SLOVENSKI STANDARD
SIST EN 13184:2002

01-junij-2002

Neporušitveno preskušanje - Preskušanje tesnosti - Metoda spremembe tlaka

Non-destructive testing - Leak testing - Pressure change method

Zerstörungsfreie Prüfung - Dichtheitsprüfung - Druckänderungsverfahren

Essais non destructifs - Contrôle d'étanchéité - Méthode par variation de pression

Ta slovenski standard je istoveten z: **EN 13184:2001**

ICS:

19.100 Neporušitveno preskušanje Non-destructive testing

SIST EN 13184:2002 **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13184

March 2001

ICS 19.100

English version

Non-destructive testing - Leak testing - Pressure change method

Essais non destructifs - Contrôle d'étanchéité - Méthode par variation de pression

Zerstörungsfreie Prüfung - Dichtheitsprüfung - Druckänderungsverfahren

This European Standard was approved by CEN on 18 January 2001.

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 Management Centre 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 Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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

Ref. No. EN 13184:2001 E

Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 138 "Non-destructive testing", 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of an identical text or by endorsement, at the latest by September 2001, and conflicting national standards shall be withdrawn at the latest by September 2001.

This European Standard 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 standard.

Annex A is normative, the annexes B and C are 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, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This document describes the techniques for the determination of the leakage rates across the boundary of an isolated object, subjected to a pressure difference. The techniques are based on the evaluation of the change of the mass of gas within the test object. The ideal gas equation states the relationship between mass, pressure, temperature, volume of the gas contained in the internal free volume of the object. In some circumstances one or more variables may be considered constant and so the mass change can, for example, be assessed by monitoring the pressure or pressure-temperature changes within the test object.

The volume change of the object (due to pressure and temperature changes during the test) should be taken into account. In most industrial applications, however, this change is so small that can be neglected. Therefore the main part of this standard considers the volume as a constant during the test.

The deformability of the object under test is normally be considered in drafting of the test specification and, if test precision can be affected by a volume change, alternative formulas or some techniques of keeping the pressure constant (flow measurement) can be used.

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 473 *Qualification and certification of NDT personnel - General principles*

EN 1330-8 *Non destructive testing - Terminology- Part 8 - Terms used in leak tightness testing*

EN 1779 *Non destructive testing - Leak testing - Criteria for method and technique selection*

EN 13185:2001 *Non destructive testing -Leak testing - Tracer gas method*

prEN 13625:2001 *Non destructive testing - Leak test - Guide to the selection of instrumentation for the measurement of gas leakage*

3 Terms and definitions

For the purposes of this European Standard, the following terms and definitions given in EN 1330-8 and the following apply.

3.1
differential pressure gauge
instrument measuring the difference between two pressures

4 Personnel qualification

It is assumed that leak tightness testing is performed by qualified and capable personnel. In order to prove this qualification, it is recommended to certify the personnel according to EN 473 or equivalent.

NOTE For pressure equipment see directive 97/23/EC (Annex I, paragraph 3.1.3) : "For pressure equipment in categories III and IV, the personnel must be approved by a third party organization recognized by a Member State"

5 General Requirements

5.1 Safety

The design of the object under test shall be checked to ensure its integrity under the pressure differential, at the temperature of the test, having regard for the effects of the temperature increases due to ambient changes, solar heating, etc. Specific devices to prevent excessive pressure gradients may have to be provided in accordance with local safety regulations to assure that the design limits cannot be exceeded.

5.2 Feasibility

The leakage rate determines the change in the total pressure that takes place over a given period of time. Because of this, the resolution of gauges should be such that the pressure change can be determined accurately. The instrument sensitivity is related to the final reading: this sensitivity should be at minimum five to ten times higher than the pressure to be expected.

The instrument resolution has to be defined with the acceptance criteria.

5.3 Test intruments

5.3.1 Types of gauges - see prEN 13625:2001

— Vacuum gauges suitable for the test pressure range;

— Pressure gauges: Absolute or differential pressure gauges may be used. When differential pressure gauges are used, reference pressure variations shall be monitored and taken into account;

— Thermometers: Resistance thermometers are generally used for temperature measurements, but other devices may be employed;

— Hygrometer: For the measurements of the humidity or the dew point of test gas, capacitive or resistive type instruments may be used;

— Flowmeters may be of mass or volumetric types, with an integrator device.

All instruments shall have ranges, resolution, accuracy, and repeatability compatible with the acceptance criteria.

5.3.2 Location

For pressure measurement either single or a small number of sensors are normally used.

NOTE Sensors should be placed in the most appropriate position in the test object.

