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Internal combustion engines — Piston rings —

Part 4:
General specifications

Moteurs à combustion interne — Segments de piston —

Partie 4: Spécifications générales

Reference number
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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 6621-4 was prepared by Technical Committee ISO/TC 22, *Road vehicles*.

This second edition cancels and replaces the first edition (ISO 6621-4:1988), which has been technically revised.

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

ISO 6621 is one of a series of International Standards dealing with piston rings for reciprocating internal combustion engines. Others are ISO 6622 [1], [2], ISO 6623 [3], ISO 6624 [4], [5], [6], [7], ISO 6625 [8], ISO 6626 [9], [10] and ISO 6627 [11].

Internal combustion engines — Piston rings —

Part 4:
General specifications

1 Scope

This part of ISO 6621 specifies the general characteristics of piston rings for both reciprocating internal combustion engines and compressors (the individual dimensional criteria for these rings are given in the relevant International Standards). It also provides a system for ring coding, designation and marking. It is applicable to all such rings of a diameter $\leqslant$ 200 mm.

2 Normative references

The following referenced documents are indispensable for the application 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 6507-3, *Metallic materials — Vickers hardness test — Part 3: Calibration of reference blocks*

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

ISO 6621-2:2003, *Internal combustion engines — Piston rings — Part 2: Inspection measuring principles*

3 Terms and definitions

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

4 Piston ring codes

Codes used for piston rings shall be as given in Table 1, corresponding to their explanatory descriptions.

Table 1 — Codes and descriptions

Code	Description	Relevant International Standard
R	Straight faced rectangular ring	ISO 6622-1, ISO 6622-2
B	Barrel faced rectangular ring	ISO 6622-1, ISO 6622-2
BA	Asymmetrical barrel faced rectangular ring	ISO 6622-1, ISO 6622-2
M1 ...M5	Taper faced rectangular ring	ISO 6622-1, ISO 6622-2
N	Napier ring (undercut step)	ISO 6623
NM1 ... NM4	Napier ring (undercut step), taper faced	ISO 6623
E	Scraper ring (stepped)	ISO 6623
EM1 ... EM4	Scraper ring (stepped), taper faced	ISO 6623
T	Straight faced keystone ring 6°	ISO 6624-1, ISO 6624-3
TB	Barrel faced keystone ring 6°	ISO 6624-1, ISO 6624-3
TBA	Asymmetrical barrel faced keystone ring 6°	ISO 6624-1, ISO 6624-3
TM1 ... TM5	Taper faced keystone ring 6°	ISO 6624-1, ISO 6624-3
K	Straight faced keystone ring 15°	ISO 6624-1, ISO 6624-3
KB	Barrel faced keystone ring 15°	ISO 6624-1, ISO 6624-3
KBA	Asymmetrical barrel faced keystone ring 15°	ISO 6624-1, ISO 6624-3
KM1 ... KM5	Taper faced keystone ring 15°	ISO 6624-1, ISO 6624-3
HK	Straight faced half keystone ring 7°	ISO 6624-2, ISO 6624-4
HKB	Barrel faced half keystone ring 7°	ISO 6624-2, ISO 6624-4
S	Slotted oil control ring	ISO 6625
G	Double bevelled oil control ring	ISO 6625
D	Bevelled edge oil control ring	ISO 6625
DV	Bevelled edge V-groove oil control ring	ISO 6625
DSF-C	Coil spring loaded bevelled edge oil control ring, chromium plated and profile ground	ISO 6626, ISO 6626-2
DSF-CNP	Coil spring loaded bevelled edge oil control ring, chromium plated, not profile ground	ISO 6626
SSF	Coil spring loaded slotted oil control ring	ISO 6626, ISO 6626-2
GSF	Coil spring loaded double bevelled oil control ring	ISO 6626, ISO 6626-2
DSF	Coil spring loaded bevelled edge oil control ring	ISO 6626, ISO 6626-2
DSF-NG	Coil spring loaded bevelled edge oil control ring(face geometry similar type DSF-C or DSF-CNP)	ISO 6626
SSF-L	Coil spring loaded slotted oil control ring with 0,6 mm nominal land width	ISO 6626, ISO 6626-2
ES-1 ... ES-4	Expander/ segment oil control rings	ISO 6627
D22	Radial wall thickness for “D/22”	ISO 6622-1, ISO 6623
MC11 ... MC68	Material subclasses	ISO 6621-3
MR	Ratio $m/(d_1 - a_1)$ reduced	ISO 6621-4
Z	Ring shape round	ISO 6621-4

