BRITISH STANDARD

BS EN 12516-3:2002
Incorporating Corrigendum No. 1

Valves — Shell design strength —

Part 3: Experimental method

The European Standard EN 12516-3:2002 has the status of a British Standard

ICS 23.060.01

British Standards

National foreword

This British Standard is the official English language version of EN 12516-3:2002, including Corrigendum September 2003.

The UK participation in its preparation was entrusted by Technical Committee PSE/7, Industrial valves, to Subcommittee PSE/7/1, Basic standards, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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This British Standard, having been prepared under the direction of the Engineering Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 28 October 2002

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English version

Valves - Shell design strength - Part 3: Experimental method

Appareils de robinetterie - Résistance mécanique des enveloppes - Partie 3: Méthode expérimentale

Armaturen - Gehäusefestigkeit - Teil 3: Experimentelles Verfahren

This European Standard was approved by CEN on 1 August 2002.

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Contents

Foreword

This document (EN 12516-3:2002) has been prepared by Technical Committee CEN /TC 69, "Industrial Valves", the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by April 2003, and conflicting national standards shall be withdrawn at the latest by April 2003.

EN 12516 consists of three parts :

- Part 1 : Tabulation method for steel valve shells ;
- Part 2 : Calculation method for steel valve shells ;
- Part 3 : Experimental method.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative annex ZA, which is an integral part of this document.

Annex A is informative

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

Introduction

This standard establishes an experimental method of assessing the strength of valve shells by applying an elevated hydrostatic pressure test at room temperature.

The experimental test factor, *C*, for use in the equation to determine the elevated hydrostatic test pressure, takes into account the ductility of the various materials. Information on the origin of the experimental test factor, *C*, is given in annex A.

This standard may be used as an alternative method to those to be specified in Part 1 (Tabulation method) or Part 2, (Calculation method) within the limits specified in the scope.

1 Scope

This standard specifies requirements for an experimental method to prove that representative samples of valve shells and their body ends, made in cast iron, steel or copper alloy materials, are designed to possess the required pressure containing capability, with an adequate margin of safety.

This standard is not applicable to valves designed on the basis of time dependent strength values (creep) or valves designed for pulsating pressure applications (fatigue).

NOTE For valves needing to comply with the EU Directive 97/23/EC (PED), the upper limit for application of this standard without calculation, is when the maximum allowable pressure at room temperature, PS_{RT}, multiplied by the DN-number is less than 3000 bar. This standard may be used to supplement the Tabulation method for steel valves, Part 1, and the Calculation method for steel valves, Part 2 without limit.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 736-2, *Valves — Terminology — Part 2 : Definition of components of valves.*

EN 736-3, *Valves — Terminology — Part 3 : Definition of terms.*

3 Terms and definitions

For the purposes of this standard, the terms and definitions given in EN 736-2 and EN 736-3 apply.

In this standard, the term component shall be taken to mean the body, the bonnet and the cover.

4 Symbols

The following symbols are used in this standard *:*

A is the percentage elongation after fracture, in per cent ;

C is the experimental test factor ;

C_b is the experimental test factor for the body ;

C_{bc} is the experimental test factor for the bonnet or cover ;

e_{mes} is the measured wall thickness, in millimetres ;

e_{min} is the minimum specified drawing wall thickness, in millimetres ;

K is the factor for calculating of the experimental test pressure $p_{t, exp}$;

K_b is the K for the body ;

K_{bc} is the K for the bonnet or cover ;

p is the design pressure, in bar ;

PS is the maximum allowable pressure, in bar ;

PS_{RT} is the maximum allowable pressure at room temperature, in bar ;

PS_t is the maximum allowable pressure at temperature t, in bar ;

$p_{t, exp}$ is the experimental test pressure, in bar ;

$p_{t, exp/RT}$ is the experimental test pressure at room temperature, in bar ;

$p_{t, exp\ b/RT}$ is the experimental test pressure at room temperature for the body, in bar ;

$p_{t, exp\ bc/RT}$ is the experimental test pressure at room temperature for the bonnet or cover, in bar ;

p'' is the elevated test pressure used for type testing of series-manufactured valves, in bar ;

$R_{m/RT}$ is the tensile strength at room temperature, in Newtons per square millimetre ;

$R_{p1,0}$ is the 1,0 % proof strength, in Newtons per square millimetre ;

