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Third edition
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Paper and board — Determination of roughness/smoothness (air leak methods) —

Part 4: **Print-surf method**

Papier et carton — Détermination de la rugosité/du lissé (méthodes du débit d'air) —

Partie 4: Méthode Print-surf

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*, Subcommittee SC 2, *Test methods and quality specifications for paper and board*.

This third edition cancels and replaces the second edition (ISO 8791-4:2007), which has been technically revised.

The main changes compared to the previous edition are as follows:

— Annex D and Annex E describing the calibration of Print-surf instruments have been removed;

— some minor editorial changes have been made.

A list of all parts in the ISO 8791 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Paper and board — Determination of roughness/ smoothness (air leak methods) —

Part 4: Print-surf method

1 Scope

This document specifies a method for determining the roughness of paper and board using an apparatus which conforms to the Print-surf method, as defined in this document. It is applicable to all printing papers and boards with which it is possible to form a substantially airtight seal against the guard lands of the measuring head.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 186, *Paper and board — Sampling to determine average quality*

ISO 187, *Paper, board and pulps — Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
print-surf roughness
mean gap between a sheet of paper or board and a flat circular land pressed against it under specified conditions

Note 1 to entry: The mean gap is expressed as the cube root mean cube gap calculated as specified in Annex A. The Print-surf roughness is expressed directly as the average value of roughness, in micrometres.

3.2
print-surf compressibility
K
percentage decrease in surface roughness when measurements are made consecutively at the two standard clamping pressures specified in this document

4 Principle

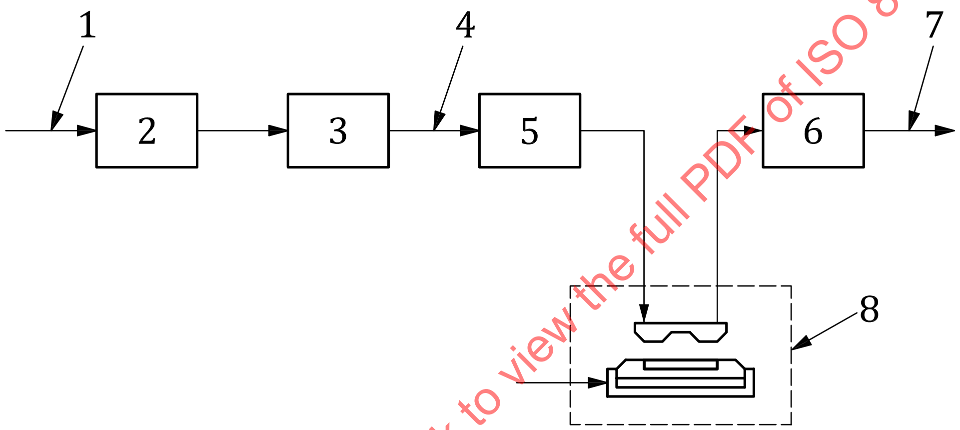
The test piece is placed between a circular flat metal sensing surface and a resilient backing, and inner and outer circular lands form a seal with the test piece. Under the influence of a pressure difference, air flows across the measuring land between the measuring land and the test piece. The rate of air flow is measured on a variable-area flowmeter, or the pressure difference across the measuring land is compared to the pressure difference across a known impedance. In both cases, the result is expressed as the air gap, in micrometres.

5 Apparatus

5.1 Print-surf tester (two types)

5.1.1 Print-surf tester, which operates according to one of the following principles.

5.1.1.1 Variable-area flowmeter type, in which a standard pressure difference is created across the measuring land and the air-flow rate is measured on a variable-area flowmeter. The air-flow rate varies with roughness and the flow rate is converted to roughness, in micrometres. The flow diagram for this type of instrument is shown in Figure 1.

