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# Internal combustion engines — Piston rings —

## Part 5: Quality requirements

*Moteurs à combustion interne — Segments de piston —*

*Partie 5: Exigences de qualité*



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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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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 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 fourth edition cancels and replaces the third edition (ISO 6621-5:2013), which has been technically revised.

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

— changed procedure for counting defects.

A list of all parts in the ISO 6621 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.



# Introduction

This document is one of a number of series of International Standards dealing with piston rings for reciprocating internal combustion engines.

The common features and dimensional tables presented in this document constitute a broad range of variables, and the designer, in selecting a particular ring type, should bear in mind the conditions under which it will be required to operate. The designer should also refer to the specifications and requirements of ISO 6621-3 and ISO 6621-4 before completing his selection.

The difficulty of trying to define in absolute terms the quality attainable in normal commercial manufacture of piston rings is well known. In this document, the commonly encountered aspects of quality in terms of casting defects and other departures from ideal are quantified. Many minor defects are clearly quite acceptable; other defects because of size or number are inadmissible.

# Internal combustion engines — Piston rings —

# Part 5: Quality requirements

## 1 Scope

This document specifies quality aspects that can be defined but that are not normally found on a drawing specification.

It covers the following:

— single-piece piston rings of grey cast iron or steel;

— multi-piece piston rings (oil control rings) consisting of cast iron parts and spring components; and

— single-piece and multi-piece oil control rings of steel, i.e. oil control rings in the form of strip steel components or steel segments (rails) with spring expander components.

In addition to specifying some of the limits of acceptance relating to inspection measuring principles (covered by ISO 6621-2), this document also covers those features for which no recognized quantitative measurement procedures exist and which are only checked visually with normal eyesight (glasses if worn normally) and without magnification. Such features (superficial defects) are additional to the standard tolerances of ring width, radial wall thickness and closed gap.

This document does not establish acceptable quality levels (AQL), it being left to manufacturer and customer to decide the appropriate levels jointly. In this case, the recommendations of ISO 2859-1 are followed.

This document specifies the quality requirements of piston rings for reciprocating internal combustion engines for road vehicles and other applications. It is applicable to all such rings of a nominal diameter from 30 mm up to and including 200 mm.

## 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 6621-1, *Internal combustion engines — Piston rings — Part 1: Vocabulary*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6621-1 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/

# 4 Visible defects

## 4.1 General

Visible defects are divided into two principle classes as described in 4.2 to 4.5.

The first class covers those defects frequently found in castings and includes such defects as porosity, sand inclusions, cavities, etc.

The second class of defect covers mechanical abrasions which may occur during forming, machining or handling of the rings, and includes scratches, dents, chipping, burrs and cracks.

Inspection of piston rings for such defects is generally carried out visually, without magnification, by inspectors having normal eyesight, corrected if necessary.

It is not intended that every ring be rigorously inspected for size and distribution of defects, but rather that the values given in the tables and text be used as a general guide. However, in case of doubt, the values given should be used as the means of judging the quality of the rings.

## 4.2 Pores, cavities and sand inclusions

Such defects are permissible on uncoated surfaces and edges provided that the values given in Table 1 for size, number and spacing are not exceeded.

**Table 1 — Permissible values of size, number and spacing of pores, cavities and sand inclusions**

Dimensions in millimetres

| Nominal diameter $d_1$ | Defect size max. | | | | Number of defects per ring max. | Spacing of defects[c] min. |
|---|---|---|---|---|---|---|
| | on peripheral surface[a] | on other surfaces[a] | on peripheral edges | on other edges[b] | | |
| $30 \leq d_1 < 60$ | 0,1 | 0,3 | 0,1 | 0,1 | 2 | 4 |
| $60 \leq d_1 < 100$ | 0,15 | 0,5 | 0,1 | 0,2 | 4 | 4 |
| $100 \leq d_1 < 150$ | 0,2 | 0,5 | 0,1 | 0,3 | 6 | 8 |
| $150 \leq d_1 \leq 200$ | 0,2 | 0,8 | 0,1 | 0,4 | 8 | 8 |

[a] The defects should not be closer to an edge than one-half of the maximum permissible size of the defect, with a minimum of 0,2 mm.

[b] Does not apply to inside gap edges of piston rings with internal notch.

[c] Spacing includes defects on adjacent or opposite surfaces.

