
**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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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. www.iso.org/directives

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The committee responsible for this document is ISO/TC 22, *Road vehicles*.

This third edition cancels and replaces the second edition (ISO 6621-5:2005), of which it constitutes a minor revision.

ISO 6621 consists of the following parts, under the general title *Internal combustion engines — Piston rings*:

- *Part 1: Vocabulary*
- *Part 2: Inspection measuring principles*
- *Part 3: Material specifications*
- *Part 4: General specifications*
- *Part 5: Quality requirements*

Introduction

This International Standard is one of a number of series of International Standards dealing with piston rings for reciprocating internal combustion engines. Others are ISO 6622, ISO 6623, ISO 6624, ISO 6625, ISO 6626, and ISO 6627.

The common features and dimensional tables presented in this part of ISO 6621 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 also refers 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 part of ISO 6621, 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.

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Internal combustion engines — Piston rings —

Part 5: Quality requirements

1 Scope

This part of ISO 6621 specifies those quality aspects that are capable of definition but not normally found on a drawing specification.

It is applicable to 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;
- 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 certain of the limits of acceptance relating to inspection measuring principles (covered by ISO 6621-2), this part of ISO 6621 also covers those features for which no recognized quantitative measurement procedures exist and which are only checked visually with normal eyesight (spectacles 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 part of ISO 6621 does not establish acceptable quality levels (AQL), it being left to manufacturer and client to decide the appropriate levels jointly. In this case, the recommendations of ISO 2859 are followed.

This part of ISO 6621 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, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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*

ISO 6621-3, *Internal combustion engines — Piston rings — Part 3: Material specifications*

ISO 6622 (all parts), *Internal combustion engines — Piston rings*

ISO 6623, *Internal combustion engines — Piston rings — Scraper rings made of cast iron*

ISO 6624 (all parts), *Internal combustion engines — Piston rings*

ISO 6625, *Internal combustion engines — Piston rings — Oil control rings*

ISO 6626, *Internal combustion engines — Piston rings — Coil-spring-loaded oil control rings*

ISO 6626-2, *Internal combustion engines — Piston rings — Part 2: Coil-spring-loaded oil control rings of narrow width made of cast iron*

ISO 6626-3, *Internal combustion engines — Piston rings — Part 3: Coil-spring-loaded oil control rings made of steel*

ISO 6627, *Internal combustion engines — Piston rings — Expander/segment oil-control rings*

3 Terms and definitions

For the purposes of this document, the terms and definitions in ISO 6621-1 apply.

4 Visible defects

4.1 General

Visible defects are divided into two principal 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 defects 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.

^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 and 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.

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:	Cast iron and steel single and two-piece rings	Maximum size of burr		
		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, peripheral edges of the gap, outside gap corners, and on peripheral chamfers

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 half the width of any witness land on, for example, taper-faced rings, and

- 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 chamfers on all rings.

Typical defects are illustrated in [Figures 1](#) to [6](#).

K_1 , K_2 , and K_3 are always the dimensions of the defect measured along the edge cut by the defect.

F_1 , F_2 , and F_3 are always the dimensions of the defect measured from normal to the edge cut by the defect.

However, when chipping or other defects occur on outside gap corners, i.e. when the defect crosses the intersecting edges of the peripheral edge and the peripheral edge of the gap, a convention is required.

The defect is taken as appropriate to the edge that contains the larger amount of the defect. For example, in [Figure 3](#), most of the left side defect is on the peripheral edge and therefore the defect is appropriate to that edge. Hence, the K value lies along the peripheral edge and is denoted K_3 while the F value, although it lies along the peripheral edge of the gap, is taken as the dimension measured normal to the peripheral edge and is denoted F_3 .

In the case of the defect on the right side corner, most of the defect lies along the peripheral edge of the gap and the defect is therefore appropriate to this edge. The measurement K_3 in this case is therefore measured along the peripheral edge of the gap and F_3 is its dimension normal to the edge of the gap.

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 Peripheral edges

Defects to be included in the assessment of the peripheral edges are all values of F_2 and K_2 as well as the F_3 and K_3 values of outside gap corner defects, if these are appropriate to the peripheral edges, e.g. the left hand defect illustrated in [Figure 3](#).

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

4.4.2.2 Peripheral edges of the gap

Defects to be included in the assessment of the peripheral edges of the gap are all values of F_1 and K_1 as well as the F_3 and K_3 values of outside gap corner defects, if these are appropriate to the peripheral edges of the gap, e.g. the right hand defect illustrated in [Figure 3](#).

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

However, an additional limitation is that the sum of the defect sizes measured in the axial direction, i.e. along the peripheral edge of the gap, shall not exceed the values given in [Tables 5](#), [6](#), and [7](#).