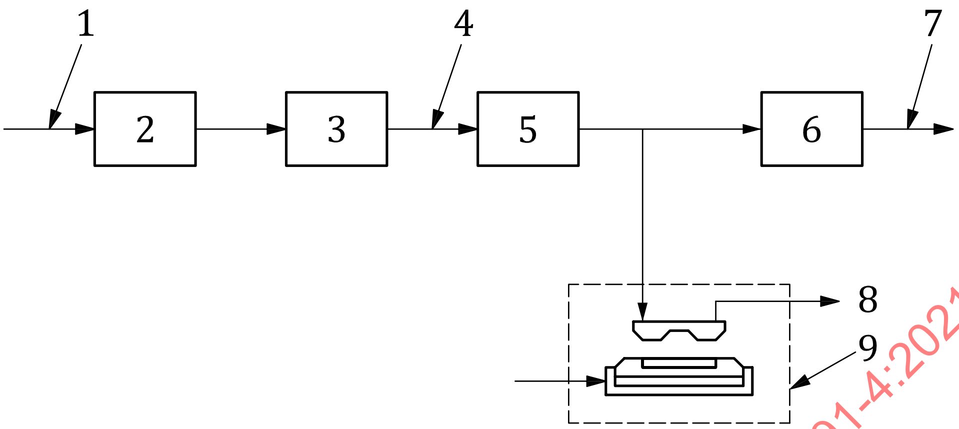


Key

1 incoming air — 300 kPa to 600 kPa
2 filter
3 pressure-regulator valve
4 6,2 kPa or 19,6 kPa
5 on/off valve
6 flow indicator tubes
7 to atmosphere
8 sensing head and clamping device

Figure 1 — Flow diagram for variable-area flowmeter type

5.1.1.2 Impedance type, in which the air from the controlled pressure source passes first through a fluidic impedance and then through the sensing head, after which it discharges to atmosphere. The pressure differences across the fluidic impedance and across the land are each measured by a transducer. These pressure differences vary with roughness and the signals are converted to roughness, in micrometres. The flow diagram for this type of instrument is shown in Figure 2.



Key

1 incoming air — 300 kPa to 600 kPa
2 filter
3 pressure-regulator valve
4 19,6 kPa
5 fluidic impedance
6 pressure transducer
7 analogue signal
8 to atmosphere
9 sensing head and clamping device

Figure 2 — Flow diagram for impedance instrument type

5.1.2 The procedures for maintaining these testers in good working order given in Annex B apply.

5.2 Principal components of the system

5.2.1 Air supply, in which the air from the controlled pressure source passes first through a fluidic impedance and then through a pressure transducer.

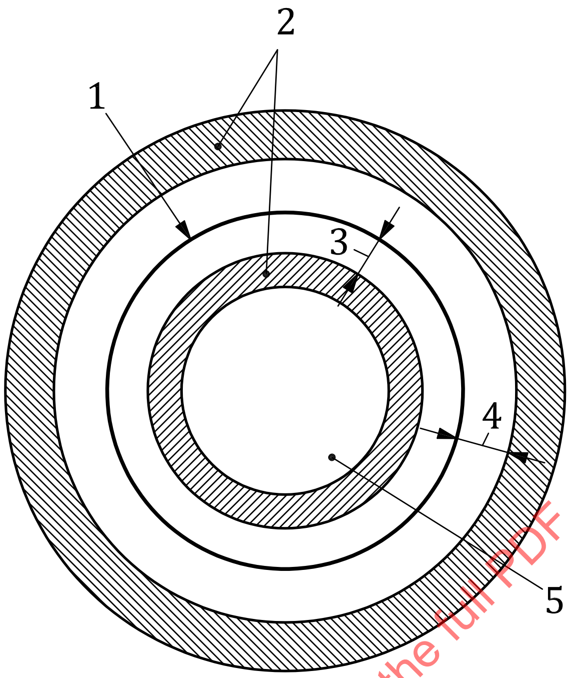
5.2.2 Sensing-head pressure regulator, allowing setting of the sensing-head differential pressure to 19,6 kPa ± 0,1 kPa or, on variable-area flowmeter instruments only, to either 6,2 kPa ± 0,1 kPa or 19,6 kPa ± 0,1 kPa.

5.2.3 Sensing head, (see Figures 3 and 4), consisting of three concentric, annular lands composed of suitable material which have coplanar, polished surfaces. The centre or measuring land shall be 51,0 µm ± 1,5 µm wide and have an effective length of 98,0 mm ± 0,5 mm. The two guard lands shall each be at least 1 000 µm wide at any point, and the radial distance between them at any point shall be 152 µm ± 10 µm. The measuring land shall be centred between them to within ±10 µm.

