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Third edition
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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

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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 document 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).

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 34, *Propulsion, powertrain and powertrain fluids*.

This third edition cancels and replaces the second edition (ISO 18669-2:2020), which has been technically revised.

The main changes are as follows:

— the reference for material defects by eddy current inspection has been updated to align with ISO 18669-1.

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 the purchaser and the manufacturer agree, 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 21920-1, *Geometrical product specifications (GPS) — Surface texture: Profile — Part 1: Indication of surface texture*

ISO 21920-2, *Geometrical product specifications (GPS) — Surface texture: Profile — Part 2: Terms, definitions and surface texture parameters*

ISO 21920-3, *Geometrical product specifications (GPS) — Surface texture: Profile — Part 3: Specification operators*

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 12180-2, *Geometrical product specifications (GPS) — Cylindricity — Part 2: Specification operators*

ISO 12181-2, *Geometrical product specifications (GPS) — Roundness — Part 2: Specification operators*

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

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

ISO 18669-1:2021, *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 terminology databases for use in standardization at the following addresses:

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

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

3.1
outside diameter
OD
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 18669-1:2021, 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
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
ID
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
s
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 around the axis during rotation.

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* (3.26) 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, H_s, 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 within the whole volume and on surfaces of the pin

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
marks on bore surface of cold-formed end-web pins

3.26
tapered bore
pin with conical-shaped inside diameter near the ends that reduces the weight of the piston pin

[SOURCE: ISO 18669-1:2021, 3.2.1.3]

4 Measurement principles

4.1 General measuring conditions

The following general requirements are applicable to all measurement 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) “Measurement 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 that can guarantee the required measurement accuracy are allowed with prior agreement between manufacturer and customer.

4.2 Characteristics and measurement principles

4.2.1 Outside diameter, d_1

Reference method: Measure with a precision calliper having spherical measuring probes each of radius 1,0 mm min. exerting a measuring force of approximately 1 N (see Figure 1).

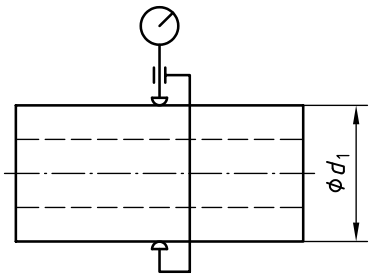

Figure 1 — Outside-diameter measurement principle

Other methods: Any method that can guarantee the required measurement uncertainty. The manufacturer and the client shall agree on the method.

The measurement uncertainty is ±0,000 5 mm according to the ISO 14253 series.

4.2.2 Cylindricity of the outside diameter, d_1

Record and evaluate multiple polar diagrams (measuring in a minimum of three planes, centre of pin and near each end avoiding edge features), in accordance with ISO 12180-2.

This method has the following parameters:

— reference cylinder: least squares

— filter: Gaussian

— stylus tip radius: 1,0 mm

— undulations per revolution (UPR): 1–50

4.2.3 Circularity of the outside diameter, d_1

Record and evaluate a macro-form diagram in the circumferential direction avoiding edge features (polar diagram), in accordance with ISO 12181-2.

This method has the following parameters:

— reference circle: least squares

— filter: Gaussian

— stylus tip radius: 1,0 mm

— UPR: 1–50

4.2.4 Circumferential waviness

Record the circumferential undulations on the OD surface.

This method has the following parameters:

— reference circle: least squares

— filter: Gaussian

— stylus tip radius: 1,0 mm

— UPR: 1–50

Analysis method A: Sector roundness

Departure from true circle (DFTC) within a defined angular window (e.g. 15 ° or 30 ° DFTC window).

Analysis method B: Filtered bandwidth

Peak-to-valley roundness deviation with defined band pass filtering (e.g. 10–50 UPR or 15–50 UPR).

Analysis method C: Dominant roundness waviness

Dominant roundness waviness with defined band pass filtering (e.g. 10-50 UPR or 15-50 UPR).

4.2.5 Edge drop-off, *b, c*

Record and evaluate a macro-form diagram on both ends in the axial direction (profile lines) (see ISO 18669-1:2021, Figure 12).

4.2.6 Inside diameter, d_2, d_4

Measure with inside measuring devices.

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

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

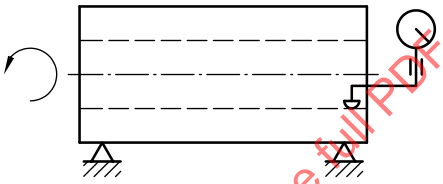

Figure 2 — Inside-diameter concentricity (radial runout)

Method B: Measure with a calliper or probe indicator by 360 ° rotation in a V-block (see Figure 3).

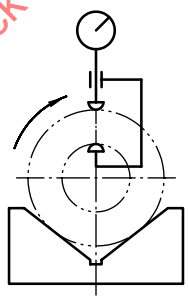

Figure 3 — Wall-thickness measurement principle

4.2.8 Length, l_1

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

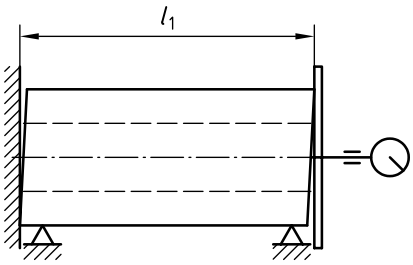

Figure 4 — Length measurement principle

When using other methods, the runout shall be considered to determine the total length of the pin.

