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Pressure equipment and assemblies

Part 8: Proof test

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National foreword

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European foreword

This document (CEN/TS 764-8:2016) has been prepared by Technical Committee CEN/TC 54 “Unfired pressure vessels”, the secretariat of which is held by BSI.

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This European Standard consists of eight parts, which are currently:

Part 1 *Vocabulary;*

Part 2 *Quantities, symbols and units;*

Part 4 *Establishment of technical delivery conditions for metallic materials;*

Part 5 *Inspection documentation of metallic materials and compliance with the material specification;*

Part 6 *Structure and content of operating instructions [technical report];*

Part 7 *Safety systems for unfired pressure equipment;*

Part 8 *Proof test [technical specification].*

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Introduction

This document is intended to establish a common approach for the proof testing by pressure test of items of pressure equipment and assemblies, in order to fulfil the essential requirement 3.2.2 of Annex 1 of the pressure equipment directive 97/23/CE.

It is intended to be used as a basis in the specific product standards, or directly by a manufacturer.

It takes into account the existing guidelines adopted by the European Commission, detailed in Annex A.

For the determination of the pressure test value, this document provides two methods in 5.1. Further investigation will take place, in order to better specify the method to be retained in the future. The determination of the nominal design stress will be part of this analysis.

CEN technical committees, which apply this document in their product standard, are encouraged to give feedback to CEN/TC 54, for the future revision of this document.

1 Scope

This document specifies the purpose, form and procedure of proof testing by pressure test of items of pressure equipment and assemblies.

It also specifies how to determine the value of the test pressure.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE Other useful definitions can be found in EN 764–1 to -7.

2.1
pressure equipment
vessel, piping, safety accessory or pressure accessory with a maximum allowable pressure PS greater than 0,5 bar

Note 1 to entry: Where applicable, pressure equipment includes elements attached to pressurized parts, such as flanges, nozzles, couplings, supports, lifting lugs, etc.

[SOURCE: Directive 97/23/CE]

2.2
assembly
several pieces of pressure equipment assembled by a manufacturer to constitute an integrated and functional whole

[SOURCE: Directive 97/23/CE]

2.3
product standard
standard that specifies requirements to be fulfilled by a product or a group of products, to establish its fitness for purpose

Note 1 to entry: For this document, a product standard is a standard dealing with a pressure equipment or an assembly.

[SOURCE: EN 45020]

2.4
maximum allowable pressure
PS
p_s
maximum pressure for which the equipment is designed, as specified by the manufacturer

Note 1 to entry: The subscript “max” is added to the symbol for maximum values.

[SOURCE: EN 764-1]

2.5
test pressure
PT
***p*t**
pressure to which the equipment is subjected for test purposes

[SOURCE: EN 764-1]

3 Symbols and abbreviations

For the purposes of this document, the symbols and abbreviations shall be in accordance with Table 1.

Table 1 — Symbols, descriptions and units

Symbol	Description	Unit
PS, p_s a	maximum allowable pressure	MPa b
PT, p_t a	test pressure	MPa b
k c	material strength characteristic	MPa
a p_s or p_t for calculation purposes ; PS or PT for marking purposes b MPa for calculation purpose, otherwise the unit may be bar (1 MPa = 10 bar) c subscript 20 or T is used for ambient temperature or maximum allowable temperature, respectively		

4 General

4.1 Purpose of proof testing by pressure test

Proof testing by pressure test shall be a test for the pressure containment aspect, which verifies the adequacy of manufacture. In addition, it can demonstrate tightness of the equipment.

NOTE 1 The proof testing by pressure test is not primarily intended to prove the design or to change material behaviour or dimensioning of the equipment.

NOTE 2 Leak tightness, in the frame of this document, only considers testing under positive hydraulic or pneumatic pressure and aims at ensuring a visually leak tight assembly without a precise quantification. If necessary, additional tightness test are conducted as per the requirements of the product standard.

4.2 Form of the pressure test

For pressure equipment, the hydrostatic pressure test, as described in 5.1, shall be the standard pressure test. If this is not practical then it may be substituted by:

a) a pneumatic test as described in 5.2;

b) a combined hydrostatic/pneumatic test.

The manufacturer shall document the form of the pressure test in the documentation, which shall be reviewed before manufacturing commencing.

For assemblies, refer to Clause 6.

NOTE Local regulations may apply to the performance of pneumatic testing.

4.3 Pressure test procedure

Any item of pressure equipment shall be subjected to a pressure test; however items of category I may be tested on a statistical basis.

The test sequence shall consist of the following:

— filling the equipment and pressurising it gradually;

— maintaining the required test pressure for a sufficient length of time;

— reducing the pressure for inspection where necessary;

— visually inspecting it to check if there has been any deterioration, deformation and/or leak resulting from the pressure test;

— deciding if any possible deterioration, deformation and/or leak is acceptable;

— then, fully draining and cleaning the equipment.