With large vessels or complex systems, the temperature and dew point at several positions shall be monitored since these can vary across a system, particularly if there are thermally isolated, occluded or dead volumes. Such variation shall be taken into account in the calculations.

Dials and indicating/recording devices shall be readily accessible to the operator.

In long term tests, an appropriate number of sensors shall be used so that the failure of one or more sensors will not invalidate the test.

5.4 Auxiliary equipment

Auxiliary equipment used in the performance of the test includes:

— compressors or vacuum pump systems;

— pressure regulators, dryers, tight chambers;

— valves, vent lines, safety devices against over pressure or high vacuum.

6 Calibration

All the instruments shall be calibrated against devices that are traceable to National Standards.

7 Pressure Decay Technique - See EN 1779, Technique D.1

7.1 Application

This method is applicable to test objects or systems that can withstand an internal overpressure without deformation or significant variation of the volume. The internal free volume shall be known, unless the leakage rate is specified as a rate of pressure fall within the pressure involved.

If the test is carried out under conditions different from those characteristics of normal operation (different operating fluids, different pressure), this shall be taken into account in the test procedures and in the test acceptance limits.

7.2 Working principle

The object under test is subjected to a positive differential pressure (either by pressurization or by placing it in a vacuum chamber). The pressure source is then isolated and, after a suitable temperature stabilization time, the pressure and the temperature reading (dew point readings if required) are recorded at regular intervals.

Two techniques may be used:

7.2.1 Absolute technique

The indicated pressure is the absolute pressure.

7.2.2 Reference vessel technique

The pressure within the test object is compared to the pressure inside a reference object. The latter may be a sealed volume located within the test object, of such a geometry that it can assume the temperature of the atmosphere of the object. The reference volume shall have a pressure slightly lower than the object and shall be tested for tightness before and after the test; its temperature shall also be recorded.

7.3 Free volume measurement

The internal free volume of the object shall be accurately assessed if the leakage rate is to be stated as a mass flow.

Volume can be estimated, for example, from several measurements of a significant pressure fall over a short given time caused by a measured leakage rate through a valve. The volume can be estimated from the average value of the pressure drop and the total gas lost.

If the leakage rate is expressed as a percentage of the total mass of enclosed gas lost per unit time, then a knowledge of the enclosed free volume is not required.

7.4 Procedure

7.4.1 Object preparation

The object shall be clean and dry. All internal components that cannot withstand the test pressure shall be removed. Part of the system not subjected to the test shall be isolated, using suitable devices, including temporary blank flanges, welded if necessary.

Large thin-walled tanks should be monitored (strain gauges) in order to take into account sudden volume changes due to boundary instability.

Care shall be taken where trapped or poorly- accessible volumes may be encountered (double bead welds, settles, double-gasket penetrations) because they can increase the stabilization time and the uncertainty of the test.

If the procedure requires the reference vessel, this shall be placed in position, with temperature sensors fitted.

Air circulating systems, such as fans, can be installed in large vessels to increase the uniformity of conditions, but the system heat sources shall be taken into account.

7.4.2 Pressurization

The object shall be pressurized using gas clean, free of contaminants and as dry as possible.

Cylinder gases or air compressors with a dryer system may be used. To reduce the temperature stabilization time, the inlet gas temperature should be close to that of the air in the object.

7.4.3 Stabilization time

After the test pressure is reached the pressure source is insulated. A stabilization period of not less than 1 h is necessary, mainly for temperature and moisture equalization. However, with vessels or systems having a large capacity (e.g. several hundreds of m^3), stability can be considered to have been reached when the temperature, averaged over 1 h, does not deviate by more than 0,5°C from the average change over the previous 2 h.

7.4.4 Test procedure

It is desirable to minimize the effects of draughts and sunlight.

After the stabilization period, the test commences and the actual pressure is recorded. The temperature and dew point (moisture content) are also recorded if required. The pressure or the pressure decay (referred to the initial pressure), corrected for the temperature effect, is plotted against the elapsed time. If, during the test, in all areas of the object and at any temperature conditions, the relative humidity remains below 90%, perfect gas behaviour can be assumed. This assumption is possible in most industrial conditions because in this range the change of the specific volume of the moist air, due to the temperature changes, at constant specific humidity, differs less than 0,1% from that of the dry air change. If these conditions are not fulfilled, the calculations shall be performed using a psychrometric chart, in order to take into account the specific volume changes of the moist air and the possible condensation of water (assume volume 0 for condensed phase).

If the pressure reading is relative to atmospheric pressure, the barometric pressure shall also be recorded.

