Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0 °C and –165 °C —

Part 5: Testing, drying, purging and cool-down

The European Standard EN 14620-5:2006 has the status of a British Standard

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British Standards

National foreword

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English Version

Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0 °C and -165 °C - Part 5: Testing, drying, purging and cool-down

Conception et fabrication de réservoirs en acier à fond plat, verticaux, cylindriques, construits sur site, destinés au stockage des gaz réfrigérés, liquéfiés, dont les températures de service sont comprises entre 0 °C et -165 °C - Partie 5: Essais, séchage, inertage et mise en froid

Auslegung und Herstellung standortgefertigter, stehender, zylindrischer Flachboden-Stahltanks für die Lagerung von tiefkalt verflüssigten Gasen bei Betriebstemperaturen zwischen 0 °C und -165 °C - Teil 5: Prüfen, Trocknen, Inertisieren und Kaltfahren

This European Standard was approved by CEN on 20 February 2006.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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Management Centre: rue de Stassart, 36 B-1050 Brussels

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Contents

Foreword

This European Standard (EN 14620-5:2006) has been prepared by Technical Committee CEN/TC 265 “Site built metallic tanks for the storage of liquids”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2007, and conflicting national standards shall be withdrawn at the latest by March 2007.

EN 14620 *Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0 °C and -165 °C* consists of the following parts:

— Part 1: General;

— Part 2: Metallic components;

— Part 3: Concrete components;

— Part 4: Insulation components;

— Part 5: Testing, drying, purging and cool-down.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

This European Standard specifies the requirements for testing, drying, purging and cool-down of the refrigerated liquefied gas storage tanks.

This European Standards deals with the design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0 °C and –165 °C.

2 Normative references

The following referenced documents are indispensable for the application of this European Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 14620-1:2006, *Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0°C and –165 °C — Part 1: General*

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 14620-1:2006 apply.

4 Hydrostatic and pneumatic testing

4.1 Hydrostatic test

4.1.1 General

A hydrostatic test shall be carried out. The hydrostatic test shall demonstrate that:

— tank is designed and constructed to contain the product (no leakage);

NOTE A leakage test is not applicable for membrane tanks. Instead an ‘ammonia test’ is carried out on the membrane after completion of welding. An ammonia sensitive paint is applied on the weld seam on the inside of the tank. Ammonia vapour is introduced in the insulation space and in case of a leak the ammonia will react with the paint resulting in a change of colour from yellow to blue. In order to calibrate the test, reference holes are made in the membrane so that proper performance of the inspection method is ensured. After closing of all leaks, another test is carried out. The paint on the inside of the tank is removed by ‘vacuum cleaning’. For reference, the NF A 09-107 note.

— foundation is able to support the tank contents.

4.1.2 Test requirements for each type of tank

For the various tank types, the hydrostatic test shall be carried out in accordance with Table 1.

The contractor shall prepare a specification with all the actions to be taken. The test results shall be documented.

Table 1 — Hydrostatic test requirements

Contents	Single containment	Double containment	Full containment	Membrane tank
Ammonia, butane, propane, and propylene	**Tank** (type II-III steels): FH	**Inner tank** (type I-II steels): FH	**Inner tank** (type I-II steels): FH	
		Outer tank (type I-II steels): FH	**Outer tank** (type I-II steels): FH	
		Outer tank (pre-stressed conc): No test (see NOTE 2)	**Outer tank** (pre-stressed conc): No test (see NOTE 2)	**Outer tank** (pre-stressed conc): PH (see [a])
Ethane, Ethylene and LNG	**Tank** (type IV steel): PH	**Inner tank** (type IV steel): PH	**Inner tank** (type IV steel): PH	
		Outer tank steel (type IV steel): PH	**Outer tank steel** (type IV steel): PH	
		Outer tank (pre-stressed conc): No test (see NOTE 2)	**Outer tank** (pre-stressed conc): No test (see NOTE 2)	**Outer tank** (pre-stressed conc): PH (see NOTE 2)

[a] In the case of a membrane tank, the membrane can't be hydrostatically tested. To ensure that the foundation is able to support the tank contents and the tank integrity is ensured, the concrete outer tank shall be hydrostatically tested before the insulation and membrane are installed.