## 4.3 Scratches, indentations, depressions and cracks

### 4.3.1 Scratches

Isolated scratches are permissible provided that:

— no burrs are produced exceeding the permissible values given in 4.4.1.1;

— on turned peripheral surfaces, they are not deeper than the tool marks;

— on non-turned peripheral surfaces, they are not deeper than 0,004 mm;

— on the side faces, they are not deeper than 0,01 mm; and

— on other surfaces, they are not deeper than 0,06 mm.

#### 4.3.2 Indentations, depressions

Indentations and depressions are permissible provided that:

— the values given in Table 1 for number and spacing of defects are met;

— no burrs are produced exceeding the permissible values given in 4.4.1.1; and

— they do not exceed the values for size and depth given in Table 2.

Rings of a plated/coated/nitrided type shall not have indentations or depressions on the periphery.

NOTE Indentations arising from hardness measurements on the side faces are acceptable provided that they do not exceed the limits given in Tables 2 and 11.

#### 4.3.3 Cracks

No cracks are permissible in the base material.

See also 4.5.4 for chromium-plated peripheral surfaces and 4.5.6 for nitrided surfaces.

**Table 2 — Permissible size of indentations and depressions**

Dimensions in millimetres

| Nominal diameter $d_1$ | Defect size max. | | Depth max. |
|---|---|---|---|
| | on peripheral surface | on side face | |
| $30 \leq d_1 < 100$ | 0,3 | 0,6 | 10 % of corresponding max. defect size |
| $100 \leq d_1 \leq 200$ | 0,5 | 1 | |

### 4.4 Edges

#### 4.4.1 Edge configuration

All edges of the piston ring shall be sharp; ideally, they should be free from burrs and from ragged edges, whether arising from crumbling of material or from deburring. Such conditions are almost impossible to achieve regularly in volume production and hence both burrs and removal of edge material is permitted up to the maximum sizes given in 4.4.1.1 and 4.4.1.2.

##### 4.4.1.1 Burrs

Burrs are permitted up to the maximum values given in Table 3. The orientation and direction of burrs shall relate to the functional surfaces of the piston ring; any burr present should point in the direction of sliding motion of the ring and not normal to the direction of sliding.

Any burrs remaining on the edges of rings should be firmly attached, forming an integral part of the edge.

**Table 3 — Permissible size of burrs for all sizes of ring**

Dimensions in millimetres

| Burrs on edges adjacent to: | Maximum size of burr | | | |
|---|---|---|---|---|
| | Cast iron and steel single and 2-piece rings | Expander/segment oil control rings | | |
| | | Expander | Plated segment | Nitrided segment |
| Peripheral surface | 0,006 | 0,01 | 0,004 | 0,004 |
| Side faces | 0,006 | 0,01 | 0,02 | 0,01 |
| Butt ends (gap surface) | 0,04 | 0,1 | 0,1 | 0,04 |
| The outside groove face (oil rings) | 0,2 | — | — | — |
| The inside surface and the ends of the slots (oil rings) | 0,5 | 0,5 | 0,1 | 0,1 |
| All other surfaces | 0,1 | 0,1 | 0,1 | 0,1 |

#### 4.4.1.2 Edge material removal

To eliminate protruding burrs in any direction, it is permissible to remove material from the edges to the values given in Table 4.

**Table 4 — Edge material removal in deburr operations**

Dimensions in millimetres

| Location of edge | Removal of material max. |
|---|---|
| On peripheral edges | 0,08 |
| On peripheral edges of the gap[a] | 0,15 |
| On inside edges of the gap | 0,5 in circumferential direction |
| | 0,25 in radial direction |
| On other edges | 0,25 |

[a] Does not apply to rings which have specified gap edge chamfers.

### 4.4.2 Chipping and similar defects on peripheral edges and peripheral edges at the gap.

Chipping and similar defects are permitted at these points provided that:

— they are free of loosely adhering particles;

— no burrs are produced exceeding the values permitted in 4.4.1.1;

— they do not exceed the values given in the following tables:

  — Table 5 for plain rings;

  — Table 6 for chromium plated or nitrided rings;

  — Table 7 for spray coated rings;

  — Table 8 for PVD (excluding DLC) coated rings;

  — Table 9 for chamfers on all rings.

Typical defects are illustrated in Figures 1 and 2.

$L_1$ is always the length dimension of a defect that intersects with the ring face and measured parallel to the gap edge cut by the defect (axial defect).

$L_2$ is always the length dimension of a defect that intersects with the ring face and measured parallel to the side edge cut by the defect (circumferential defect).

$L_3$ is always the length dimensions of a defect that does not intersect with the ring face.

$W$ is always the width dimension of the defect measured perpendicular to the length of the defect.

