SLOVENSKI STANDARD
# SIST EN 14359:2007

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**Hidropnevmatski zalogovniki za hidravliļ ne razvode**

Gas-loaded accumulators for fluid power applications

Hydrospeicher für Hydraulikanwendungen

Accumulateurs hydropneumatiques pour transmissions hydrauliques



**Ta slovenski standard je istoveten z: EN 14359:2006**



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**ICS:**

| | | |
|---|---|---|
| 23.100.99 | Drugi sestavni deli hidravliļ nih sistemov | Other fluid power system components |

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# Gas-loaded accumulators for fluid power applications

Accumulateurs hydropneumatiques pour transmissions hydrauliques

Hydrospeicher für Hydraulikanwendungen

This European Standard was approved by CEN on 18 September 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.

CEN members are the national standards bodies of 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.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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## Contents

Page

# Foreword

This document (EN 14359:2006) has been prepared by Technical Committee CEN/TC 54 “Unfired pressure vessels”, 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of an identical text or by endorsement, at the latest by April 2007, and conflicting national standards shall be withdrawn at the latest by April 2007.

Where appropriate, equations and techniques are consistent with the requirements of EN 13445-3:2002 but this European Standard is presumed to satisfy the essential requirements of the Pressure Equipment Directive 97/23/EC in its own right.

NOTE If any matter of interpretation or doubt arises as to the meaning or effect of any normative part of this European Standard, or as to whether anything should be done or has been omitted to be done, in order that this European Standard should be complied with in full, the matter needs to be referred to the CEN/TC 54 Committee.

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.



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

**1.1** This European Standard specifies the requirements for materials, design, manufacture, testing inspection, safety systems and documentation (including instructions for first operation), for commonly-used types of gas-loaded accumulators and gas bottles for fluid power applications (see 1.2).

**1.2** This European Standard applies to the following types of components, defined as the pressure-containing envelope of gas-loaded accumulators:

— bladder type;

— diaphragm type;

— piston type;

— transfer type;

— gas bottles used to provide additional gas capacity.

They consist of one or several parts joined together by a variety of mechanical means and by welding.

**1.3** This European Standard applies to gas-loaded accumulators which operate with the following conditions:



— subject to an internal gauge pressure greater than 0,5 bar;

— working temperature of not lower than –50 °C and not higher than +200 °C;



— containing Group 2 liquids and gases as defined in the Pressure Equipment Directive 97/23/EC.

It does not apply to:

— accumulators for use with dangerous fluids (see NOTE 1).

NOTE 1 Fluid power applications utilize non-dangerous fluids as categorized in ISO 6743-4 in addition to an inert gas (e.g. nitrogen) which is used as the pre-charging medium.

NOTE 2 There are no design limits to the volume of the accumulator.

## 2 Normative references

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

EN 1043-1, *Destructive tests on welds in metallic materials — Hardness testing — Part 1: Hardness test on arc welded joints*

EN 1968:2002, *Transportable gas cylinders — Periodic inspection and testing of seamless steel gas cylinders*

EN 10002-1, *Metallic materials — Tensile testing — Part 1: Method of test at ambient temperature*

EN 10045-1, *Metallic materials — Charpy impact test — Part 1: Test method*

EN 10204:2004, *Metallic products — Types of inspection documents*

EN 13018, *Non-destructive testing — Visual testing — General principles*

EN 13445-2:2002, *Unfired pressure vessels — Part 2: Materials*

EN 13445-3:2002, *Unfired pressure vessels — Part 3: Design*

EN 13445-4, *Unfired pressure vessels — Part 4: Fabrication*



EN ISO 898-1:1999, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs (ISO 898-1:1999)*



EN ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method (ISO 6506-1:2005)*

EN ISO 6506-2, *Metallic materials — Brinell hardness test — Part 2: Verification and calibration of testing machines (ISO 6506-2:2005)*

EN ISO 6506-3, *Metallic materials — Brinell hardness test — Part 3: Calibration of reference blocks (ISO 6506-3:2005)*