4.2.9 Gauge length, l_5

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).

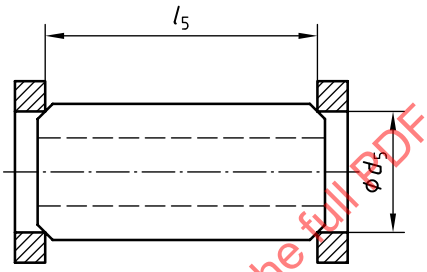

Figure 5 — Gauge-length measurement principle

NOTE Other lengths: all methods that can measure the characteristics according to specification.

4.2.10 Runout of the end faces, s

Supporting surface: The V-block with longitudinal stop is at least as large as the outside diameter d_1. Measurement is obtained by 360 ° rotation in the V-block. The measured value is the axial eccentricity or runout (see Figure 6).

For reference, see ISO 18669-1:2021, Figure 14.

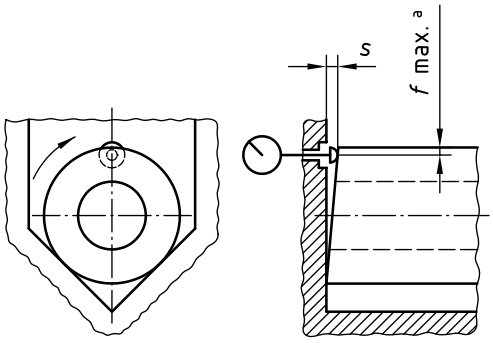

Figure 6 — Runout measurement principle

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

The maximum axial deviation of the end face surface is described as the end-face concavity or end-face step.

Method A: Place pin on flat plate. There is 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).

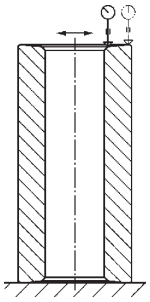

Figure 7 — End face measurement principle

Method B: Use of contour-measuring equipment.

4.2.12 End face diameter, d_6

Measure using optical techniques or contour-measuring equipment.

4.2.13 Outside-edge profile

Measure the transition using contour-measuring method or other appropriate methods (see ISO 18669-1:2021, Figure 14).

4.2.14 Inside chamfer, t_1

Measure using calliper, optical techniques or contour-measuring equipment (see ISO 18669-1:2021, Figure 15).

4.2.15 Tapered bore diameter, d_3

Measure using, for example, a calliper or contour-measuring equipment (see ISO 18669-1:2021, Figure 16).

4.2.16 Tapered bore angle, α

Measure using contour-measuring equipment (see ISO 18669-1:2021, Figure 16).

4.2.17 Runout tapered bore, e

Measure using an internal calliper by 360 ° rotation in a V-block. The measuring point shall be located 1 mm max. from the end face (see Figure 8).

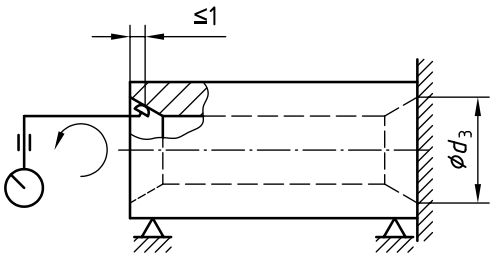

Figure 8 — Runout tapered bore measurement

4.2.18 Roughness

Values shall be in accordance with ISO 21920-1 and ISO 21920-2.

Measurement with electrical stylus instruments shall be in accordance with ISO 21920-1 and ISO 21920-2.

This method has the following parameters:

— cut off length: 0,8 mm

— measuring length: 4,0 mm

— stylus tip radius: 2,0 µm

— filter: Gaussian

Tool marks and scratches on the outer and inner cylindrical surface are measured by tracing with a micro-stylus system in a longitudinal or circumferential direction depending on the defect type. Measurement is carried out in the zone that is the worst visually.

Evaluation and comparability shall be in accordance with ISO 21920-3.

4.2.19 Carburised and nitrided case depth

The depth at which the limit hardness, H_s, exists shall be determined in HV 1 or HV 0,3 according to ISO 18203.

Limit hardness, H_s, of carburised case-hardened piston pins:

— 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

— 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

Limit hardness, H_s, of nitrided piston pins:

  — 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

4.2.20 Core hardness

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

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

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 meet the requirements of 4.2.1. The test shall be performed under the following conditions:

— uniform heating at the test temperature;

— 4 h holding time at the test temperature;

— temperature deviation limited 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

Method A: Magnetic particle inspection

Magnetic particle inspection shall be in accordance with the ISO 9934 series. Magnetize 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.

This method uses transverse waves. Inspect the piston pin using the pulse-echo technique with a direct contact angle-beam probe (see Figure 9) or by using the immersion technique.