Items that have a value of p_t less than that determined in accordance with the requirements of Clause 5, and that are not part of the pressure-bearing housing of the equipment, shall be removed or isolated during the pressure test.

For assemblies, refer to Clause 6.

5 Pressure equipment

5.1 Hydrostatic test

5.1.1 Basic rule

The test pressure shall be based on p_s and k, with possible specific adjustment as stated in 5.1.2.

NOTE 1 Design takes account of maximum loadings and variation in allowable stresses across the design temperature range. This leads to selection of material grades, thicknesses and permanent joining processes. To test the adequacy of manufacture, the value of k is considered a practical parameter, which is applicable to determining the temperature related effects.

The test pressure shall be determined by the greater of the following values for p_t:

$$p_t = a \cdot p_s \frac{k_{20}}{k_T}$$

or

$$p_t = b \cdot p_s$$

where

a and b are coefficients depending on the type of pressure equipment, defined as follows:

— for vessels, a = 1,25 and b = 1,43;

— for piping, pressure accessories, safety accessories, or items of pressure equipment constituting boilers, a and b are defined in the product standard, generally the same values as for vessels.

NOTE 2 Boilers as such are considered as assemblies, covered under Clause 6.

k is defined in accordance with one of the following two methods:

— *k* is the nominal design stress of the considered material whenever this value is determined for the design;

— *k* is a material property defined in the technical specification for the material below the creep range, to be used for the item of pressure equipment. *k* is either the yield strength or rupture strength as appropriate, to be decided in the product standard.

NOTE 3 The above equations intentionally do not relate to the remaining thickness after corrosion has taken place.

For items of pressure equipment that consists of several pressure parts (with several ratios), the smallest of the ratios in the above formula shall be used. Further details can be specified in the product standard.

5.1.2 Specific adjustment

In specific cases, it may be necessary to adjust the basic rule to take account of more complex situations (e.g. PS_{max} and TS_{max} not coincidental, compensation for water column etc.). The purpose of the adjusted rule shall still comply with 4.1 without resulting in "over-engineering". It shall be described in the relevant product standards.

For specific applications, when a pressure test at the value according to 5.1.1 is not possible, a lower pressure value may be found in the product standard with additional compensatory measures.

5.1.3 Creep consideration

Creep, when applicable, shall be taken into account in the equipment design.

Due to its short duration, the pressure test can confirm the strength of equipment only with respect to the time-independent failure hazards. It cannot provide any indication on its long-term strength, in particular on its strength against the degradation of the material with time when the service temperature lies inside the creep range.

Thus, creep (i.e. creep values used for the design) shall not be taken into account for the determination of the test pressure.

As a basic requirement, the determination of p_t shall use the values corresponding to the highest temperature at which time-independent characteristics are given in the relevant harmonized material standard.

5.2 Pneumatic test

The hydrostatic test may be substituted by a pneumatic test when hydrostatic testing would be harmful or impractical, for example (non-exhaustive):

— unacceptable presence of residual water for the process (e.g. ice) or the equipment (e.g. corrosion that may be detrimental to the stability/usability of the equipment);

— technical constraints like loads due to the water weight on either pressure equipment, supports or the ground that would possibly cause damage;

— environmental constraints with respect to large amounts of water of controlled purity.

For pneumatic test, p_t shall be determined as follows:

1) If possible, use p_t as calculated in 5.1, and place the equipment in a safe place like a bunker or area with restricted access.

2) If this is not feasible, lower the stored energy (normally by lowering the test pressure) for personnel safety reasons (public and manufacturers' employees) and conduct additional tests of recognized value, e.g. additional NDT or complementary production test specimens.

NOTE A typical value for the lowered test pressure is 1,1 x p_S.

6 Assemblies

As far as possible, the different items of pressure equipment of an assembly shall be pressure tested individually.

When the different items of pressure equipment of an assembly are pressure tested individually, and when the piping is tested when connected to the assembly, no further proof pressure test of the assembly is necessary.

For the final joints, if an additional pressure test is not feasible, the final permanent joints shall be subjected to NDT, possibly supplemented by a tightness test. Flange connections not subjected to the proof pressure test shall be tested for leak tightness.

If the individual tests cannot be performed because some items cannot be isolated or tested individually, a proof test on the assembly shall be performed at a value determined according to 5 where p_s is the maximum allowable pressure determined for the assembly.

Annex A
(informative)

Guidelines from the European Commission

The guidelines adopted by the European Commission on the subject of pressure test are reproduced below.

NOTE The guidelines have been agreed to by the Commission's Working Group "Pressure" and represent a reference for ensuring consistent application of the directive by all those involved, but they are not a legally binding interpretation of the directive and can be changed by the working group at any time. The last version of the guideline can be found at the following address:
http://ec.europa.eu/growth/index_en.htm

Guideline 3/6 (accepted by Working Group "Pressure" on: 2000-03-24)

Does a hydrostatic pressure test have to be carried out on an assembly and should the value laid down in section 7.4 then be followed?