The lands shall be mounted in an airtight mounting, constructed so that air can be passed into the gap between one guard land and the measuring land, and exhausted from the gap between the measuring land and the other guard land. The back of the mounting shall be flat and form a ground mating surface with the flat surface of a manifold fitted with air inlet and outlet ports.

A spring-loaded protective collar may be fitted outside the guard lands. If such a protective collar is fitted, the force exerted by the loading spring shall be taken into account when setting the clamping pressure.

NOTE In many instruments fitted with the protective collar, the force exerted by the loading spring is 9,8 N.



Key

1 measuring land

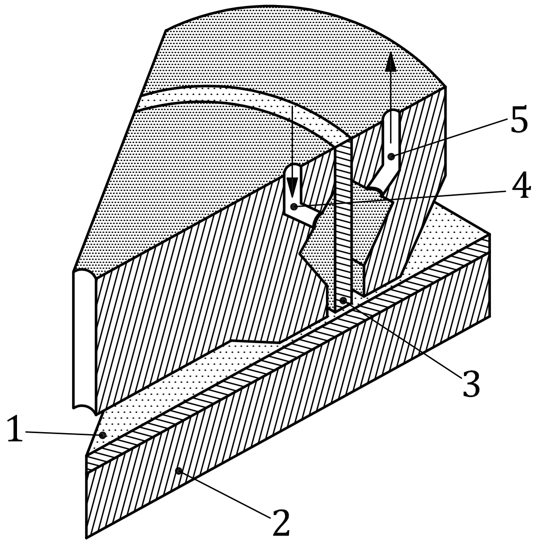
2 guard lands

3 passage air connected to air supply

4 passage leading to flowmeters or atmosphere

5 fluidic impedance

Figure 3 — Plan of the measuring and guard lands of the sensing head



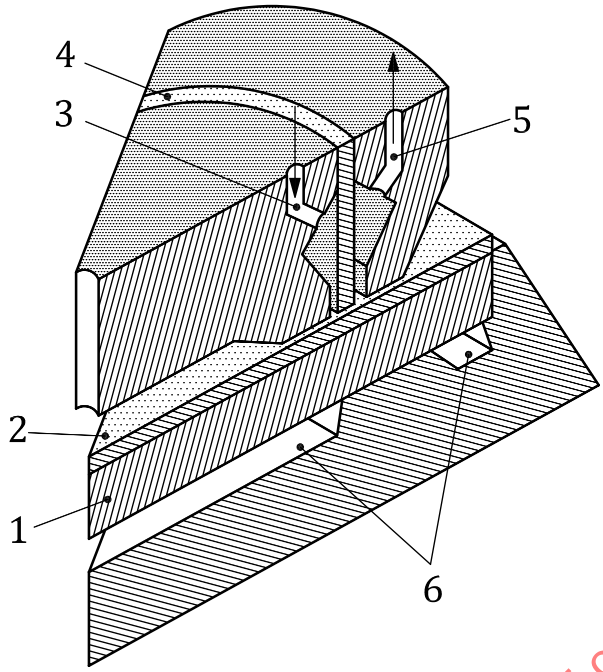
Key

1 paper
2 resilient backing
3 measuring land
4 regulated low-pressure air
5 to flowmeters or atmosphere

Figure 4 — The sensing head sectioned on two radii

5.2.4 Backing holders, consisting of rigid metal discs of known mass, each recessed to accommodate a resilient backing at least 10 mm greater in diameter than the outside diameter of the outer guard land. The mass of both the resilient backing and the holder shall be allowed for in the initial adjustment of the clamping pressure.

It has been observed that high-stiffness papers and boards can interact negatively with the flat metal backing holder and cause erroneously high roughness results. This problem can be solved by using a modified backing holder which relieves those areas of the backing holder not directly below the measuring land, as shown in Figure 5.