The defects to be added taken from the examples in [Figure 4](#) are K_3 (right hand corner) + K_1 + F_3 (left hand corner).

4.4.2.3 Opposite gap corners

Defects at outside gap corners are accounted for in the assessments shown in [4.4.2.1](#) and [4.4.2.2](#) either as peripheral edge defects or as peripheral edge of the gap defects.

However, an additional limitation is that the sum of the defects measured circumferentially on opposite corners shall not exceed the values given in [Tables 5](#), [6](#), and [7](#).

The defects to be added in [Figure 5](#) are the K_3 value of the left hand corner plus the K_3 value on the opposite corner and the F_3 value of the right hand corner plus the K_3 value of the opposite corner.

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

Ring width h_1	Land width h_5	Defect in direction normal to the peripheral surface ^{ab}		Defect in direction along edge ^{ab}	
		On peripheral edge of gap F_1, F_3 max.	On peripheral edge F_2, F_3 max.	On peripheral edge of gap ^c K_1, K_3 max.	On peripheral edge K_2, K_3 max.
$h_1 < 1,5$	—	0,15		0,4	
$1,5 \leq h_1 < 2$	—	0,2		0,5	
$2 \leq h_1 < 4$	—	0,3		0,6	
$4 \leq h_1 \leq 6$	—	0,3		0,6	
—	$< 0,5$	0,1		0,1	0,2
—	$\geq 0,5$	0,2		0,2	0,2

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

b See [Figures 1, 2, 3, 4](#), and [5](#).

c The sum of defects is subject to a maximum of one-third of peripheral width of ring or land.

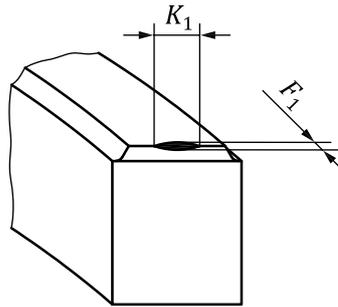
Table 6 — Permissible size of chipping and defects on rings with a chromium-plated or nitrided peripheral surface, on the peripheral edges, peripheral edges of the gap, and the outside gap corners

Ring width h_1	Land width h_5	Defect in direction normal to the peripheral surface ^{ab}		Defect in direction along edge ^{ab}	
		On peripheral edge of gap F_1, F_3 max.	On peripheral edge F_2, F_3 max.	On peripheral edge of gap ^c K_1, K_3 max.	On peripheral edge K_2, K_3 max.
$h_1 < 2$	—	0,2		0,3	
$2 \leq h_1 < 4$	—	0,2		0,4	
$4 \leq h_1 \leq 6$	—	0,3		0,4	
—	$< 0,5$	0,1	0,1	0,1	0,2
—	$\geq 0,5$	0,2	0,1	0,2	0,2

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

b See [Figures 1, 2, 3, 4](#), and [5](#).

c The sum of defects is subject to a maximum of one-third of peripheral width of ring or land. (Not applicable to rings with a chamferless end gap. The acceptable amount is subject to negotiations between the supplier and customer.)