The limitations for chipping and similar defects on peripheral edges, peripheral edges of the gap and opposite gap corners are given in 4.4.2.1 to 4.4.2.3.

#### 4.4.2.1 Defects that intersect with the peripheral edge in the circumferential direction.

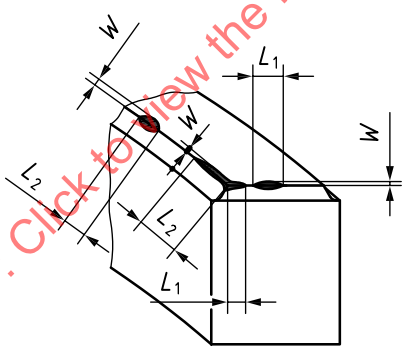
Defects to be included in the assessment of the peripheral edge are all values of $L_2$ as well as the W, for example the left-hand defect illustrated in Figure 1.

Maximum sizes are given in Tables 5, 6, 7 and 8 (peripheral edge column).

#### 4.4.2.2 Defects that intersect with the peripheral edge along the axial direction of the gap

Defects to be included in the assessment of the peripheral edges of the gap are all values of $L_1$ as well as the W, for example the right-hand defect illustrated in Figure 1.

Maximum sizes are given in Tables 5, 6, 7 and 8 (peripheral edge of gap column).




**Key**

$L_1$ length dimension of the defect measured parallel to the gap edge cut by the defect
$L_2$ length dimension of the defect measured parallel to the side edge cut by the defect
$W$ width dimension of the defect measured perpendicular to the length of the defect

**Figure 1 — Chipping on peripheral edges and peripheral edges of the gap**

**Table 5 — Permissible size of chipping and defects on plain rings on peripheral edges, peripheral edges of the gap and outside gap corners**

Dimensions in millimetres

| Compression ring width $h_1$ | Oil control ring land width $h_5$ | Defect length[a,b] | | Defect width[a,b] $W$ max. |
|---|---|---|---|---|
| | | on peripheral edge of the gap $L_1$[c] max. | on peripheral edge $L_2$ max. | |
| $h_1 < 1{,}5$ | — | 0,4 | | 0,15 |
| $1{,}5 \leq h_1 < 2$ | — | 0,5 | | 0,2 |
| $2 \leq h_1 < 4$ | — | 0,6 | | 0,3 |
| $4 \leq h_1 \leq 6$ | — | 0,6 | | 0,3 |
| — | <0,5 | 0,1 | 0,2 | 0,1 |
| — | ≥0,5 | 0,2 | | 0,2 |

[a] Number and spacing of defects to be in accordance with Table 1.

[b] See Figure 1.

[c] The sum of defects shall be less than one-third of peripheral width of ring or land along the gap for ring widths greater than 1,8 mm and shall be less than half of rings equal to or less than 1,8 mm in width. Not applicable to rings with a chamferless end gap. The acceptable amount is subject to negotiations between the manufacturer and customer.

**Table 6 — Permissible size of chipping and defects on rings with a chromium plated or nitrided peripheral surface, on the peripheral edges, peripheral edges of the gap and the outside gap corners**

Dimensions in millimetres

| Compression ring width $h_1$ | Oil control ring land width $h_5$ | Defect length[a,b] | | Defect width[a,b] $W$ max. |
|---|---|---|---|---|
| | | on peripheral edge of the gap $L_1$[c] max. | on peripheral edge $L_2$ max. | |
| $h_1 < 2$ | — | 0,3 | | 0,2 |
| $2 \leq h_1 < 4$ | — | 0,4 | | 0,2 |
| $4 \leq h_1 \leq 6$ | — | 0,4 | | 0,3 |
| — | <0,5 | 0,1 | 0,2 | 0,1 |
| — | ≥0,5 | 0,2 | | 0,2 |

[a] Number and spacing of defects shall be in accordance with Table 1.

[b] See Figure 1.

[c] The sum of defects shall be less than one-third of peripheral width of ring or land along the gap for ring widths greater than 1,8 mm and shall be less than half of rings equal to or less than 1,8 mm in width. Not applicable to rings with a chamferless end gap. The acceptable amount is subject to negotiations between the manufacturer and customer.

