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Internal combustion engines — Piston pins —

Part 2: Inspection measuring principles

Moteurs à combustion interne — Axes de pistons —

Partie 2: Principes de mesure pour le contrôle

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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).

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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 22, *Road vehicles*, Subcommittee SC 34, *Propulsion, powertrain and powertrain fluids*.

This second edition cancels and replaces the first edition (ISO 18669-2:2004), which has been technically revised.

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

— the scope has been defined more in detail; and

— references have been updated.

A list of all parts in the ISO 18669 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.

Internal combustion engines — Piston pins —

Part 2: Inspection measuring principles

1 Scope

This document defines the measuring principles used for measuring piston pins; it applies to piston pins with a nominal outer diameter from 8 mm up to and including 100 mm, for reciprocating internal combustion engines for road vehicles and other applications.

In certain applications, except road vehicles, and provided that mutual agreement is made between the purchaser and the manufacturer, this document can be used with suitable modifications.

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 1302, *Geometrical Product Specifications (GPS) — Indication of surface texture in technical product documentation*

ISO 18203, *Steel — Determination of the thickness of surface-hardened layers*

ISO 4287, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters*

ISO 4288, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture*

ISO 9934 (all parts), *Non-destructive testing — Magnetic particle testing*

ISO 6506 (all parts), *Metallic materials — Brinell hardness test*

ISO 6507 (all parts), *Metallic materials — Vickers hardness test*

ISO 6508 (all parts), *Metallic materials — Rockwell hardness test*

ISO 8015, *Geometrical product specifications (GPS) — Fundamentals — Concepts, principles and rules*

ISO 14104:2017, *Gears — Surface temper etch inspection after grinding, chemical method*

ISO 14253 (all parts), *Geometrical product specifications (GPS) — Inspection by measurement of workpieces and measuring equipment*

ISO 15548 (all parts), *Non-destructive testing — Equipment for eddy current examination*

ISO 16810, *Non-destructive testing — Ultrasonic testing — General principles*

ISO 18265, *Metallic materials — Conversion of hardness values*

ISO 18669-1:2013, *Internal combustion engines — Piston pins — Part 1: General specifications*

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
outside diameter
d_1
diameter of the outer surface measured at any point excluding areas of *edge drop-off (b)* (3.5)

Note 1 to entry: See ISO 18669-1:2013, Figure 12.

3.2
cylindricity of the outside diameter
CYLt
peak-to-valley cylindricity deviation; geometric form of the peripheral surface excluding areas of *edge drop-off (b)* (3.5)

Note 1 to entry: Characteristics measured in the axial direction are taper, convexity, concavity and waviness.

Note 2 to entry: See ISO 1101.

3.3
circularity of the outside diameter
RONt
peak-to-valley roundness deviation; deviations of the peripheral surface from circularity such as waviness, ovality and spherical-triangular forms

Note 1 to entry: See ISO 1101.

3.4
circumferential waviness
undulations of the peripheral surface from circularity in a waveform

3.5
edge drop-off
b
c
geometric form of the peripheral surface at the outside edges

3.6
inside diameter
d_2
d_4
diameter of the bore measured at any point

3.7
concentricity of inside diameter relative to outside diameter
difference between the maximum and minimum dimensions of the wall thickness (*a*) as measured in a plane perpendicular to the peripheral surface

Note 1 to entry: See ISO 1101.

3.8
length
l_1
Maximum dimension measured between two planes perpendicular to the peripheral surface.

3.9
gauge length
l_5
dimension between the gauge points measured perpendicular to the peripheral surface

3.10
runout of the end faces
axial distance between two circles located concentrically to the axis of the piston pin

Note 1 to entry: All points of the end face of the piston pin must lie during rotation around the axis.

