G2 Liquefied gas cargo tanks and process pressure vessels

G2
(1974)
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(Rev.3
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G2.1 General

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 4.1 of ~~IMO Resolution MSC.370(93) Amendments to the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (~~IGC Code~~)~~. 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.

G2.1.5 IGC Code means the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (as amended by IMO Resolutions MSC.370(93), MSC.411(97) and MSC.441(99)).

Note:

1. The Rev.2 of this UR is to be uniformly implemented by IACS Societies for independent cargo tanks type C (pressure cargo tanks) such as defined in 4.23 of the IGC Code:

   i) when an application for certification is dated on or after 1 January 2020; and

   ii) which are installed in new ships for which the date of contract for construction is on or after 1 January 2020.

2. 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.

3. The Rev.3 of this UR is to be uniformly implemented by IACS Societies for independent cargo tanks type C (pressure cargo tanks) such as defined in 4.23 of the IGC Code :

   i) when an application for certification is dated on or after 1 July 2024; and

   ii) which are installed in new ships for which the date of contract for construction is on or after 1 July 2024.

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G2.2 Scope

The requirements here below apply to independent cargo tanks type C (pressure cargo tanks) such as defined in 4.23 of the IGC Code. 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 and the IGC Code.

G2.3 Calculation of thickness under internal pressure

G2.3.1 General

For pressure vessels, the thickness calculated according to 4.23.2.4 of the IGC Code shall be considered as a minimum thickness after forming, without any negative tolerance.

Scantlings based on internal pressure shall be calculated as follows: the thickness and form of pressure containing parts of pressure vessels under internal pressure, including flanges, are to be determined according to the 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 4.13.2 of the IGC Code is to be taken into account in the internal pressure calculations.

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 G2.9.2 (i) are carried out.

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 G2.9.2 (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 stress

The maximum allowable stresses to be used in calculation according to G2.3.1 shall not exceed the value defined in 4.23.3.1 of the IGC Code.

G2.3.5 Corrosion allowance

Corrosion allowance need not be required in addition to the thickness resulting from the structural analysis. However, where there is no environmental control, such as inerting around the cargo tank, or where the cargo is of a corrosive nature, the Classification Society may require a suitable corrosion allowance.

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G2.3.6 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

G2.4.1 General

Buckling criteria shall be as follows: 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:

$$P_e = P_1 + P_2 + P_3 + P_4\,(MPa)$$

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 MPa.

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

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 4.12 to 4.15 of the IGC

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Code, are to be used. Stresses in way of the supports are to be according to a recognized standard acceptable to the Classification Society.

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

G2.5.4 In special cases, a fatigue analysis may be required by the Classification Society.

G2.6 Accident design condition

G2.6.1 The tanks and the tank supporting structures shall be designed for the accidental loads and design conditions specified in 4.3.4.3 and 4.15 of the IGC Code, as applicable.

G2.6.2 When subjected to the accidental loads specified in 4.15 of the IGC Code, the stress shall comply with the acceptance criteria specified in 4.23.3.1 of the IGC Code, modified as appropriate taking into account their lower probability of occurrence.

G2.7 Welding joints details

G2.7.1 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 except from very small process pressure vessels. Other edge preparations may be permitted depending on the results of the tests carried out at the approval of the welding procedure.

G2.7.2 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 a standard acceptable to the Classification Society. 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.

G2.8 Stress relieving

G2.8.1 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. Post-weld treatment in all other cases and for materials other than those mentioned above shall be to recognized standards acceptable to the Classification Society. The soaking temperature and holding time are to be according to the recognized standards acceptable to the Classification Society.

G2.8.2 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 conditions of 6.6.2.3 of the IGC Code.

G2.9 Inspection and nondestructive examination

G2.9.1 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 recognized standards acceptable to the Classification Society. The tolerances are also to be related to the buckling analysis (see G2.4).

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G2.9.2 Nondestructive examination

The extent of nondestructive testing shall be total or partial according to recognized standards acceptable to the Classification Society, but the controls to be carried out shall not be less than the following:

(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

G2.10 Pressure testing

G2.10.1 Each pressure vessel 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, In no case during the pressure test is the calculated primary membrane stress at any point to exceed 90% of the yield stress of material (for definition of P_0, see 4.1.2 of the IGC Code). 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.

G2.10.2 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.

G2.10.3 The pressure is to be held for two hours per 25 mm of thickness but in no case less than two hours.

G2.10.4 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 G2.10.1, G2.10.2 and G2.10.3.

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G2.10.5 Special consideration will be given to testing of tanks in which higher allowable stresses are used depending on service temperature. However, the requirements of G2.10.1 are to be fully complied with.

G2.10.6 After completion and assembly, each pressure vessel and relative fittings are to be subjected to an adequate tightness test which may be performed in combination with the pressure testing referred to in G2.10.1.

G2.10.7 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.

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