**Table 7 — Permissible size of chipping and defects on spray coated rings on peripheral edges, peripheral edges of the gap and outside gap corners**

Dimensions in millimetres

| Compression ring width $h_1$ | Defect length[a,b] | | Defect width[a,b] |
|---|---|---|---|
| | on peripheral edge of the gap $L_1$[d] max. | on peripheral edge $L_2$[c] max. | $W$ max. |
| $h_1 < 2$ | 0,5 | | 0,3 |
| $2 \leq h_1 < 4$ | 0,6 | | 0,3 |
| $4 \leq h_1 \leq 6$ | 0,8 | | 0,4 |

[a] Number and spacing of defects to be in accordance with Table 1.

[b] See Figure 1.

[c] Only for fully faced and semi-inlaid design.

[d] The sum of defects shall be less than one-third of peripheral width of ring or land along the gap for ring widths greater than 1,8 mm and shall be less than half of rings equal to or less than 1,8 mm in width Not applicable to rings with a chamferless end gap. The acceptable amount is subject to negotiations between the manufacturer and customer.

**Table 8 — Permissible size of chipping and defects on PVD coated rings on peripheral edges, peripheral edges of the gap and outside gap corners**

Dimensions in millimetres

| Compression ring width $h_1$ | Oil control ring Land width $h_5$ | Defect length[a,b] | | Defect width[a,b,d] |
|---|---|---|---|---|
| | | on peripheral edge of the gap (axial) $L_1$[c] max. | on peripheral edge (circumferential) $L_2$ max. | $W$ max. |
| $h_1 \leq 1$ | — | 0,5 | 0,6 | 0,3 |
| $1 < h_1 \leq 2{,}5$ | — | 0,6 | 0,6 | 0,3 |
| $2{,}5 < h_1 \leq 3$ | — | 0,8 | 0,8 | 0,3 |
| $3 < h_1 \leq 6$ | — | 1,0 | 1,0 | 0,3 |
| — | ≤0,25 | 0,1 | 0,6 | 0,1 |
| — | >0,25 | 0,2 | 0,6 | 0,2 |

[a] 6 total defects allowed on the circumference ($L_2$). 2 defects allowed to be greater than the $L_2$ specification in the table but shall not exceed 2 mm. These 2 defects shall be separated by more than 90°. No exceptions are allowed for $W$.

[b] See Figure 1.

[c] The sum of defects shall be less than one-third of peripheral width of ring or land along the gap for ring widths greater than 1,8 mm and shall be less than half of rings equal to or less than 1,8 mm in width. Not applicable to rings with a chamferless end gap. The acceptable amount is subject to negotiations between the manufacturer and customer.

[d] A chip must not reach the peak point of the barrel on the ring peripheral face.



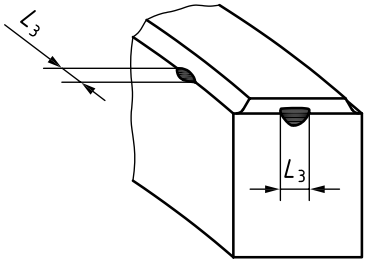
#### 4.4.2.3 Defects that do not intersect with the peripheral edges circumferentially or axially

The limitations for chipping and similar defects on the chamfers at the peripheral edge and at the peripheral edge of the gap are as follows.

This type of defect is illustrated in Figure 2 and is more likely to occur on chromium plated chamfers (machined or un-machined), on machined chamfers on sprayed rings (fully coated), on PVD coated rings, and on machined chamfers on grey iron rings. The maximum values of the defects allowable are

given in Table 9 and are the same for all rings with chamfers on peripheral edge and peripheral edge of the gap.

Defects counted as on the chamfers shall not cut peripheral edges or peripheral edges of the gap but may just cut side faces or gap faces.




**Key**

$L_3$ dimensions of the defects

**Figure 2 — Chipping on chamfers**

**Table 9 — Permissible size of chipping and defects on chamfers at the peripheral edge and peripheral edge of the gap**

Dimensions in millimetres

| Ring width $h_1$ | Size of defect $L_3$[a] max. |
|---|---|
| $h_1 < 2$ | 0,8 |
| $2 \leq h_1 < 4$ | 1,0 |
| $4 \leq h_1 \leq 6$ | 1,5 |

[a] Number and spacing of defects to be in accordance with Table 1.

### 4.4.3 Chipping and defects on non-peripheral edges

Chipping and defects on non-peripheral edges are permissible provided that:

— no burrs are produced exceeding the values given in 4.4.1.1;

— they do not exceed the maximum established values given in Table 1 for pores, cavities and sand inclusions.

### 4.4.4 Chipping and defects on inside gap corners

Chipping and defects on inside gap corners are permitted provided that:

— no burrs are produced exceeding the values given in 4.4.1.1;

— the rings do not have an internal notch;

— they do not exceed 0,3 mm in the radial direction and 0,5 mm in the circumferential and axial directions for coil spring-loaded oil control rings;

— they do not exceed the values given in Table 10 for remaining ring designs.