3.11
end face diameter
d_6
maximum diameter of end face concavity or end face step

3.12
outside-edge profile
transition from the peripheral surface to the end face of piston pin

3.13
inside chamfer
t_1
transition from the inside cylindrical surface to the end face

3.14
tapered bore diameter
d_3
diameter of the taper at the end face

3.15
tapered bore angle
α
angle of inclination measured from the peripheral surface

3.16
runout tapered bore
e
concentricity of the tapered bore to the *outside diameter* (3.1)

3.17
carburised and nitrided case depth
thickness of the surface layer with a hardness value which is greater than the limit hardness *Hs*, measured perpendicular to the piston pin peripheral surface or bore surface on the finish-machined piston pin

3.18
core hardness
hardness in the core zone that is not affected by the case-hardened or the nitrided layer

3.19
peripheral surface hardness
hardness measured on the peripheral surface of the carburised or nitrided layer

3.20
volume change
change in volume detected as a permanent outside-diameter dimensional deviation at reference temperature after being heated to a test temperature for a specified period of time

3.21
material defect
defects occurring on the peripheral surface, bore surface and core zone

EXAMPLE Grinding cracks, hardening cracks, stress cracks, inclusions, slag lines and seams.

3.22
residual magnetism
remaining magnetism after demagnetisation

3.23
visual defect
visible defects detected without magnification, by inspectors having normal eyesight (corrected if necessary) or detected automatically with opto-electronic systems

3.24
grinder burn
localised over- heating on ground surfaces, resulting in surface tempering and/or reheating with measurable changes in surface hardness

3.25
streaks on bore surface
forming streaks on bore surface of cold-formed end-web pins

4 Measuring principles

4.1 General measuring conditions

The following general requirements are applicable to all measuring principles unless otherwise specified:

a) Measurements shall be made using instruments with a resolution not exceeding 10 % of the tolerance of the dimension being measured.

b) "Measuring uncertainty" according to the ISO 14253 series shall apply.

c) "Measurement systems analysis" reference AIAG IATF 16949 applies.

d) The reference temperature for outside-diameter measurements shall be 20 °C ± 1 °C.

e) The "principle of independence" according to ISO 8015 shall apply.

f) **Other methods** which are able to guarantee the required measurement accuracy are allowed with prior agreement between manufacturer and customer.

4.2 Characteristics and measuring principles

4.2.1 Outside diameter, d_1

Measuring principle
— Reference method: Measure with a precision calliper having spherical measuring probes each of radius 1,5 mm min. exerting a measuring force of approximately 1 N (see Figure 1).

Measuring principle

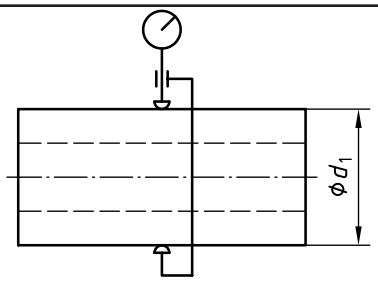



Figure 1 — Outside-diameter measuring principle
Measurement uncertainty:
±0,000 5 mm in accordance with the ISO 14253 series.

4.2.2 Cylindricity of the outside diameter (d_1)

Measuring principle
Record and evaluate multiple polar diagrams (measuring in a minimum of 3 planes, centre of pin and near each end avoiding edge features), in accordance with ISO 12180.
Reference cylinder: Least squares (LSCY)
Filter: Gaussian (G)
Stylus tip radius: 1,0 mm
Undulations per revolution (UPR): 1 - 50

4.2.3 Circularity of the outside diameter (d_1)

Measuring principle
Recording and evaluation of a macro-form diagram in the circumferential direction avoiding edge features (polar diagram), in accordance with ISO 12181.
Reference circle: Least squares (LSCI)
Filter: Gaussian (G)
Stylus tip radius: 1,0 mm
Undulations per revolution (UPR): 1 – 50

4.2.4 Circumferential waviness

Measuring principle
Recording circumferential undulations on the OD surface.
Reference circle: Least squares (LSCI)
Filter: Gaussian (G)
Stylus tip radius: 1,0 mm
Undulations per revolution (UPR): 1 – 50
Analysis method A: Sector roundness
Departure from true circle (DFTC) within a defined angular window (example: 15° or 30° DFTC window).
Analysis method B: Filtered bandwidth
Peak-to-valley roundness deviation (RONt) with defined band pass filtering (example: 10 – 50 UPR or 15 – 50 UPR).
Analysis method C: Dominant roundness waviness
Dominant roundness waviness (RONWDt) with defined band pass filtering (example: 10-50 UPR or 15-50 UPR).

4.2.5 Edge drop-off, *b, c*

Measuring principle
Record and evaluate a macro-form diagram on both ends in the axial direction (profile lines), (see ISO 18669-1:2013, Figure 12).