NOTE 1 FH means Full height hydrostatic test;

PH means Partial height hydrostatic test.

NOTE 2 Hydrostatic testing of the pre-stressed concrete outer tank is not required, see prEN 14620-3:2005, A.2.

4.1.3 Additional requirements

The following additional requirements shall apply:

- for a full height hydrostatic test, the inner tank shall be filled to the maximum design liquid level. The same quantity of water shall be used for testing of the outer tank;
- for a partial height hydrostatic test of the inner tank, the test level shall be equal to 1,25 times the height of the maximum design liquid level multiplied by the density of the specified product to be stored. The same quantity of water contained shall be used for testing of the outer tank;
- when outer tanks are hydrostatically tested, a suitable water barrier shall be provided to prevent that test water ingress in to the bottom insulation;
- care shall be taken during filling of the annular space that water levels are controlled and regulated to prevent differential levels between the inner and annular spaces;
- hydrostatic test shall not be carried out until all welded accessories to the shell and the bottom of the tank are in place. Welding shall not be allowed after completion of the hydrostatic test;
- for tanks which are to be insulated with perlite powder, the hydrostatic test shall be carried out before installation of the perlite powder;
- test level of a membrane tank shall be based on the partial hydrostatic test requirement indicated above;
- contractor shall ensure that the quality of the water is such that no damage to the steel/concrete can occur.

4.1.4 Quality of the water

The suitability of the water for hydrostatic testing shall be demonstrated. Special attention shall be paid to possible corrosion.

The following types of corrosion shall be considered:

- general corrosion;
- galvanic corrosion

NOTE 1 galvanic corrosion (fresh and seawater) is an electrochemical form of corrosion that can occur when a metal or alloy is electrically connected to another metal or alloy with a different electrochemical potential. Both metals should be exposed to a common electrolyte and electrical path. Welding of metals can lead to dissimilar metal compositions between the weld, Heat Affected Zone (HAZ) and the plate material. The most anodic material area will corrode because of the galvanic effect with the cathodic material areas.

- localised corrosion (pitting, under deposit corrosion, bacterial corrosion);

NOTE 2 localised corrosion will occur under circumstances that promote the formation of localised cells:

1. presence of deposits and or solids;
2. presence of sulphate reducing bacteria;
3. locations where a low oxygen content is present.

Deposits or solids, present in the seawater, may settle down on the steel surface during hydrostatic testing and localised corrosion cells may develop. This can lead to high corrosion penetration rates.

NOTE 3 The main corrosion concerns, when using seawater during hydrostatic testing of 9 % nickel steel tanks, are:

1) galvanic activity between plate material, weld and HAZ;

2) when soils/deposits are present in the seawater, localised corrosion when cells can develop;

3) effect of sulphate reducing bacteria resulting in sour “corrosive” environment and possible formation of hydrogen;

4) protection of stainless steel internal components and exposed flange gasket surfaces;

5) removal/prevention of dried mineral deposits resulting from draining of sea water.

The need for cathodic protection should be investigated to avoid galvanic corrosion and to reduce general corrosion. Cathodic protection promotes the cathodic reaction, which in de-aerated conditions (under deposits) generates hydrogen and therefore increases the risk of hydrogen stress cracking, if H_2S is present at the same time.

The cathodic protection system shall be designed so that the risk of hydrogen embrittlement is avoided.

If the required water quality can’t be achieved then alternative test methods utilizing suitable inhibitors shall be considered.

In view of discharge of the water, the environmental impact shall be investigated.

4.1.5 Conditions of implementation

Before the start of the test, the tank shall be cleaned. Any spatter and slag shall be removed from the welds, and all materials, objects or temporary installations used during its construction, shall also be removed.

A permanent or temporary pressure relief system shall be used during the test. The pressure relief system shall have sufficient capacity to ensure that the internal positive and negative test pressures do not exceed those specified in the design of the tank. A water column gauge shall also be used to measure the pressure.

NOTE A corrosion inhibitor may be required.