$R_{p0,2\ act/RT}$ is the actual 0,2 % proof strength at room temperature, in Newtons per square millimetre ;

$R_{p0,2\ min/RT}$ is the minimum 0,2 % proof strength at room temperature specified in the appropriate material standard, in Newtons per square millimetre ;

$R_{p0,2\ min/t}$ is the minimum 0,2 % proof strength at temperature t specified in the appropriate material standard, in Newtons per square millimetre ;

S is the safety factor ;

S'' is the safety factor depending on the material ;

X is the ratio of e_{mes} to e_{min} ;

$X_{b\ max}$ is the maximum value of X for the body ;

$X_{bc\ max}$ is the maximum value of X for the bonnet or cover ;

Y is the ratio of $R_{p0,2\ act/RT}/R_{p0,2\ min/RT}$;

Y_b is the Y for the body ;

Y_{bc} is the Y for the bonnet or cover.

NOTE The term maximum allowable pressure, PS, defined in EU Directive 97/23/EC (PED) is equivalent to the term allowable pressure, p_s, defined in EN 736-3.

5 Description of test

The valve body ends shall be closed using suitable sealing components e.g. flanges, threaded plugs, welded caps etc. corresponding to the type of body ends.

The test equipment shall be of such a design, that it does not subject the shell to externally applied loads and does not apply any reinforcement to the components, which may affect the results of the tests.

NOTE The test equipment can apply external loads sufficient to react to the forces resulting from the test pressure.

The test pressure shall be applied to the shell assembly or to the assembled valve. The components may be tested separately.

6 Test method

6.1 Safety aspects

Safety aspects during testing are not covered by this standard. The users of this standard should analyse the hazard resulting from the pressure and take proper safety precautions.

6.2 Wall thickness

The shape and thickness of the metal of the component to be tested shall be in accordance with the minimum requirements as specified on the manufacturing drawing.

No component shall be used for this test which has a measured thickness that exceeds the minimum thickness specified on the drawing by the greater of 2,5 mm (if the thickness is less than 10 mm) or 25 % of the specified minimum thickness.

The thickness e_{mes} of the component shall be measured at all locations where the thickness is specified on the drawing.

In the case where a general thickness is specified on the drawing, without reference to a specific location, the actual thickness shall be checked at a minimum of three locations. These locations shall be chosen at positions, which adequately reflect possible wall thickness variations due to the manufacturing process and possible failure zones.

Wall thicknesses measured in areas smaller than $10\sqrt{\mathrm{DN}}$ mm^2 shall not be taken into account when calculating the values of X.

NOTE This restriction prevents the use of X values which are not representative of the general wall thickness.

The measured wall thickness e_{mes} shall be divided by the minimum specified drawing wall thickness e_{min} to find the values of X from the equation :

$$X = \frac{e_{\mathrm{mes}}}{e_{\mathrm{min}}} \quad (1)$$

The largest value for each component, $X_{b\,max}$ and $X_{bc\,max}$ shall be selected for the purpose of determining the value of K according to equations (3) and (4).

6.3 Material strength

The material test certificates for each component shall be checked to ensure that the components to be tested are in accordance with the requirements of the material specification.

Using the actual proof strength, $R_{p0,2\ act/RT}$ from the material test certificates for each component the ratio Y of actual proof strength, $R_{p0,2\ act/RT}$ divided by the minimum proof strength, $R_{p0,2\ min/RT}$ specified in the appropriate material standard shall be calculated for each component.

$$Y = \frac{R_{p0,2\ act/RT}}{R_{p0,2\ min/RT}} \quad (2)$$

For materials where other mechanical properties are specified e.g. $R_{m/RT}$ for grey iron, $R_{p1,0}$ for austenitic steels, these properties shall be used.

6.4 Experimental test pressure

Using the experimental test factor, C, specified in Table 1 for the material used, values for K_b and K_{bc} shall be calculated from the equations :

$$K_b = C_b \times X_{b\ max} \times Y_b \quad (3)$$

$$K_{bc} = C_{bc} \times X_{bc\ max} \times Y_{bc} \quad (4)$$

The experimental test pressure $p_{t,\ exp}$ shall be calculated from the equations :

— for the body, $p_{t,\ exp\ b/RT} = K_b \times PS_{RT}$ (5)

— for the bonnet/cover, $p_{t,\ exp\ bc/RT} = K_{bc} \times PS_{RT}$ (6)

The lower of the two experimental test pressures calculated in equations (5) or (6) shall be applied. After testing at this pressure for the minimum test duration (see 6.6), the pressure shall be increased to the higher pressure calculated in equations (5) and (6). The higher pressure shall be applied for the minimum test duration.