4.2.6 Inside diameter, d_2, d_4

Measuring principle
Measured with inside measuring devices.

4.2.7 Concentricity of inside diameter (ID) relative to outside diameter (OD)

Measuring principle
Method A:
Measured with a thickness gauge (e.g. dial calliper or comparable gauges) (see Figure 2).

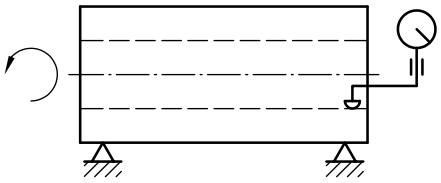



Figure 2 — Inside-diameter concentricity (Radial runout)
Method B:
Measured with a calliper or probe-indicator by 360° rotation in a V-block (see Figure 3).

Measuring principle

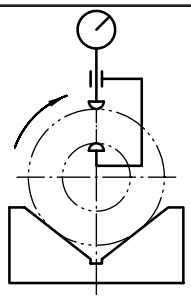



Figure 3 — Wall-thickness measuring principle

4.2.8 Length, l_1

Measuring principle
Reference method: Measured between two planes parallel to each other and perpendicular to the outside surface (see Figure 4). The envelope principle according to ISO 14405-1 (see Bibliography) does not apply.

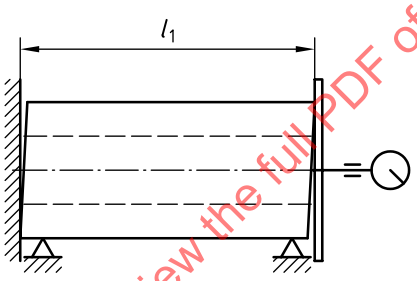



Figure 4 — Length measuring principle
When using other methods, the runout shall be considered to determine the total length of the pin.

4.2.9 Gauge length, l_5

Measuring principle
The pin is put between two ring gauges perpendicular to the outside surface, with inside diameters d_5. The sharp edges of these gauges measure from contact point to contact point. This "assembly" of pin and two rings is put in a height gauge and measured. A known standard is used to set the gauge at "0" (see Figure 5).

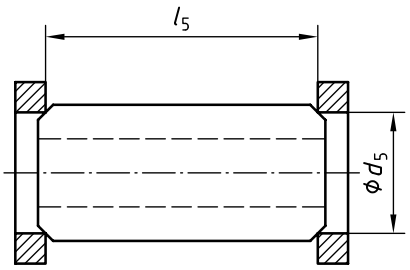
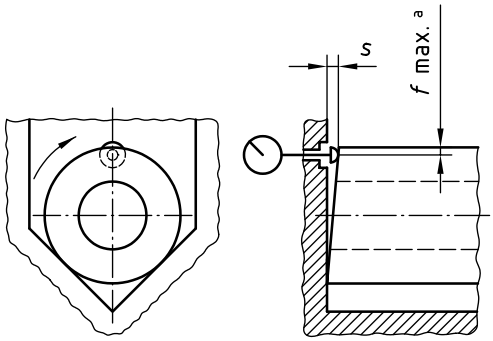
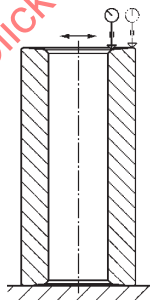



Figure 5 — Gauge-length measuring principle
NOTE Other lengths: all methods which are able to measure the characteristics according to specification.

4.2.10 Runout of the end faces, s

Measuring principle
Supporting surface: V-block with longitudinal stop at least as large as the outside diameter d_1. Measurement by 360° rotation in the V-block. Measured value = axial eccentricity or runout (see Figure 6). f / r: see ISO 18669-1:2013, Figure 14.    **Figure 6 — Runout measuring principle**

4.2.11 End face concavity, h_1, and end face step, h_2

Measuring principle
Maximum axial deviation of the end face surface as described as end face concavity or end face step. **Method A:** Place pin on flat plate. Zero gauge at highest axial position. Slide pin on flat surface recording maximum axial deviation of the end face surface avoiding edge features (see Figure 7).  **Figure 7 — End face measuring principle** **Method B:** Use of contour-measuring equipment.