4.1.6 Examination during filling

4.1.6.1 Peripheral level check

Before filling, the following markers shall be installed on the outer surface of the tank:

— four markers for tanks with a diameter ≤ 10 m;

— eight markers for tanks with a larger diameter.

Markers shall also be installed on the inner tank shell, in double and full containment tank systems, so that settlement of the inner tank can be monitored simultaneously with that of the outer tank.

The markers shall be of such a type that they remain visible/usable after the tank is painted.

The settlement of the tank shall be monitored during the filling and emptying of the tank. As a minimum, this shall be done when the tank is half full, three-quarters full and full.

4.1.6.2 Bottom surface level check

For tanks, where bottom differential settlements of more than 30 mm can be expected (e.g. tanks with raft foundation), provisions shall be provided so that the settlements in the centre of the tank can be monitored.

NOTE An inclinometer may be used.

4.1.7 Filling

The rate of filling shall be determined based on water/equipment availability and subsoil conditions.

The full water load shall be maintained for at least 24 h. During the test, a visual inspection of the shell welds for possible leakage shall be carried out.

The tightness of all welded joints above the test water level of an open top tank shall be inspected by vacuum box testing.

The anchors, if present, shall be adjusted when the water is at a constant height (at least 70 % of the maximum design liquid level).

During the work, the observed settlements shall be compared with the predicted values. If differences occur, the geotechnical expert, involved in the foundation design, shall be consulted (see EN 14620-1:2006, 7.1.9) and the purchaser shall be informed.

4.2 Pneumatic test

4.2.1 Pressure test

A pressure test shall be carried out at a test pressure equal to 1,25 times the design pressure of the tank.

The test pressure shall be applied to the vapour space above the test water, except that in the case of a double wall tank with open-top inner tank, the inner tank may be completely or partially emptied of water before the pressure test.

The following actions shall be considered:

— pressure relief valves shall be adjusted to open at the test pressure, or provide a temporary pressure relief system to prevent the pressure exceeding the test pressure. The test pressure, when reached, shall be held for at least 30 min. Thereafter the test pressure shall be reduced to the design pressure;

— soap solution test of all welded joints, subjected to the pressure test, shall be performed;

NOTE 1 If the joint has previously been vacuum box tested, the soap solution test may be substituted by visual inspection.

— repairs shall not be made while the tank is under pressure;

NOTE 2 Repairs may be made later and individually vacuum box tested.

— pressure shall be reduced and pressure relief valves shall be adjusted to open at the design pressure. The set pressure of the pressure relief valve shall be verified by pumping air into the vapour space.

4.2.2 Negative pressure test

A negative pressure test shall be carried out at a pressure equal to the design internal negative pressure of the tank.

NOTE 1 A minimum holding time is not required. The test may be terminated as soon as the design internal negative pressure has been reached.

NOTE 2 The negative pressure test should be carried out while there is still water in the tank. This will prevent possible uplift of the bottom and the thermal protection system (TPS).

The following actions shall be considered:

— vacuum relief valves shall be installed, which shall have been adjusted to open at the negative test pressure, or provide a temporary vacuum relief system to prevent the negative pressure exceeding negative test pressure;

— all openings shall be closed except those of the vacuum relief valves. The required negative pressure may be obtained by lowering the water level or by the use of an air-ejector;

— negative pressure shall be reduced and the vacuum relief valves shall be adjusted to open at the specified set pressure. The set pressure of the vacuum relief valve shall be verified by withdrawing water or using an air-ejector.

4.2.3 Empty checks

When the tank is at atmospheric pressure, has been emptied, dried and cleaned (all residue and sludge removed and cleaned with broom), the following actions shall be considered:

— anchorage, if provided, shall be re-checked for tightness against the hold-down brackets;

— air pressure, equal to the design pressure, shall be applied to the empty tank, and the anchorage, if provided, and the foundation shall be checked for uplift;

— bottom shall be checked for abnormalities and all bottom welds shall be vacuum box tested again;

— when bottom connections are fitted, all welds shall be inspected by 100 % visual inspection and 100 % dye penetrant or magnetic particle examination;

— metallic wall liners fitted to the inner surfaces of the concrete outer tanks shall be visually inspected.