EN ISO 15614-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys (ISO 15614-1:2004)*

ISO 262, *ISO general-purpose metric screw threads — Selected sizes for screws, bolts and nuts*

ISO 9110-1, *Hydraulic fluid power — Measurement techniques — Part 1: General measurement principles*

ISO 9110-2, *Hydraulic fluid power — Measurement techniques — Part 2: Measurement of average steady-state pressure in a closed conduit*

ISO 10771-1, *Hydraulic fluid power — Fatigue pressure testing of metal pressure-containing envelopes — Part 1: Test method*

# 3 Terms, definitions, symbols, units and abbreviated terms

## 3.1 Terms and definitions

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

**3.1.1**
**gas-loaded accumulator**
hydraulic accumulator with separator between liquid and gas where the liquid is pressurized using the compressibility of an inert gas (for example nitrogen). The separator can be a bladder, a diaphragm or a piston.

Gas-loaded accumulators have shells, which can consist of cylinders, dished ends and flat plates. Openings are always isolated, located on the axis centre line and positioned at both ends of the accumulator. It is assumed that such vessels are axis-symmetrical

**3.1.2**
**bladder accumulator**
gas-loaded accumulator consisting of pressure-retaining shell, either spun-forged from seamless tube, hammer-forged from hollow bar or of welded construction, in which the liquid and gas are separated by a flexible bag or bladder normally retained at one end of the shell

**3.1.3**
**diaphragm accumulator**
gas-loaded accumulator consisting of pressure-retaining shell assembly, in which the construction can either be screwed or welded, with integral ports in which the liquid and gas are separated by a flexible membrane normally retained at its largest diameter to the shell



**3.1.4**
**piston accumulator**
gas-loaded accumulator consisting of cylinder body and end cap assemblies in which the liquid and gas are separated by a rigid sliding piston

**3.1.5**
**transfer type accumulator**
gas-loaded accumulator with a port for connecting additional gas capacity from one or more gas bottle(s)

**3.1.6**
**gas bottle**
inter-connected pressure vessels consisting of body and, depending upon construction, port assemblies used to provide additional gas capacity and communicating with the gas chamber of the accumulator by means of a pipe connection

## 3.2 Symbols, units and abbreviated terms

### 3.2.1 General

For the purposes of this document, the following symbols, units and abbreviated terms apply.