7.4.5 Test duration

The duration of the test depends on the dimensions of the test object or the test accuracy or scope (e.g. short duration tests for pass/fail differentiation). If calculations are required however to determine the actual leakage value, the duration of the test period shall be sufficient to enable adequate data to be accumulated to calculate the leakage rate. Furthermore, statistical analysis of the results and the upper confidence limit may be required. In this case, a minimum of 20 sets of data points, at approximately equal time intervals, should be available and the test should not last less than 8 h, after initial stabilization.

For large vessels, complex systems or outdoor vessels in the sunlight, a period of 24 h (or multiples of this) is recommended, to reach similar ambient conditions at the beginning and end of the test.

7.4.6 Calculations

The mass of the contained test gas is determined at any point from the application of the ideal gas law:

$$p \times V = \frac{m}{M} \times R \times T \qquad m = \frac{p \times M \times V}{R \times T}$$

$$m' = \frac{M \times V}{R \times T} \times (p - p_V(T))$$

where

V is the internal free volume in cubic metres;

R is the universal gas constant, in joules per mole and kelvin;

p is the total pressure, in pascals;

$p_V(T)$ is the partial pressure of water vapour, in pascals, at temperature T, in kelvins;

m is the total mass of non-condensable gas, in kilograms;

M is the molar mass of the test gas, in kilograms per mole;

T is the temperature of the test gas, in kelvins;

m' is the mass of the test gas, in kilograms.

The mass loss is:

$$m_1' - m_2' = \frac{M \times V}{R} \times \left[\frac{p_1 - p_V(T_1)}{T_1} - \frac{p_2 - p_V(T_2)}{T_2} \right]$$

where the subscripts $_{1,\,2}$ refer to the test gas at the beginning and the end of the test respectively.

Within the limits of 7.4.4 for relative humidity, water vapour can be considered to behave as an ideal gas and the expression results:

$$m_1' - m_2' = \frac{M \times V}{R} \times \left(\frac{p_1}{T_1} - \frac{p_2}{T_2} \right)$$

The mass loss can be converted to a volume loss at standard conditions p_S, T_S , since:

$$V_s = \frac{n \times R \times T_s}{p_s}$$

with $n = \frac{m}{M}$

where

n is the number of moles

So, the leakage rate given as pV throughput becomes:

$$q_p V = \frac{V \times T_s}{\Delta t} \times \left(\frac{p_1}{T_1} - \frac{p_2}{T_2} \right)$$

where

Δt is the duration of the test;

and the leakage rate, expressed as a percentage of loss (mass, pressure):

$$\Delta\% = \left(1 - \frac{p_2 \times T_1}{p_1 \times T_2}\right) \times 100$$

7.5 Data analysis and confidence interval

(The procedure described apply only to high precision tests or to large critical components)

Analysis should be carried out on the mass versus time plot throughout the test period. It is suggested that the mass loss obtained from the readings is checked every four hours at time t_0, t_4, t_8,... repeating a second series at time t_2, t_6, t_{10},....

The spread of the result in each sequence or between the two sequences can indicate the importance of the effect of unforeseen variables on the test.

The average between these values may sometimes be sufficient for determining leakage rate.

If required however or if the spread of the results is too large, a linear regression in the form of:

$$y = A + B\,T$$

where

y is the calculated quantity (mass) at time t;

A is the intercept of the line on y-axis;

B is the slope of the line;

T is the time elapsed from the beginning of the test;

shall be calculated and an upper confidence limit shall be defined.

NOTE It is assumed that the difference between the initial and final test pressure is small compared with the pressure difference across the boundary in order to consider the flow rate constant and to apply the linear regression

Examples of application are given in annex A.

7.6 Verification of leakage test accuracy

(The procedure described applies only to high precision tests or to large critical components)

The following method may be used to verify the validity of the leakage rate measurements.

7.6.1 A small-metered quantity of test gas shall be either admitted or removed from the test object rapidly. The mass change indicated by test instrument shall be compared to the metered quantity introduced in or lost from the test object. The agreement shall be better than 20%.

7.6.2 A leak, the leakage rate of which is known under test conditions, is superimposed on the existing leak at the end of the test, as continuation of the test.

This may be carried out by a calibrated orifice connected to the test object via a valve. The orifice should provide, under test pressure, a flow similar to the total existing leaks.

If B is the slope of the calculated regression line during the test and B' is the slope after the calibrated leak valve is open, the correction of leakage rate measured during the test is given by:

$$q_v = B \times \frac{q_{CL}}{B' - B}$$