Table 1 (*continued*)

Code	Description	Relevant International Standard
Y	Ring shape negative ovality	ISO 6621-4
S005 ... S100	Closed gap (minimum values)	ISO 6621-4
CRF ... CR4	Peripheral surface chromium plated fully faced design	ISO 6621-4
CR1E ... CR2E	Peripheral surface chromium plated semi-inlaid design	ISO 6621-4
CR1F ... CR2F	Peripheral surface chromium plated inlaid design	ISO 6621-4
SC1 ... SC4	Peripheral surface spray coated fully faced design	ISO 6621-4
SC1E ... SC4E	Peripheral surface spray coated semi-inlaid design	ISO 6621-4
SC1F ... SC4F	Peripheral surface spray coated inlaid design	ISO 6621-4
NT030 ... NT130	Nitrided surface, case depth specified on peripheral surface and side faces	ISO 6621-4
NB030 ... NB130	Nitrided surface, case depth specified on peripheral surface and bottom side	ISO 6621-4
NP030 ... NP130	Nitrided surface, case depth specified on peripheral surface only	ISO 6621-4
NS010 ... NS050	Nitrided surface, case depth on segments	ISO 6627
NX	Nitrided surface of expanders/spacers	ISO 6627
LF	Uncoated ring peripheral surface or uncoated land peripheral surface, fully lapped	ISO 6621-4
LP	Taper faced piston ring with lapped land over the whole circumference but not over the whole width of the peripheral surface	ISO 6621-4
LM	Taper faced piston ring with partly cylindrical machined peripheral surface	ISO 6621-4
FE	Ferro oxided on all sides	ISO 6621-4
PO	Phosphated on all sides	ISO 6621-4
PR	Phosphated on all sides (for rust protection purposes)	ISO 6621-4
KA	Peripheral edges chamfered	ISO 6622
KI	Inside edges chamfered	ISO 6622
IF	Internal bevel (top side)	ISO 6622, ISO 6624-1, ISO 6624-3
IFU	Internal bevel (bottom side)	ISO 6622
IW	Internal step (top side)	ISO 6622-1, ISO 6624-1
IWU	Internal step (bottom side)	ISO 6622-1
IFV	Variable internal bevel (top side) for defined twist	ISO 6622-1
IFVU	Variable internal bevel (bottom side) for defined twist	ISO 6622-1
KU	Reduced peripheral bottom edge chromium plated fully faced design	ISO 6621-4
KG	Reduced size of peripheral edges at the gap of chromium plated/ spray coated/ nitrided rings	ISO 6621-4
NE1 ... NE3	Ring joint with lateral stop	ISO 6621-4
NH1 ... NH3	Ring joint with internal stop	ISO 6621-4

Table 1 (*continued*)

Code	Description	Relevant International Standard
WK	Reduced slot length	ISO 6626, ISO 6626-2
WF	Reduced heat set	ISO 6621-5, ISO 6626, ISO 6626-2
CSN, CSG, CSE	Type of coil spring	ISO 6626, ISO 6626-2
PNE, PNL, PNR, PNM, PNH, PNV	Contact pressure class	ISO 6626, ISO 6626-2, ISO 6627
	Additional marking	
MM	Manufacturer's mark	ISO 6621-4
MZ	Mark for required ring shape “round”	ISO 6621-4
MY	Mark for required ring shape “negative ovality”	ISO 6621-4
MX	Material mark [a]	ISO 6621-4
MU	Any other additional mark [b]	ISO 6621-4

[a] Material mark (for alternative materials) at the discretion of the manufacturer.

[b] Any other additional marking on client’s request, which shall be quoted clearly in the order, shall be agreed between manufacturer and client.

5 Designation of piston rings

5.1 Designation elements and order

5.1.1 General

When designating piston rings complying with the relevant International Standards, the following details shall be provided, in the order given, using the codes according to Table 1.

5.1.2 Mandatory elements

The following mandatory elements shall constitute the designation of a piston ring:

— designation, i.e. piston ring;

— number of International Standard;

— type of piston ring, e.g. R;

— hyphen;

— size of piston ring, $d_1 \times h_1$;

— radial wall thickness “regular” without code;

— Code D22 if the selected wall thickness, in accordance with ISO 6622-1 and ISO 6623, is D/22;

— hyphen;

— material code, e.g. MC11.

5.1.3 Additional elements

The following optional elements may be added to the designation of a piston ring and, if so added, shall be positioned on a second line beneath, or separated by a slash (/) from, the mandatory elements given in 5.1.2.