As an alternative to testing at both pressures, the test may be conducted using the higher pressure only applied for the minimum duration.

When a component has already been shown, according to any part of EN 12516, to have the required pressure containing capability, at an allowable pressure at least equal to that of the shell to be tested, then the experimental test pressure calculated for this component shall not be applied.

If the allowable pressure PS is given only for an elevated temperature *t*, then the experimental test pressure $p_{t,\ exp}$ shall be calculated from the following equations :

— for the body, $p_{t,\ exp\ b/RT} = K_b \times PS_t \times \frac{R_{p0,2\ min/RT}}{R_{p0,2\ min/t}}$ (7)

— for the bonnet/cover, $p_{t,\ exp\ bc/RT} = K_{bc} \times PS_t \times \frac{R_{p0,2\ min/RT}}{R_{p0,2\ min/t}}$ (8)

Table 1 — Values for the experimental test factor *C*

Material		*C*
Grey cast iron		3,5
Spheroidal Graphite cast iron	3 % ≤ *A* < 7 %	2,5
	7 % ≤ *A* ≤ 15 %	2,0
	15 % < *A*	1,85
Steel	casting	1,85
	forging, plate, bar etc.	1,75
Copper alloy	casting	2,5
	forging, plate, bar etc.	2,0
NOTE The origin of the experimental test factor, *C*, is explained in annex A.		

6.5 Test fluid

Water shall be used as the test fluid. The test fluid temperature shall be between 5 °C and 40 °C.

6.6 Test duration

The minimum test duration shall be 10 minutes.

6.7 Documentation

The performance of the test and all test parameters and test results shall be fully documented.

7 Acceptance criteria

There shall be no visible leakage through any metallic part of the shell. Leakage from the gasket between two components shall not be a cause for rejection. If any such leakage makes it difficult to assess whether any other leakage is taking place it is permissible to fit a seal which is different than that used in the finished commercial product.

If the test was carried out successfully at the lower pressure determined by equation (5) and (6) or (7) and (8) then failure of the component with the smaller *K* value when testing at the higher experimental test pressure is not cause for rejection of this component.

Annex A
(informative)

Information on the origin of the experimental test factor, *C*

The philosophy of carrying out an elevated pressure test on a valve body as a means of verifying its strength was established in DIN 3840. However, DIN 3840 only permitted this method of strength verification for cast iron valves up to and including DN 400.

The elevated test pressure was either a multiple of the hydrostatic test pressure or, in the case of valves subject to regular supervision, was a multiple of the design pressure.

In all cases the multiplier applied to the hydrostatic test pressure or the design pressure was less than, or equal to, the safety factor, S, applied to the material property for the purposes of calculation of the allowable stress. This ensures that a body, which has been calculated in accordance with DIN 3840 would pass the elevated pressure test.

In other words, the actual stresses in the component during the elevated pressure test are unlikely to exceed the minimum capability of the material as specified in the material standard.

The values from DIN 3840 are given in Table A.1 below :

Table A.1 — Values from DIN 3840

Material		S''	p''	S	p''
Grey cast iron		3,5	$5,25 \times PS_{RT}$	9,0	$9,0 \times p$
Spheroidal	A = 7 %	2,0	$3,00 \times PS_{RT}$	8,0	$8,0 \times p$
Graphite	A = 15 %	1,7	$2,55 \times PS_{RT}$	7,2	$7,2 \times p$
cast iron	A > 15 %	1,5	$2,25 \times PS_{RT}$	4,8	$4,8 \times p$

$p'' = S'' \times 1,5 \times PS_{RT}$

$p'' = S \times p$

The safety factor, S, applied to these materials in DIN 3840 are in Table A.2 as follows :

Table A.2 — Safety factor, S applied in DIN 3840

Material		Safety factor, S, in relation to :	
		$R_{m/RT}$	$R_{p0,2\ min/RT}$
Grey cast iron		9,0	—
Spheroidal	A = 7 %	8,0	5,0
Graphite	A = 15 %	7,2	4,5
cast iron	A > 15 %	4,8	3,0

