessels. For design temperature below -10°C, all welds connecting nozzles, domes or other penetrations to the vessel and all welds connecting flanges to the vessel or nozzles, are to be full penetration welds extending through the entire thickness of the vessel wall or nozzle wall, unless specially approved for small nozzle diameters. ◀

G2.7 Stress relieving(1974)
(Rev. 1979)

For pressure vessels made of carbon and carbon-manganese steel, post-weld heat treatment is to be performed after welding if the design temperature is below -10°C. ▶

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Post-weld treatment in all other cases and for materials other than those mentioned above is to be in accordance with the Rules of the Classification Society.

The soaking temperature and holding time are to be in accordance with the Rules of the Classification Society. In the case of large cargo pressure vessels of carbon or carbon-manganese steel for which it is difficult to perform the heat treatment, mechanical stress relieving by pressurizing may be carried out as an alternative to the heat treatment if agreed by the Classification Society and subject to the following conditions:

- complicated welded pressure vessel parts (i.e. domes with nozzles, sumps, etc.) with adjacent shell plates are to be heat treated before they are welded to larger parts of the vessel;
- the plate thicknesses are not to exceed those given by the Rules of the Classification Society for pressure vessels depending on type of materials;
- a detailed stress analysis is to be performed to ascertain that the maximum primary membrane stress during the mechanical stress relieving, closely approaches, but does not exceed, 0,9 times the yield stress of the material. Strain measurements during the stress relief pressurization may be required by the Classification Society for verifying the calculations;
- the procedure for mechanical stress relieving is to be submitted beforehand to the Classification Society for approval. ◀

G2.8 Inspection and nondestructive examination (1974) (Rev. 1979)

G2.8.1 Manufacture and workmanship

The tolerances relating to manufacture and workmanship (i.e. out-of-roundness, local deviations from the true form, welded joints alignment, tapering of plates having different thicknesses, etc.) are to comply with the Rules of the Classification Society. The tolerances are also to be related to the buckling analysis (see G2.4).

G2.8.2 Nondestructive examination

As far as completion and extension of nondestructive checking of welded joints are concerned, the following applies.

The extent of nondestructive examination is to be total or partial according to the Rules of the Classification Society, but the controls to be carried out are not to be less than the following ones:

- (i) *Total nondestructive examination (see G2.3.3)*
 - Radiography
 - butt welds: 100%
 - Surface crack detection
 - all welds: 10%
 - reinforcement rings around holes, nozzles, etc: 100%
 - Ultrasonic testing
 - Ultrasonic testing may be accepted for replacing partially the radiographic examination, if so specially allowed by the Classification Society. In addition the Society may require a total ultrasonic examination on welding of reinforcement rings and holes, nozzles, etc.
- (ii) *Partial nondestructive examination (see G2.3.3)*
 - Radiography
 - butt welds: all welded joints crossing and at least 10% of the full length at selected positions uniformly distributed
 - Surface crack detection
 - reinforcement rings around holes; nozzles, etc 100%
 - Ultrasonic testing
 - as may be required by the Classification Society in each instance. ◀

G2
(cont'd)**G2.9 Pressure testing**
(1974)
(Rev. 1979)

G2.9.1 Each pressure vessel, when completely manufactured, is to be subjected to a hydrostatic test according to the Rules of the Classification Society, at a pressure, measured at the top of the tanks, of not less than $1,5 P_0$, but in no case during the pressure test is the calculated primary membrane stress at any point to exceed 0,9 times the yield stress of material (for definition of P_0 , see G1). To ensure that this condition is satisfied where calculations indicate that this stress will exceed 0,75 times the yield strength, the prototype test is to be monitored by the use of strain gauges or other suitable equipment in pressure vessels except simple cylindrical and spherical pressure vessels.

G2.9.2 The temperature of the water used for test is to be at least 30°C above the nil ductility transition temperature of the material as fabricated.

G2.9.3 The pressure is to be held for two hours per 25mm of thickness but in no case less than two hours.

G2.9.4 Where necessary for cargo pressure vessels, there may be carried out with specific approval of the Classification Society, a hydropneumatic test in the conditions prescribed under G2.9.1, G2.9.2 and G2.9.3.

G2.9.5 Special consideration will be given to testing of tanks in which higher allowable stresses are used depending on service temperature. However, the requirements of G2.9.1 are to be fully complied with.

G2.9.6 After completion and assembly, each pressure vessel and relative fittings are to be subjected to an adequate tightness test.

G2.9.7 Pneumatic testing of pressure vessels other than cargo tanks will be considered on an individual case basis by the Classification Society. Such testing will be permitted only for those vessels which are so designed and/or supported that they cannot be safely filled with water, or for those vessels which cannot be dried and are to be used in a service where traces of the testing medium cannot be tolerated. ◀ ◀

G3 Liquefied gas cargo and process piping**G3.1 General**
(1974)
(Rev. 1 1979)

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
(1974)
(Rev. 1 1979)

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. ◀ ▶