Using the global conformity assessment of Article 10.2, each item of pressure equipment and the integration of the items of pressure equipment (Annex I, section 2.8) should be assessed.

Annex I, first preliminary observation, determines that the requirements of Annex I also apply to assemblies, if corresponding hazard exists.

Each item of pressure equipment making up the assembly and referred to in Article 3.1 shall meet Annex I, section 3.2.2, and the pressure containment aspects for the connections/joining should be assessed by appropriate methods, for example pressure test, NDT.

Guideline 3/7 (accepted by Working Group "Pressure" on: 2000-11-07)

Which conditions shall be used in the assessment of an item of pressure equipment referred to in Article 3.1 without a separate CE marking in an assembly being subject to the global conformity assessment procedure?

The conditions to be used to determine the category of this item shall be:

— the volume or nominal size DN, as appropriate, of the item;

— at least the conditions PS, TS or group of fluid, for which the assembly is designed, which can be lower than the intrinsic conditions of the item.

For safety accessories, article 2 of Annex II applies.

REASON According to article 10.2 a) the global conformity assessment procedure shall comprise assessment of each item of pressure equipment making up the assembly and referred to in Article 3 1) which has not been previously subjected to a conformity assessment procedure and to a separate CE marking. The assessment procedure shall be determined by the category of the item, which may be based on the conditions of the assembly.

Guideline 8/2 (accepted by Working Group "Pressure" on: 1996-11-08)

Final assessment (Annex I, section 3.2.2) of pressure equipment shall include a test for pressure containment at a pressure at least equal, where appropriate, to the value laid down in section 7.4. This section only refers to pressure vessels. Does this mean that 7.4 does not apply to piping, and pressure and safety accessories?

In accordance with Annex I, 3.2.2 in the course of the final assessment pressure equipment shall be subjected to a test for the pressure containment aspect. As a rule, this test for the pressure containment aspect is supposed to be carried out in the form of a hydrostatic pressure test. Where this is not possible or disadvantageous, other procedures are permissible.

The pressure value chosen for carrying out a hydrostatic pressure test shall be such as to ensure testing the pressure containment aspect of the pressure equipment with due consideration of the determined safety factors without causing a damage to the pressure equipment. Annex I, 7.4 provides additional formulas which may be applied only in due consideration of the above described general criteria (3.2.2). The formulas in Annex I, section 7.4 should be considered for all items of pressure equipment, not only pressure vessels.

Guideline 8/14 (accepted by Working Group "Pressure" on: 2005-01-19)

Is it possible to undertake statistical proof testing of series-produced safety valves?

Yes, when the body of the safety valve classified according to Annex II section 3 does not exceed category I and subject it is supported by the hazard analysis.

REASON The proof test is intended to verify the pressure containment aspect of the item of pressure equipment. The proof test does not address the safety function which is covered by Annex I section 2.11.1.

NOTE 1 The safety function of such safety valves needs to be assessed according to category IV (except for safety valves manufactured for specific equipment of category lower than IV).

NOTE 2 The same reasoning is not applicable to the other items of pressure equipment which are classified by the PED in a higher category than the category derived from their intrinsic characteristics.

Guideline 8/16 (accepted by Working Group "Pressure" on: 2005-01-19)

If the hydrostatic pressure test required by Annex I section 3.2.2 is replaced by a pneumatic pressure test because filling with water is harmful or impractical, what value shall be used for the pressure test?

Either the values given in Annex I section 7.4 are to be used for the pneumatic pressure test or the manufacturer has to achieve an equivalent level of safety using other appropriate means.

See Guideline 8/2.

Whether the test is pneumatic or hydrostatic, when the value of the pressure deviates from the value of Annex 1 section 7.4, additional measures shall be applied to verify the pressure containment aspect including tightness (see Guideline 5/3).

Attention is drawn to the fact that pneumatic testing can be highly dangerous. Reference should be made to the appropriate national authorities for regulation or guidance on the procedures to be followed.

Bibliography

EN 764-1, *Pressure equipment — Part 1: Vocabulary*

EN 764-2, *Pressure equipment — Part 2: Quantities, symbols and units*

EN 764-4, *Pressure equipment — Part 4: Establishment of technical delivery conditions for metallic materials*

EN 764-5, *Pressure equipment — Part 5: Inspection documentation of metallic materials and compliance with the material specification*

CEN/TR 764-6, *Pressure equipment — Part 6: Structure and content of operating instructions*

EN 764-7, *Pressure equipment — Part 7: Safety systems for unfired pressure equipment*

Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of laws of the Member States concerning pressure equipment

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