- reduced ratio $m/(d_1 - a_1)$, MR;
- ring shape, e.g. Z;
- selected nominal closed gap if it differs from the closed gap specified in the dimension Tables, e.g. S05;
- the selected coating, e.g. CR3;
- uncoated rings with fully lapped peripheral surface, e.g. for LF taper faced rings with partly cylindrical peripheral surface, LM (machined) or LP (lapped);
- selected surface treatment, e.g. PO;
- selected inside edge feature, e.g. KA;
- inside step of bevel, e.g. IWU;
- selected notch to prevent ring rotation, e.g. NH1;
- reduced slot length, if required, WK;
- coil spring with reduced heat set, if required, e.g. WF;
- selected type of coil spring, e.g. CSG;
- selected pressure class, e.g. PNM.

5.1.4 Elements for additional marking

Any additional marking shall following the additional elements of 5.1.3:

- manufacturer's mark, if required, MM;
- marking of required ring shape, e.g. MZ;
- material, MX (see Table 1, Footnote a);
- code for any other marking, MU (see Table 1, Footnote b).

5.2 Designation examples

5.2.1 Designation example of a piston ring in accordance with ISO 6622-1

For

- a straight-faced rectangular ring (R),
- of nominal diameter d_1 = 90 mm (90),
- of nominal ring width h_1 = 2,5 mm (2,5), and
- made of grey cast iron, non heat-treated, material subclass 11 (MC11):

Piston ring ISO 6622-1 R - 90 × 2,5 - MC11

5.2.2 Designation example of a piston ring in accordance with ISO 6624-1

For

— a keystone ring 6°, taper faced 60′ (TM3),

— of nominal diameter d_1 = 105 mm (105),

— and nominal ring width h_1 = 2,5 mm (2,5),

— made of spheroidal graphite cast iron, martensitic type, material subclass 51 (MC51),

— ring shape round (Z),

— with a selected closed gap of 0,3 mm (S003),

— inside edges chamfered (KI), and

— peripheral surface chromium plated, with plating thickness 0,1 mm minimum (CR2):

Piston ring ISO 6624-1 TM3 - 105 × 2,5 - MC51 / Z S003 KI CR2

5.2.3 Designation example of a piston ring in accordance with ISO 6626

For

— a coil spring loaded, bevelled edge oil control ring, chromium plated and profile ground (DSF-C),

— of nominal diameter d_1 = 125 mm (125),

— and nominal ring width h_1 = 5 mm (5),

— made of grey cast iron, non heat-treated, material subclass 11 (MC11),

— with a selected closed gap of 0,2 mm (S002),

— having a chromium plating thickness on the lands of 0,15 mm minimum (CR3),

— phosphated on all cast iron surfaces to a depth of 0,002 mm minimum (PO),

— with reduced slot length (WK),

— a coil spring with reduced heat seat (WF),

— having a variable pitch with coil diameter, d_1 ground (CSE),

— tangential force F_t according to the medium nominal contact pressure class (PNM),

— marked with manufacturer's mark (MM):

Piston ring ISO 6626 DSF-C - 125 × 5 - MC11 / S002 CR3 PO WK WF CSE PNM MM

6 Marking of piston rings

6.1 General

The requirements and recommendations for piston ring marking according to 6.2 and 6.3 apply to piston rings of 1,6 mm radial wall thickness and above. Marking of piston rings of less than 1,6 mm is at the discretion of the manufacturer.

6.2 Mandatory top-side marking

All rings requiring orientation shall be marked to indicate the top side only, i.e. the side nearest the combustion chamber.

In the absence of any other mark agreed between manufacturer and client, the mark “TOP” should be used.

Marking of the top side applies to *all* the following types of ring:

— taper faced rings;

— asymmetrical barrel faced rings;

— rings with reduced peripheral bottom edge;

— internally bevelled or stepped rings;

— semi-inlaid rings;

— scraper rings;

— half keystone rings;

— directional oil control rings.

All such rings requiring marking are specified in the relevant International Standards (see Foreword and Bibliography).

6.3 Additional marking

Additional marking of piston rings is optional or at the client's request.

Such additional marking may comprise the following:

— manufacturer's mark;

— mark for required ring shape;

— material mark (for alternative materials);

— any other additional mark agreed between manufacturer and client.

7 General characteristics

7.1 Ring shape

Degrees of ovality only apply to rectangular rings [1], [2], scraper rings [3] and keystone rings [4], [5], [6], [7]. The forms of ovality are

— positive ovality, without code,

— round, Code Z, and

— negative ovality, Code Y.