4.2.12 End face diameter, d_6

Measuring principle
Measure using optical techniques or contour measuring equipment.

4.2.13 Outside-edge profile

Measuring principle
Measuring of the transition using contour-measuring method, or other appropriate methods (see ISO 18669-1:2013, Figure 14).

4.2.14 Inside chamfer, t_1

Measuring principle
Measurement using calliper, optical techniques or contour-measuring equipment (see ISO 18669-1:2013, Figure 15).

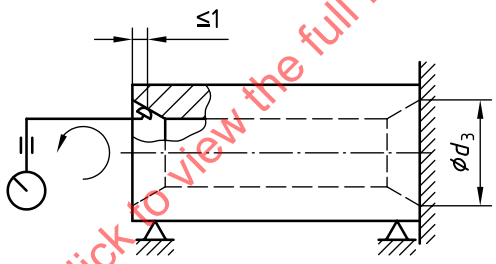
4.2.15 Tapered bore diameter, d_3

Measuring principle
Measured by using, for example calliper or contour-measuring equipment (see ISO 18669-1:2013, Figure 16).

4.2.16 Tapered bore angle, α

Measuring principle
Measured by using contour-measuring equipment (see ISO 18669-1:2013, Figure 16).

4.2.17 Runout tapered bore, e

Measuring principle
Measured with an internal calliper by 360° rotation in a V-block. Measuring point shall be located 1 mm max. from the end face (see Figure 8).    **Figure 8 — Runout tapered bore measuring**

4.2.18 Roughness

Measuring principle
Values shall be in accordance with ISO 1302 and ISO 4287. Measurement with electrical stylus instruments shall be in accordance with ISO 1302 and ISO 4287. Cut off length: 0,8 mm Measuring length: 4,0 mm Stylus tip radius: 2,0 µm Filter: Gaussian Measurement of tool marks and scratches on the outer and inner cylindrical surface is accomplished by tracing with a micro-stylus system in a longitudinal or circumferential direction depending on the defect type. Measurement is carried out in the visually worst zone. Evaluation and comparability shall be in accordance with ISO 4288.

4.2.19 Carburised and nitrided case depth

Measuring principle
Determination of the depth at which the limit hardness H_s exists, shall be measured in HV 1 or HV 0,3 according to ISO 18203. Limit hardness H_s of carburised case-hardened piston pins: 1. non-limited volume change H_s = 550 HV 0,3 with carburised case depth ≤ 0,2 mm H_s = 550 HV 1 with carburised case depth > 0,2 mm 2. limited volume change H_s = 500 HV 0,3 with carburised case depth ≤ 0,2 mm H_s = 500 HV 1 with carburised case depth > 0,2 mm Limit hardness H_s of nitrided piston pins: H_s = 550 HV 0,3 with nitrided case depth ≤ 0,2 mm H_s = 550 HV 1 with nitrided case depth > 0,2 mm

4.2.20 Core hardness

Measuring principle
Method A: Reference method Testing with Vickers HV 30 shall be in accordance with the ISO 6507 series. **Method B:** Testing with Brinell HB 2,5/187,5 shall be in accordance with the ISO 6506 series. **Method C:** Testing with Rockwell C shall be in accordance with the ISO 6508 series. Measure in the centre of the core zone that is not affected by the case-hardened or nitrided layer. The core zone, when sampled, shall not be cold-hardened or heated, and shall be located at least $1/3 \times l_1$ from the end face. The average of three measurements is taken as the determining value. No individual value may deviate more than 10 % from the average value. Values measured with methods B and C can be converted into HV and shall be according to ISO 18265.

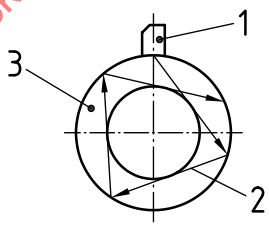
4.2.21 Peripheral surface hardness

Measuring principle
In order to attain a precise measurement result, testing should be done with the highest possible load, but with consideration to the danger of pressing through the case-hardened layer. **Method A:** Reference method Case-hardened and nitrided piston pins: Testing with Vickers HV 10 shall be in accordance with the ISO 6507 series. **Method B:** Case-hardened piston pins: Testing with Rockwell C, A or N shall be in accordance with the ISO 6508 series.