5 Drying, purging and cool-down

5.1 Procedures

Procedures shall be prepared for the drying, purging and cool-down of the tank. The purging and cool-down shall be carried out on a continuous basis and the procedures shall take into account contingency plans for the interruption to any phase of the procedure.

5.2 Drying

The tank contents shall be dried to a maximum dew point of –20 °C.

NOTE When the annular space is filled with perlite powder, then a maximum dew point of – 8 °C can be tolerated for the annular space.

For the bottom insulation space(s) no requirements apply.

5.3 Purging

The tank shall be purged before hydrocarbons are introduced. An inert gas shall be used.

NOTE 1 In general, nitrogen is used.

Purging shall be carried out until the following oxygen concentrations are reached:

— 9 % for butadiene, butane, propylene and propane tanks;

— 12 % for ammonia tanks;

— 8 % for ethylene and ethane tanks;

— 9 % for LNG tanks.

For the bottom insulation space(s) no requirement shall apply.

At critical points (bottom and top of inner tank, dome space and bottom of annular space if applicable), sample points shall be provided so that it can be demonstrated that the required purging is carried out.

NOTE 2 For full containment tanks, purging should be carried out from the inner tank to the annular space so that inward pressure on the inner tank is prevented.

NOTE 3 The presence of an inert gas, e.g. nitrogen, during cool-down may result in sub-cooling of the steel below its design temperature e.g. butane tank to –45 °C, propane tank to –70 °C and LNG tank to –180 °C. It is strongly recommended that this possible sub-cooling be prevented by the replacement of the nitrogen by warm product vapours prior to cool-down.

When hydrocarbons are introduced, significant amounts of flash vapour can be generated. Adequate vapour relief (to flare or vent) shall be installed to cover for the flash volume likely to be generated.

5.4 Cool-down

Cool-down of the primary container shall be carried out in a controlled manner to prevent major temperature differences occurring during the cool-down. The temperature of the inner tank/membrane steel shall be monitored and kept in a tolerable range.

NOTE For more details, see Annex A.

6 Decommissioning

The contractor shall make all necessary arrangements that the tank can be decommissioned in a safe manner. A procedure shall be prepared for possible decommissioning. This procedure shall be considered by the purchases if decommissioning is necessary.

In principle the decommissioning procedure the same actions as taken at the commissioning procedure but then reverse is normally used.

If leakage of the tank or other abnormalities took place, then special measures shall be taken to ensure safe decommissioning.

Annex A
(informative)

Cool-down of the tank

Cool-down is usually carried out with liquefied gas.

Cool-down procedure and the facilities should be designed carefully because it should prevent great temperature differences being generated in the steel plate, thus causing high stresses. These temperature stresses, in combination with mechanical stresses caused by bending, welding etc., may become so high that cracking will take place. This cannot be detected during the cool-down and leakage may be the result.

The best option is to design a ring main with spray system at the top of the tank. This arrangement should be designed for the cool-down rate specified based on operating pressure and liquid flow of the supply line.

On the wall and bottom of the tank temperature sensors should be installed for temperature monitoring. The temperature sensors should be located such that critical temperature differences can be measured.

For inner tanks, the following cool-down rates are typical:

— target cool-down rate for the inner tank of 3 °C/h with a maximum of 5 °C/h;

— maximum temperature difference between any two adjacent shell or bottom thermocouples of 30 °C.

For membrane tanks the following cool-down rates are typical:

— target cool-down rate for the membrane of 10 °C/h with a maximum of 15 °C/h;

— maximum temperature difference between any two adjacent wall or bottom thermocouples of 50 °C.

Bibliography

[1] EN 14620-2, *Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0°C and –165 °C — Part 2: Metallic components*

[2] EN 14620-3:2006, *Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0°C and –165 °C — Part 3: Concrete components*

[3] EN 14620-4, *Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0°C and –165 °C — Part 4: Insulation components*

[4] NF A 09-106:1979, *Testing for leak tightness by means of ammonia – Locating of leaks by overall pressurization*

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