Values are given in Table 2.

Table 2 — Ovality

Dimensions in millimetres

Nominal diameter d_1	Positive ovality	Round [a] Code: Z	Negative ovality [b] Code: Y
$30 \leqslant d_1 < 60$	0 ... + 0,60	− 0,30 ... + 0,30	− 0,60 ... 0
$60 \leqslant d_1 < 100$	+ 0,05 ... + 0,85	− 0,35 ... + 0,35	− 0,70 ... 0
$100 \leqslant d_1 < 150$	+ 0,10 ... + 1,10	− 0,45 ... + 0,45	− 0,95 ... − 0,05
$150 \leqslant d_1 \leqslant 200$	+ 0,15 ... + 1,35	− 0,50 ... + 0,50	− 1,10 ... − 0,10

[a] For taper faced coated and uncoated rings with lapped land, the recommended ring shape is round.

[b] Not applicable for material Class 10 of ISO 6621-3.

7.2 Light tightness

At least 90 % of the circumference of the piston ring peripheral surface shall be light-tight.

At least 95 % of the circumference on the peripheral surface of a taper faced ring with plated/coated or nitrided and ground peripheral surface shall be light-tight.

100 % of the circumference on the peripheral surface of the following piston ring designs shall be light-tight:

— piston rings with machined land over the whole circumference of the peripheral surface;

— taper-faced piston rings with machined land over the whole circumference of the peripheral surface.

In the case of piston rings with a treated surface, the light tightness is normally measured prior to surface treatment. When it is checked after treatment, rotation of the ring in the gauge will be required. In the case of rings with negative point deflection, visible light is permitted at the butt ends, but should be confined to the angle θ as defined in ISO 6621-2.

7.3 Closed gap

Whenever the selected closed gap differs from that given in the dimensional tables of the relevant International Standard, Table 3 shall apply and the tolerances shall remain the same.

Table 3 — Closed gap

Dimensions in millimetres

Code	S005	S010	S015	S020	S025	S030	S035	S040	S045	S050	S055	S060	S070	S080	S090	S100
Closed gap	0,05	0,10	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,55	0,60	0,70	0,80	0,90	1,00

7.4 Tangential force, F_t, and diametral force, F_d, of single piece piston rings

NOTE The individual types of piston rings are given in [1] to [8]. The definitions of F_t and F_d are given in ISO 6621-2.

7.4.1 Calculation of F_t and F_d values in dimension tables of dimensional standards

The tangential and diametral forces of piston rings are tabulated in the dimension tables of the dimensional standards.

The values are calculated for

— the basic feature of each piston ring type,

— nominal radial wall thickness a_1, and mean ring width h_1 or h_3,

— piston rings made of cast iron with a modulus of elasticity of 100 GN/m^2 (100 GN/m^2 = 100 000 MPa = 100 000 N/mm^2),

— piston rings made of steel with a modulus of elasticity of 210 GN/m^2, and

— a ratio of total free gap to nominal diameter [$m/(d_1 - a_1)$] according to Table 4.

NOTE The calculation of tangential forces and diametral forces of rectangular rings made of steel (ISO 6622-2) is based on a theoretical contact pressure of 0,16 $\pm$ 0,01 N/mm^2. The calculation of tangential forces and diametral forces of keystone rings (ISO 6624-3) and half keystone rings (ISO 6624-4) made of steel is based on the same ratio $m/(d_1 - a_1)$ used for rectangular rings (ISO 6622-2).The ratio $m/(d_1 - a_1)$ for rings made of steel is quite different from the values given in Table 4 for rings made of cast iron and depends on the nominal diameter and the special radial wall thickness. This radial wall thickness is not in a constant ratio to nominal diameter because there are steps of wall thickness which belong to a range of nominal diameters (e.g. a_1 = 2,1 mm for d_1 = 57 ... 61 mm).

7.4.2 Correction of F_t and F_d values

7.4.2.1 General

The F_t and F_d values shall be corrected whenever the following are being used:

a) additional features, such as rings with

  — coated peripheral surface, and/or

  — inside chamfered edges, and/or

  — outside chamfered edges, and/or

  — taper, and/or

  — internal step or internal bevel;

b) piston ring materials with a modulus of elasticity other than 100 GN/m^2;

c) a ratio of total free gap to nominal diameter [$m/(d_1 - a_1)$] other than that given in Table 4;

The values for the regular ratio of free gap to nominal diameter $m/(d_1 - a_1)$ regular are given in Table 4.