4.2.22 Volume change

Measuring principle
At reference temperature measure the outside diameter d_1 at a minimum of two locations. Permanently mark the locations for later measurement. The measuring gauges used shall comply with the requirements described in 4.2.1. Test conditions shall comply with the following: — Uniform heating at the test temperature. — 4 h holding time at the test temperature. — Limit temperature deviation to ±5 °C. — Cooling to reference temperature with no quenching. — New measurement at the same measuring locations. The average of the outside-diameter differences found at all measuring locations is the determining value.

4.2.23 Material defects

Measuring principle
Method A: Magnetic particle inspection Magnetic particle inspection shall be according to the ISO 9934 series. Magnetisation in axial and circumferential direction using a minimum tangential field strength of 2 500 A/m on the surface to be inspected. Evaluation shall be based on fluorescence. **Application:** Detection of defects on the surface and beneath the surface up to a depth of 0,2 mm. **Method B: Ultrasonic inspection shall be according to ISO 16810** Method using transverse waves. Inspect piston pin using the pulse-echo technique with a direct contact angle-beam probe (see Figure 9) or by using the immersion technique.  **Key** 1 ultrasonic probe 2 sound propagation 3 piston pin **Figure 9 — Ultrasonic inspection principle** Coupling or immersion in a suitable couplant. Any means of rotating the part and/or transducer that insures full volume inspection. The incident angle shall insure full mode conversion to a transverse wave (shall be equal to or greater than the first critical angle). **Frequency:** 4 to 12 MHz **Transducer-diameter for pin diameter:** — ≤ 50 mm: 6 mm — 10 mm — > 50 mm: 6 mm — 15 mm

<table>
<tr><th colspan="4">Measuring principle</th></tr>
<tr><td colspan="4">Reference: Piston pins with defined artificial or natural defects shall be used as reference for the calibration. Proposed artificial notches on external and internal surfaces as follows:</td></tr>
<tr><td>(mm)</td><td>$d_1 \leq 16$</td><td>$16 < d_1 \leq 50$</td><td>$50 < d_1 \leq 100$</td></tr>
<tr><td>width</td><td>0,10</td><td>0,10</td><td>0,20</td></tr>
<tr><td>depth</td><td>0,10</td><td>0,10</td><td>0,20</td></tr>
<tr><td>length</td><td>4,00</td><td>6,00</td><td>10,00</td></tr>
<tr><td colspan="4">Calibration: According to Figure 9, the probe is coupled to the reference pin and the echo of the internal and external reference reflectors are maximised. The highest amplitude shall be set to full (100 %) screen height.
Noise suppression may be used, but only to such a level that the noise is about to disappear. The rejection level (gate level) shall be set to 40 % screen height.
Application: Detection of defects within the whole volume and on external and internal surfaces of the pin. Preferably, defects parallel to the pin axis (longitudinal flaws).
Detection limit: Detection, which shows signals above 40 % screen height.
Method C: Eddy current inspection shall be according to ISO 15548
Traverse length of peripheral surface as piston pin is scanned using a differential probe.
Frequency range: from 200 Hz to 3 MHz.
Piston pins shall be demagnetised before Eddy current inspection.
Reference: Piston pins with defined artificial or natural defects shall be used as reference for the calibration. Proposed artificial notches on external surface as follows:</td></tr>
<tr><td>(mm)</td><td colspan="2">$16 < d_1 \leq 50$</td><td>$50 < d_1 \leq 100$</td></tr>
<tr><td>width</td><td colspan="2">0,05</td><td>0,10</td></tr>
<tr><td>depth</td><td colspan="2">0,05</td><td>0,10</td></tr>
<tr><td>length</td><td colspan="2">3,00</td><td>5,00</td></tr>
<tr><td colspan="4">Calibration: The probe is to be set to the reference pin at a distance of approximately 0,2 mm.
Application: Detection of material defects on the scanned surface and beneath surface up to a depth of 0,05 mm.
Detection limit: Detection, which shows signals above the reference pin limit.</td></tr>
</table>

4.2.24 Residual magnetism

Measuring principle
Measuring instrument: Residual-field-intensity instrument. Measure at the following locations: — End faces; — Outside chamfers; — 3 points (minimum) on peripheral surface.