**Table 3.2-1 — Symbols, characteristics and units**

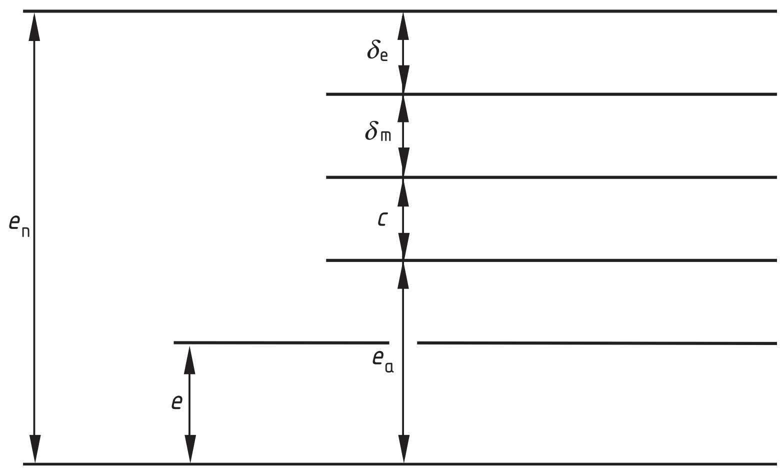
| Symbol | Characteristics | Unit |
|---|---|---|
| $e$ | Required thickness of the component, when obtained by direct calculation or the assumed thickness of the component, when obtained by non-direct calculation | mm [a] |
| $e_a$ | Analysis thickness of the component = $e_n$-$\delta_e$-$\delta_m$-$c$ | mm [a] |
| $e_n$ | Nominal thickness of the component, as specified on the manufacturing detail drawings | mm [a] |
| $c$ | Corrosion allowance | mm [a] |
| $\delta_e$ | Absolute value of the negative tolerance taken from the material standard of the component | mm [a] |
| $\delta_m$ | Possible thinning during manufacturing process of the component | mm [a] |
| $N$ | Number of pressure cycles | |
| $P_0$ | Pre-charging pressure; the gas pressure in the accumulator when the hydraulic circuit is not under pressure (initial state) at a temperature of (20 ± 5) °C | MPa [b] |
| $P_1$ | Minimum working pressure of the hydraulic circuit | MPa [b] |
| $P_2$ | Maximum working pressure of the hydraulic circuit | MPa [b] |
| $P_3$ | Set pressure of the safety accessory for the accumulator, if one is fitted | MPa [b] |
| $PS$ | Maximum allowable pressure, the pressure for which the accumulator has been designed and/or qualified by test | MPa [b] |
| $PT$ | Test pressure | MPa [b] |
| $P_2/P_0$ | Allowable pressure ratio below which the accumulator type can be used | |
| $R_{eH}$ | Minimum upper yield strength | MPa [b] |
| $R_m$ | Minimum tensile strength | MPa [b] |
| $R_{m/t}$ | Minimum tensile strength at design temperature t °C | MPa [b] |
| $R_{p0,2}$ | Minimum 0,2 % - proof strength | MPa [b] |
| $R_{p0,2/t}$ | Minimum 0,2 % - proof strength at design temperature t °C | MPa [b] |
| $R_{p1,0}$ | Minimum 1,0 % - proof strength | MPa [b] |
| $R_{p1,0/t}$ | Minimum 1,0 % - proof strength at design temperature t °C | MPa [b] |
| $TS_{min}$ | Minimum operating temperature of the hydraulic fluid or of the environment, whichever is lower or equal | °C |
| $TS_{max}$ | Maximum operating temperature of the hydraulic fluid or of the environment, whichever is higher or equal | °C |
| $V$ | Internal volume of the gas chamber | litre |
| $V_0$ | Gas volume at pressure $P_0$ | litre |
| $V_1$, $V_2$ | Volumes occupied by the gas contained in the accumulator and the additional chambers, if any, at pressures $P_1$ and $P_2$ at their respective temperatures | litre |
| $z$ | Weld joint coefficient | |

[a] The relationships between the defined thicknesses are shown in Figure 3.1.

[b] MPa for calculation purposes only, otherwise the unit should be bar (1 MPa = 10 bar).

### 3.2.2 Inter-relation of thickness definitions

The inter-relation of the various definitions of thickness is shown in Figure 3.1.




**Key**

$e$ required thickness

$e_n$ nominal thickness

$e_a$ analysis thickness ($e_n$-$\delta_e$-$\delta_m$-$c$)

$c$ corrosion allowance

$\delta_e$ absolute value of the negative tolerance taken from the material standard of the component

$\delta_m$ possible thinning during manufacturing process of the component



**Figure 3.1 — Relationship of thickness definitions**

# 4 Materials

## 4.1 Requirements for metallic materials

The pressure containing envelope of gas-loaded accumulators shall be constructed of either:

— harmonised materials used for the manufacture of unfired pressure vessels and meeting the requirements of EN 13445-2:2002;

— materials other than those specified in EN 13445-2:2002 provided that they have been accepted by a particular material appraisal;

— materials covered by a European approval for materials in accordance with Article 11 of Pressure Equipment Directive 97/23/EC.

## 4.2 Material certificates for components of the pressure containing envelope

Components used in the manufacture of the pressure containing envelope of gas-loaded accumulators to category II, III and IV according to Annex II of the Pressure Equipment Directive 97/23/EC, shall be accompanied by an inspection document in accordance with EN 10204:2004 type 3.1 – see Annex B.

# 5 Basic design and calculation criteria

## 5.1 General

The requirements of Clause 5 shall apply when the materials and welds are not subject to localised corrosion in the presence of either products which the gas-loaded accumulator is to contain, or the environment in which it is located.