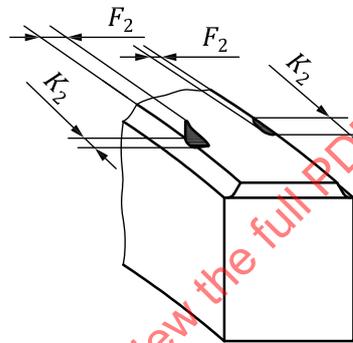


Key

K_1 dimension of the defect measured along the edge cut by the defect

F_1 dimension of the defect measured from normal to the edge cut by the defect

Figure 1 — Chipping on peripheral edges of the gap

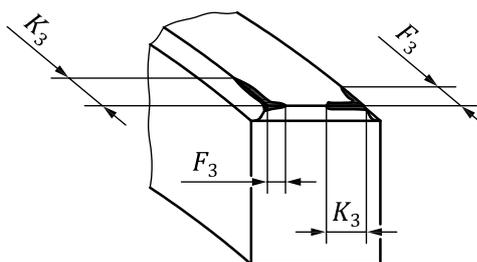


Key

K_2 dimensions of the defect measured along the edge cut by the defect

F_2 dimensions of the defect measured from normal to the edge cut by the defect

Figure 2 — Chipping on peripheral edges

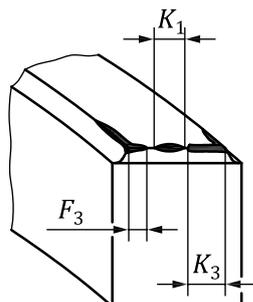


Key

K_3 dimensions of the defect measured along the edge cut by the defect

F_3 dimensions of the defect measured from normal to the edge cut by the defect

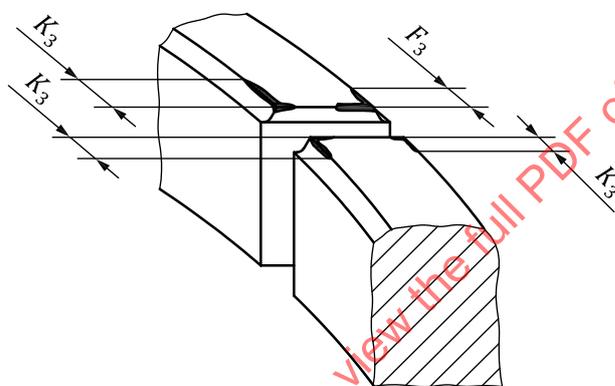
Figure 3 — Chipping on outside gap corners



Key

K_1, K_3 dimensions of the defect measured along the edge cut by the defect
 F_3 dimension of the defect measured from normal to the edge cut by the defect

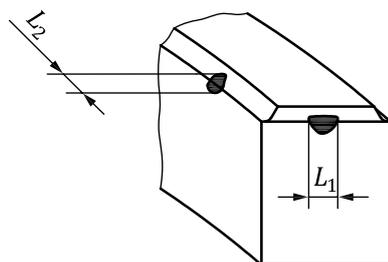
Figure 4 — Combination of Figures 1 and 3



Key

K_3 dimensions of the defect measured along the edge cut by the defect
 F_3 dimension of the defect measured from normal to the edge cut by the defect

Figure 5 — Chipping on opposite gap corners



Key

L_1, L_2 dimensions of the defects

Figure 6 — Chipping on chamfers

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

Ring width h_1	Defect in direction normal to the peripheral surface ^{ab}		Defect in direction along edge ^{ab}	
	On peripheral edges of the gap F_1, F_3 max.	On peripheral edges ^c F_2, F_3 max.	On peripheral edge of the gap ^d K_1, K_3 max.	On peripheral edge ^c K_2, K_3 max.
$h_1 < 2$	0,3		0,5	
$2 \leq h_1 < 4$	0,3		0,6	
$4 \leq h_1 \leq 6$	0,4		0,8	

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

b See [Figures 1, 2, 3, 4](#), and [5](#).

c Only for fully faced and semi-inlaid design.

d The sum of defects is subject to a maximum of one-third of peripheral width of ring or coating. (Not applicable to rings with a chamferless end gap. The acceptable amount is subject to negotiations between the supplier and customer.)

4.4.2.4 Chamfers at peripheral edges and peripheral edges of the gap

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 6](#) and is more likely to occur on chromium-plated chamfers (machined or unmachined), on machined chamfers on sprayed rings (fully coated), and on machined chamfers on grey iron rings. The maximum values of the defects allowable are given in [Table 8](#) 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.

Table 8 — 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 ^a L_1, L_2 max.
$h_1 < 2$	0,5
$2 \leq h_1 < 4$	0,8
$4 \leq h_1 \leq 6$	1,2

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

4.4.3 Chipping and defects on inner edges and other edges

Chipping and defects on inner edges and other edges are permissible on non-nitrided rings provided that

- no burrs are produced exceeding the values given in [4.4.1.1](#), and
- 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, and
- they do not exceed the values given in [Table 9](#) for remaining ring designs.

Table 9 — 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, i.e. there shall be no visible macrocracks, pores, blisters, chromium beads (undercut bulge in the surface), or pinholes.

Exceptions with regard to pinholes may be agreed upon between manufacturer and client.

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

4.5.5 Spray coatings

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

4.5.6 Nitrided surfaces

The nitrided surface shall be fully coherent, i.e. there shall be no visible macrocracks 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 must not exceed 10 % of the total side face area and there must be at least 20 mm between areas with such a defect.

5 Material

5.1 Specifications

The basic material specifications are given in ISO 6621-3.

The detail specifications and acceptance conditions may be agreed between manufacturer and client, otherwise the manufacturer's specifications apply.

5.2 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 10](#).

Table 10 — 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	10, 20, 30	12	300	3
ISO 6623	40, 50, 60	8 ^d	300	3
ISO 6624				
ISO 6625				
ISO 6626 ^b	10, 20, 30, 40, 50	25	250	5
		12	250	5
ISO 6627 ^c	60	30	220	5
		15	220	5

a WF = reduced heat set.

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

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

d For material class 60, different values may be agreed between manufacturer and client.

6 Raised material caused by marking of rings

Raised material is permitted subject to the values given in [Table 11](#).