The approach of EN 12516-3 is to extend the elevated pressure test philosophy of DIN 3840 to other materials e.g. steel and copper alloy. EN 12516-3 also takes into account the requirement of EU Directive 97/23/EC (PED) that the elevated test pressure must be determined on the basis of the differences between

a) actual wall thickness and design wall thickness ;

b) actual material property value and the minimum value specified in the material standard.

a) and b) above result in two multipliers X and Y, both of which at least equal to 1. The formula for the experimental test pressure is $p_{t, exp} = C \times X \times Y \times PS_{RT}$.

By considering a body which has the actual wall thickness equal to the design thickness at all points and which is made from material which has the minimum specified value of the material property, this standard and DIN 3840 can be compared.

Table A.3 — Comparison of values from this standard and from DIN 3840 standard

Material		p''	$p_{t, exp}$
Grey cast iron		$5,25 \times PS_{RT}$	$3,50 \times PS_{RT}$
Spheroidal	A = 7 %	$3,00 \times PS_{RT}$	$2,00 \times PS_{RT}$
Graphite	A = 15 %	$2,55 \times PS_{RT}$	$2,00 \times PS_{RT}$
cast iron	A > 15 %	$2,25 \times PS_{RT}$	$1,85 \times PS_{RT}$

This shows that the elevated test pressures determined using this standard are lower than the elevated test pressures determined from DIN 3840 in the specific case of a body with $X = 1$ and $Y = 1$.

If the actual material property is greater than the minimum specified then the experimental test pressure is increased by the same percentage. This ensures that during the elevated pressure test the actual material stress at any location in the component is the same percentage of the actual material property of the component irrespective of which component is selected for the test.

If the actual wall thickness varies from the design thickness the material stress during testing would be reduced unless the pressure is increased to compensate. However, it is likely that the wall thickness variation will be non-uniform and there will be a difference in the percentages measured at the three locations required by this standard.

By using the largest percentage difference for the value of X the experimental test pressure will compensate for the thicker material and ensure that during testing the material stress at any location will not be less than the value achieved when testing a component with an $X = 1$.

At the location where the smallest percentage difference for the value of X was measured, the component would see a higher stress than if $X = 1$. The stress at this location would be greater than the value achieved when testing a component with $X = 1$ by the ratio of $X_{largest}/X_{smallest}$.

For components with a wall thickness of 10 mm or greater the maximum value of the ratio, $X_{largest}/X_{smallest}$, permitted by this standard is 1,25. Using $X = 1,25$ the stress induced at the location of $X_{smallest}$ is now very similar to the value induced by testing a component with $X = 1$ to DIN 3840.

For components with a wall thickness less than 10 mm the ratio $X_{largest}/X_{smallest}$ may be greater than 1,25. However, manufacturing requirements and other design factors such as corrosion allowances will ensure that the wall thickness at the location of $X_{smallest}$ is adequate for the stresses induced during an elevated pressure test using the $X_{largest}$ factor to calculate the experimental test pressure.

If the experimental test pressure was determined using $X_{smallest}$ then the stress induced at the point of $X_{largest}$ would be even further reduced below the DIN 3480 levels. The elevated pressure test would also not guarantee that, if a further sample component with $X = 1$ was tested that it would pass the test.

The values of experimental test factor, C, for steel and copper alloy have been determined taking into account the safety factors, which CEN/TC 69 considered appropriate for the relevant material properties. In the case of forged steel the value of $C = 1,75$ is greater than the safety factor applied to the 0,2 % proof strength i.e. 1,5. Hence, there could be some local plastic deformation in this type of body, if tested in accordance with this standard.

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 97/23/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 97/23/EC.

Once this standard is cited in the Official Journal of the European Communities under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in table ZA confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA – Correspondence between this European Standard and Directive 97/23/EC

Clause(s)/sub-clause(s) of this EN	Essential Requirements (ERs) of Directive 97/23/EC	Qualifying remarks/Notes
5, 6 and 7	Design for adequate strength	2.2.2
5, 6 and 7	Experimental design method	2.2.4

WARNING: Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

Bibliography

[1] DIN 3840, *Valve bodies — Strength calculation in respect of internal pressure*.

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