## 5.2 Corrosion

A corrosion allowance is not normally required for accumulators covered by this European Standard. Where there is a risk of corrosion, a protection method and/or corrosion allowance shall be applied to the affected surfaces of the accumulator.

## 5.3 Qualification by similarity

Accumulators are often serially produced and it is possible to qualify a range of accumulators based upon the design, calculation and testing of one model within the range provided that other accumulators are similar. Two accumulators are similar provided that:

— they are made of the same material of the same form and origin;

— they are identical with the exception of length;

— the internal length of the cylindrical portion is not less than three times its external diameter.



If the length of the cylindrical portion is less than three times its external diameter, then a detailed stress analysis shall be undertaken.



## 5.4 Design methods

### 5.4.1 General

This European Standard specifies methods for the design by equations of accumulators or accumulator components. Satisfactory application of such equations alone shall be sufficient to demonstrate conformity to this European Standard provided the accumulator will be subjected to less than 500 pressure cycles between $P_2$ and $P_1$ during its lifetime.

Where the accumulator will be subjected to more than 500 pressure cycles between $P_2$ and $P_1$, the manufacturer shall make an assessment for the effects of fatigue, either by analysis or test. This assessment shall form part of the Technical Documentation File.

Clauses 17 and 18 of EN 13445-3:2002 shall be used as the basis for a fatigue analysis and 7.6 of this European Standard shall be used as the method for conducting a fatigue cycling test.

Figure 5.1 shows the design process to be adopted.

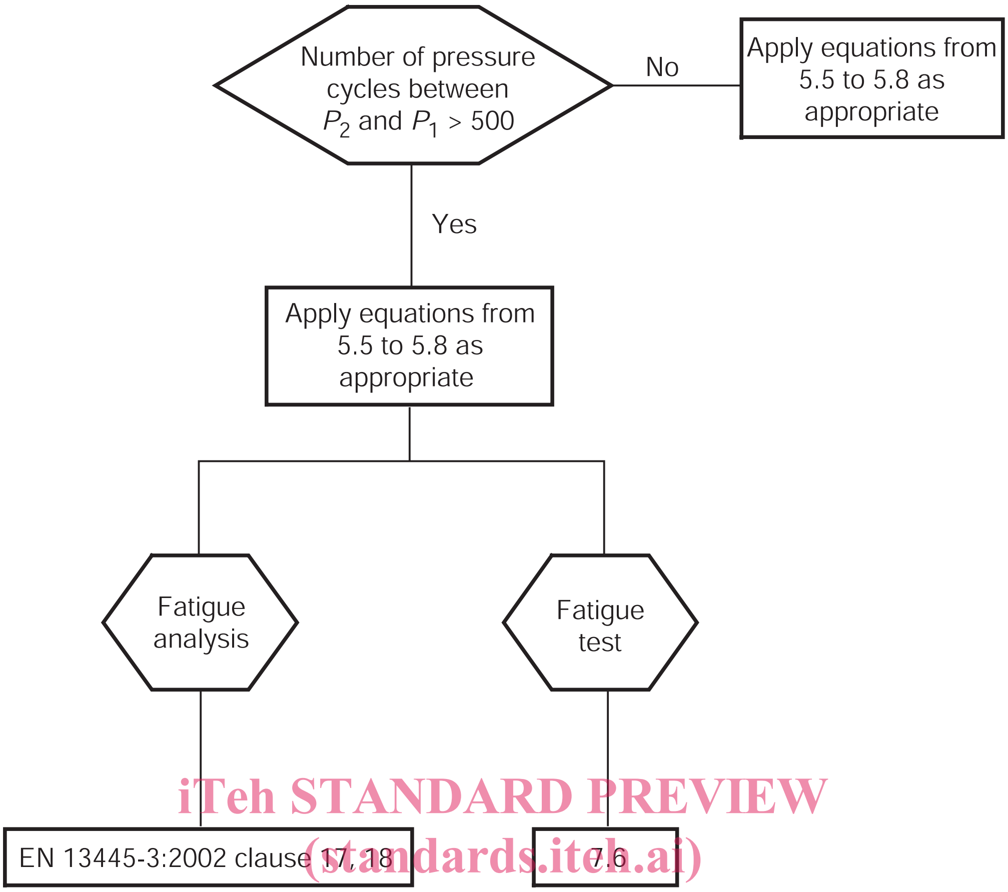





**Figure 5.1 — Design process**

### 5.4.2 Basic symbols, units and description

Table 5.4-1 lists basic symbols and units. Further and modified notation is provided in the individual sections.