**Table 10 — Permissible size of chipping and defects on inside gap corners**

Dimensions in millimetres

| Nominal diameter $d_1$ | Size of defect measured max. | | |
|---|---|---|---|
| | axially[a] | radially[a] | circumferentially |
| $30 \leq d_1 < 100$ | 0,6 | 0,8 | 1 |
| $100 \leq d_1 \leq 200$ | 0,8 | 1 | 1,5 |
| [a] Subject to a maximum of one-third of the ring width or radial wall thickness. | | | |

## 4.5 Other characteristics subject to visual inspection only

### 4.5.1 Discolouring or staining of surface

Discolouring or staining spread evenly or unevenly over the ring surfaces is permissible. This does not include rust.

### 4.5.2 Casting skin and deposits on inside surface

The following defects are permitted:

— unmachined (i.e. not cleaned up) areas within 5° of the gap ends;

— firmly adherent deposits arising from processing of the ring.

### 4.5.3 Chipping on uncoated surfaces

This is permissible provided the chip sizes do not exceed the maximum values established in Table 1 for pores, cavities and sand inclusions.

### 4.5.4 Chromium plated peripheral surface

The chromium plating shall be fully coherent, in other words there shall be no visible macro-cracks, pores, blisters, chromium beads (undercut bulge in the surface) or pin holes.

Exceptions regarding pinholes may be agreed upon between manufacturer and customer.

Chromium coatings contain a normal microscopic crack pattern which is permissible. Characteristics of the micro cracking may be determined by agreement between supplier and customer. It is not reasonable to expect no micro cracks. The customer and supplier may set a lower and upper limit to the micro cracks.

### 4.5.5 Spray coatings

Spray coatings are not homogeneous. The acceptance conditions may be agreed between the manufacturer and customer, otherwise the manufacturer's specifications apply.

### 4.5.6 Nitrided surfaces

The nitrided surface shall be fully coherent, in other words there shall be no visible macro cracks or loose material.

When a nitrided side face is specified, the depth of the hard layer may fall below the specification to a minimum depth of 0,005 mm in small areas, provided the area is no more than 0,8 mm radially and 8 mm circumferentially. In addition, the total area of this defect on the side face of the ring shall not exceed 10 % of the total side face area and there shall be at least 20 mm between areas with such a defect.

### 4.5.7 Pin Holes in PVD coated piston ring surface

Pin holes are inherent to the PVD process and the limitations are specified in Table 11.

**Table 11 — Permissible size and number of pin holes**

| Piston ring classification | Size[a] (mm) | Number of pin holes per ring[b] max. |
|---|---|---|
| Compression ring | $0,2 \leq d \leq 0,3$ | 10 |
| 2 piece oil ring | $0,1 \leq d \leq 0,2$ | 10 |
| 3 piece oil ring rails | $0,1 \leq d \leq 0,2$ | 10 |

[a] A pinhole should be smaller than actual contact surface width.

[b] Spacing of defects to be no smaller than 1,5 mm.

## 5 Loss of tangential force under temperature effects

Some loss of tangential force at engine operating conditions is acceptable; for the purposes of establishing quality, test conditions and loss of tangential force with the ring closed to nominal diameter are given in Table 12.

**Table 12 — Test conditions to measure tangential force loss**

| Piston ring reference | | Material class according to ISO 6621-3 | Loss of tangential force max. % | Test conditions (ring closed to nominal diameter) Temperature °C | Time h |
|---|---|---|---|---|---|
| ISO 6622<br>ISO 6623<br>ISO 6624<br>ISO 6625 | | 10, 20, 30 | 12 | 300 | 3 |
| | | 40, 50, 60 | 8[d] | 300 | 3 |
| ISO 6626[b] | | 10, 20, 30, 40, 50 | 25 | 250 | 5 |
| | WF[a] | | 12 | 250 | 5 |
| ISO 6627[c] | | 60 | 30 | 220 | 5 |
| | WF[a] | | 15 | 220 | 5 |

[a] WF = reduced heat set.

[b] Applies also to two-piece steel oil control rings not covered in existing ISO International Standards.

[c] Applies also to single-piece steel and expander/segment oil control rings not covered in existing ISO International Standards.

[d] For Material class 60 different values may be agreed between manufacturer and customer.

## 6 Raised material caused by marking of rings

Raised material is permitted subject to the values given in Table 13.