Key

1 resilient backing
2 paper
3 regulated low-pressure air
4 measuring lands
5 to flowmeters or atmosphere
6 new modified clamp platen showing machined cut-away

Figure 5 — The sensing head sectioned on two radii showing cut-away platen

5.2.5 Two resilient backings, of different types, which can be held in the recessed holders by means of double-sided adhesive tape:

5.2.5.1 Soft backing, resilient, consisting of an offset printing blanket composed of a layer of synthetic rubber, at least 600 µm thick, bonded to a fabric backing giving an overall thickness of 2 000 µm ± 200 µm. The apparent hardness of the complete backing shall be 83 IRHD ± 6 IRHD (International Rubber Hardness Degrees).

5.2.5.2 Hard backing, resilient, usually made from a polyester film bonded at its periphery to cork, offset blanket or similar material. A small exhaust hole shall be provided to prevent air being trapped between the film and the backing. The apparent hardness of the assembly shall be 95 IRHD ± 2 IRHD.

5.2.6 Clamping mechanism, allowing clamping of the resilient backing at pressures of either 980 kPa ± 30 kPa or 1960 kPa ± 30 kPa, the pressure being calculated from the total area of the measuring and guard lands.

NOTE 1 On some earlier instruments, these values can be displayed on the gauge as 10 kgf/cm^2 and 20 kgf/cm^2.

Note that the spring loading in the protective collar (5.2.3) and the weight of the backing and its holder need to be taken into account. The rate of clamping shall be such that the pressure reaches 90 % of its final value in about 0,4 s, and 99 % of its final value in about 0,8 s.

NOTE 2 A third pressure of 490 kPa (5 kgf/cm^2) is available on most instruments, but is not acceptable for use with this part document because of a tendency for air to leak under the guard lands.

Variable-area flowmeter measurement systems shall have a pressure gauge fitted to the instrument to indicate the clamping pressure, which shall be adjustable. Impedance measurement systems shall have integrated pneumatic and electronic circuitry which automatically controls the clamping pressure. In each case, the actual pressure achieved shall be verified as specified in B.3.

5.3 Measuring system

5.3.1 The air-flow rate shall be measured with either a set of variable-area flowmeters or by measuring the pressure drop across an impedance.

5.3.2 Variable-area flowmeter instruments shall be fitted with flowmeters which are graduated to show the "cube root mean cube gap" between the paper and the measuring land surface, in micrometres (see Annex A). The flowmeters shall be calibrated by the procedures outlined in Annex C.

5.3.3 Impedance instruments measure air leakage by means of fluidic impedance, a pressure transducer and a function generator. They display or print the roughness, in micrometres to the nearest 0,1 µm, based on automatic measurement of pressure difference, over the range 0,6 µm to 6,0 µm. The value displayed shall be the value calculated after 3 s to 5 s.

6 Sampling

If the tests are being made to evaluate a lot, the sample should be selected in accordance with ISO 186. If the tests are made on another type of sample, make sure that the test pieces taken are representative of the sample received.

7 Condition

The sample shall be conditioned in accordance with ISO 187.

8 Preparation of test pieces

Prepare the test pieces in the same atmospheric conditions as those used to condition the sample. Cut at least 10 test pieces for each side to be tested. The size of each test piece shall be 100 mm × 100 mm, and their surfaces shall be identified in some convenient way (for example, side one or side two).

The test area shall be free of all folds, wrinkles, holes or other defects, and should not include watermarks. Do not handle that part of the test piece which will become part of the test area.

9 Procedure

9.1 Carry out the test in the same atmospheric conditions as those used to condition the sample (see Clause 7).

9.2 Ensure that the instrument is on a rigid horizontal surface free from vibration and that it is level. Before use on any particular day, check the system for leakage as specified in B.1.

9.3 Select and fit the backing disc appropriate for the material being tested. In general, the hard backing should be used for papers that are to be printed by letterpress presses fitted with paper backings. Papers to be printed by other processes, and boards however printed, should be tested with the soft backing.

9.4 Select and adjust the clamping pressure, using the following as a guide:

— Hard backing letterpress	1 960 kPa ± 30 kPa
— Soft backing letterpress	1 960 kPa ± 30 kPa
— Soft backing offset	980 kPa ± 30 kPa

9.5 For a tester of the variable-area flowmeter type, select the lowest-range flowmeter which will give a reading greater than 20 % of the scale range.