**Table 5.4-1 — Basic symbols and units**

| Symbols | Characteristics | Units |
|---|---|---|
| $D_e$ | Outside diameter of the shell | mm |
| $D_i$ | Inside diameter of the shell | mm |
| $e_s$ | Required thickness of end to limit membrane stress in central part of shell | mm |
| $e_y$ | Required thickness of knuckle to avoid axis-symmetric yielding | mm |
| $f$ | Nominal design stress at design temperature | MPa [a] |
| $f_a$ | Nominal design stress at test temperature | MPa [a] |
| $f_{shear}$ | Nominal design shear stress at design temperature = $f$ x 0,8 | MPa [a] |
| $f_{test}$ | Nominal design stress for testing conditions | MPa [a] |
| $h$ | Internal height of dished end measured from cylindrical part | mm |
| $r$ | Inside radius of curvature of a knuckle | mm |
| $R$ | Inside spherical radius of central part of torispherical end | mm |

[a] MPa for calculation purposes only, otherwise the unit should be bar (1 MPa = 10 bar).

### 5.4.3 Maximum allowable values for the nominal design stress for pressure bearing parts

This subclause specifies maximum allowable values for the nominal design stress for pressure parts other than bolts and physical properties of steels.

Maximum values for the nominal design stress at operating temperatures are given in Table 5.4-2.

**Table 5.4-2 — Maximum allowable values of the nominal design stress for pressure parts other than bolts**

| | Normal | Under test conditions |
|---|---|---|
| **Steels other than austenitic with A < 30 %** | $f = \min\left(\frac{R_{p0,2/t}}{1,5}; \frac{R_{m/20}}{2,4}\right)$ | $f_{test} = \frac{R_{p0,2/t_{test}}}{1,05}$ |
| **Austenitic steels with 30 % < A ≤ 35 %** | $f = \frac{R_{p1,0/t}}{1,5}$ | $f_{test} = \frac{R_{p1,0/t_{test}}}{1,05}$ |
| **Austenitic steels with A > 35 %** | $f = \max\left[\left(\frac{R_{p1,0/t}}{1,5}\right); \min\left(\frac{R_{p1,0/t}}{1,2}; \frac{R_{m/t}}{3}\right)\right]$ | $f_{test} = \max\left(\frac{R_{p1,0/t_{test}}}{1,05}; \frac{R_{m/t_{test}}}{2}\right)$ |
| **Cast steels** | $f = \min\left(\frac{R_{p0,2/t}}{1,9}; \frac{R_{m/20}}{3}\right)$ | $f_{test} = \frac{R_{p0,2/t_{test}}}{1,33}$ |



NOTE Only $f = \frac{R_{p0,2/t}}{1,5}$ is valid for fine-grained steels and heat-treated steels.



## 5.5 Design and calculation methods common to all accumulator types

### 5.5.1 General

All applicable equations shall be used in order to demonstrate conformity with this European Standard. The maximum allowable pressure *PS* can be replaced by the test pressure *PT* when calculating for test conditions.

### 5.5.2 Specific definitions

**5.5.2.1**
**Cylinder**
right circular cylinder

**5.5.2.2**
**Torispherical end**
dished end, made up of a spherical cap, a toroidal knuckle and a cylindrical shell, the three components having common tangents where they meet

**5.5.2.3**
**Klöpper-type**
torispherical end for which $R/D_e$ = 1,0 and $r/D_e$ = 0,1

**5.5.2.4**
**Korbbogen-type**
torispherical end for which $R/D_e$ = 0,8 and $r/D_e$ = 0,154