Always start with the highest-range flowmeter and turn the flow range selector switch successively to a flowmeter of lower range, in order to avoid subjecting the low-range flowmeters to a high air flow.

9.6 Test the first test piece by the following procedure.

9.6.1 Variable-area flowmeter type

Set the sensing-head differential pressure to 6,2 kPa ± 0,1 kPa by adjusting the pressure from the low side.

NOTE 1 If the pressure gauge indicates differential pressure in metres of water gauge, 0,63 m is equivalent to 6,18 kPa.

NOTE 2 The pressure gauge on some instruments has been found to be sensitive to jolts and, if the adjustment is made downwards from a higher pressure, the resulting pressure for a given scale reading will be higher than if the adjustment is made upwards from a lower pressure.

Clamp the first test piece under the sensing head, with the side to be tested uppermost. This operation can cause the reading on the sensing-head pressure gauge to change, but such a change may be ignored. Record the reading on the flowmeter to the nearest 0,05 µm, 3 s to 5 s after application of clamping pressure. Readings shall be taken level with the top of the flowmeter float. Select the lowest-range flowmeter which gives results greater than 20 % of the scale range.

If the reading obtained is less than 20 % of the range of the lowest-range flowmeter, increase the sensing-head pressure to 19,6 kPa ± 0,5 kPa (2,0 m water gauge). All readings taken at this pressure shall be multiplied by 0,667 (for the background of this factor, see Annex A, Formula [A.1]) to give the roughness, in micrometres, unless the flowmeters are calibrated for this pressure.

9.6.2 Impedance type

Place a test piece under the head with the side to be tested uppermost. Clamp the test piece either automatically or manually. Record the reading, 3 s to 5 s after application of clamping pressure.

9.7 Repeat step 9.6 for the other test pieces and calculate the arithmetic mean and standard deviation or coefficient of variation for the side tested. For variable-area flowmeter-type instruments, do not repeat the procedure for selection of the appropriate flowmeter and sensing-head pressure.

9.8 If a result is required for the roughness of the other side, take a second set of test pieces and repeat steps 9.6 and 9.7.

9.9 If Print-surf compressibility is to be determined, the lower of the two clamping pressures shall be selected and adjusted first. Follow step 9.6 and record the result and, without unclamping the test piece, next select and adjust the higher clamping pressure and again record the result. Repeat this sequence for the other test pieces. Calculate Print-surf compressibility using the Formula (1) in Clause 10.

10 Calculation

The Print-surf compressibility, K, can be defined mathematically by Formula (1):

$$K = \frac{100(G_1 - G_2)}{G_1} \quad (1)$$

where

G_1 is the surface roughness value obtained at a nominal clamping pressure of 980 kPa;

G_2 is the surface roughness value obtained at a nominal clamping pressure of 1960 kPa.

11 Precision

The repeatability and reproducibility can be calculated as outlined in Annex D.

12 Test report

The test report shall include the following information:

— a reference to this document, i.e. ISO 8791-4:2021;

— date and place of testing;

— all the information necessary for complete identification of the sample;

— the type of instrument used;

— the backing and type of backing holder used;

— the number of test pieces tested;

— the sensing-head differential pressure, in kilopascals;

— the clamping pressure, in kilopascals;

— the mean of the test results for each side tested;

— the standard deviation or coefficient of variation for each side tested;

— any deviation from this procedure which can have affected the results.

Annex A

Calculation of roughness in micrometres

For the purposes of this document the cube root mean cube gap, G_3, in metres, in the direction of the air flow between the measuring land and the test piece is calculated from Formula (A.1):

$$G_3 = \left(\frac{12 \times \eta \times b \times q_v}{l \times \Delta p} \right)^{\frac{1}{3}} \tag{A.1}$$

where

η is the viscosity, in pascal seconds, of air at room temperature;

b is the width, in metres, of the measuring land;

q_v is the volume of air flowing in unit time, in cubic metres per second;

l is the median length, in metres, of the measuring land;

Δp is the pressure difference, in pascals, across the measuring land.

The roughness, in micrometres, is then equal to $G_3 \times 10^6$.

If the differential pressure exceeds 1 % of the absolute pressure then Δp should be calculated as in Formula (A.2) to correct for the compressibility of air:

$$\Delta p = \frac{p_u^2 - p_d^2}{2 p_m} \tag{A.2}$$

where

p_u is the absolute upstream pressure;

p_d is the absolute downstream pressure;

p_m is the pressure at which the flow q_v is measured.

Formula (A.2) is derived on the assumption that the gap between the measuring land and the test piece is uniform across the width of the land, but that it varies along its length.

Formula (A.1) is subject to the assumptions that the flow is laminar, that the temperature is constant throughout, and that the kinetic energy changes per unit volume of air are negligible compared with Δp. The flow conditions are normally well within the laminar range, but the kinetic energy can be important when rough papers are measured, unless the differential pressure is restricted. To estimate the extent of the error, the full equation for flow over the measuring land may be used:

$$\Delta p = \frac{12 \times \eta \times b \times q_v}{l \times G_3^3} + \frac{C \times \rho \times q_v^2}{2 \times l^2 \times G_3^2} \tag{A.3}$$

where

ρ is the density of air measured at pressure p_m;

C is a coefficient found by experiment for a number of papers, and is approximately equal to 2,5.

Additional information about the background of Formulae (A.1), (A.2) and (A.3) can be found in a paper published in Paper Technology[1].

Annex B
(normative)

Maintenance of Print-surf roughness testers

B.1 Leakage

B.1.1 The apparatus shall be maintained free of leakage, visible surface irregularities of the backings and pressure gauge error, as detailed in B.1.2, B.1.3 and B.3. Check for leakage at the lowest clamping pressure available and a sensing-head differential pressure of 19,6 kPa.

B.1.2 Leakage between the back of the sensing head and its supporting manifold is indicated by a measurable air flow when the soft backing is clamped directly against the head. Such leakage can be corrected by a thin smear of petroleum jelly on the mating surfaces.

B.1.3 Damage to the sensing head is detected as follows:

a) Carefully wipe the face of the sensing head with a lint- and oil-free, soft clean material.

b) Clamp a smooth scratch-free piece of 125 µm thick film, such as cellulose acetate, between the sensing head and the hard backing. Measure the air flow.

c) This test is very sensitive to dust, due to static charges and even to fingerprints. If a measurable flow is found, carefully wipe the surface of the film and repeat the test.

d) It is recommended that a suitable film be obtained from the instrument manufacturer/supplier.

e) If it is impossible to obtain a zero reading on the lowest range flowmeter, confirm damage by inspecting the measuring surface at a magnification of about × 50 with a stereoscopic microscope. On impedance instruments, a reading greater than 0,8 µm indicates the possibility of damage.

f) If pits or scratches are apparent, replace the sensing head.

B.2 Sensing head

At frequent intervals, inspect the head, preferably with a stereoscopic microscope, to ensure that the gaps between the measuring land and guard lands are free from debris. If necessary, clean as advised by the instrument manufacturer.

B.3 Pressure gauges

Whenever the instrument is used, check that both gauges register zero when the air supply is disconnected.

At least once a year, check the accuracy of pressure gauges and transducers by connecting in parallel a manometer or transducer, the latter having been calibrated against dead weights. Operate the instrument normally and record the actual static pressures achieved.

Convert the clamping pressure reading to force per unit area of guard plus measuring land surface. Correct for the weight of the resilient backing plus holder and for the force exerted by the spring-loaded protective collar. Compare the corrected clamping pressure and the measured head pressure to the gauge readings and pressure settings specified in 5.2.2 and 5.2.6.

Replace defective gauges or repair faulty control systems.

B.4 Resilient backing

Inspect the clamping surfaces daily and, as soon as any visible damage occurs, replace the backing using the procedure in the instrument manual. It is advisable to replace the backing on a regular basis and also if a zero reading cannot be obtained.

B.5 Evenness of clamping

Place a sheet of high-quality white paper on the hard backing, cover it with a piece of carbon paper, place the “sandwich” in the measuring gap and apply the clamping pressure. An uneven print indicates uneven clamping which shall be corrected by referring to the manufacturer.