Table 4 — Regular ratio of total free gap to nominal diameter

Dimensions in millimetres

Nominal diameter d_1	$m/(d_1 - a_1)$ Cast iron	Steel [a]
$30 \leqslant d_1 < 60$	0,15	0,10 ... 0,14
$60 \leqslant d_1 < 100$		
$100 \leqslant d_1 < 160$	0,17-0,0002 d_1	0,11 ... 0,13
$160 \leqslant d_1 \leqslant 200$		

[a] Variation of $m/(d_1 - a_1)$ depends on contact pressure and radial wall thickness.

7.4.2.2 Multiplier factors for common features

For common features, the necessary multiplier correction factors are tabulated in the dimensional standards [1] to [8] under "Force factors".

7.4.2.3 Multiplier force correction factors for materials

For materials specified in ISO 6621-3, the force correction factors given in Table 5 should be used.

Table 5 — Material force correction factors

Material class	Material force correction factor
10	0,9 to 1 [a]
20	1,1 to 1,3 [a]
30	1,45
40	1,6
50	1,6

[a] Force correction factors for material depend on the modulus of elasticity in the manufacturer's material specification:

$$\text{Correction factor} = \frac{\text{Typical modulus of elasticity in GN/m}^2}{100\ \text{GN/m}^2}$$

7.4.2.4 Multiplier force correction factors for ratio $m/(d_1 - a_1)$

Piston rings made of materials in Classes 30 to 50 increase the tangential force and diametral force in relationship to the modulus of elasticity (see Table 5) when ratio $m/(d_1 - a_1)$ regular is used.

For limitation of such increased forces, it is common to use reduced values of $m/(d_1 - a_1)$. See Table 6 for the recommended correction factors $m/(d_1 - a_1)$ regular and $m/(d_1 - a_1)$ reduced.

Table 6 — Force correction factors for ratio $m/(d_1 - a_1)$

Material class	Factor	
	$m/(d_1 - a_1)$ **regular**	$m/(d_1 - a_1)$ **reduced Code:MR**
10	1	—
20	1	—
30	1	0,825
40	1	0,75
50	1	0,75

For calculation of real values of ratio $m/(d_1 - a_1)$ reduced, the factors given in Table 6 apply. Therefore, the values of $m/(d_1 - a_1)$ calculated with formula given in Table 4 shall be corrected with the correction factors given in Table 6.

7.4.3 Examples for correction of F_t and F_d

7.4.3.1 First example — Selected piston ring type: ISO 6622-1 B - 95 × 2,5 - MC53 / MR CR2 IW

7.4.3.1.1 Multiplying factors

These are

— 1,6 for material Subclass 53,

— 0,75 for ratio $m/(d_1 - a_1)$ reduced,

— 0,88 for peripheral surface chromium plated CR2, and

— 0,78 for internal step IW.

7.4.3.1.2 Calculation

Total force correction factors: 1,6 × 0,75 × 0,88 × 0,78 = 0,824.

Basic values F_t and F_d according to ISO 6622-1: F_t = 18,5 N and F_d = 39,8 N.

Corrected values: F_t = 0,824 N × 18,5 N ± 20 % and F_d = 0,824 N × 39,8 N ± 20 %;

F_t = 15,2 N ± 20 and F_d = 32,8 N ± 20 %;

F_t = 12,2 N ... 18,2 N and F_d = 26,2 N ... 39,4 N.

7.4.3.2 Second example — Selected piston ring type : ISO 6623 N - 70 × 2 D22 - MC24 / SC2F

7.4.3.2.1 Multiplying factors

These are

— 1,15 for material subclass 24, and

— 0,9 for peripheral surface spray coated SC2F (inlaid type).

7.4.3.2.2 Calculation

Total force correction factor: 1,15 × 0,9 = 1,035.

Basic values F_t and F_d according to ISO 6623: F_t = 9,3 N and F_d = 20,0 N.

Corrected values: F_t = 1,035 N × 9,3 N ± 30 % and F_d = 1,035 N × 20,0 N ± 30 %;

F_t = 9,6 N ± 30 % and F_d = 20,7 N ± 30 %;

F_t = 6,7 N ... 12,5 N and F_d = 14,5 N ... 26,9 N.

7.4.3.3 Third example — Selected piston ring type : ISO 6624-1 KB - 140 × 4 - MC42 / SC4 KI

7.4.3.3.1 Multiplying factors

These are

- 1,6 for material subclass 42,
- 0,85 for peripheral surface spray coated SC4 (fully faced type), and
- 0,96 for inside chamfered edges KI.

7.4.3.3.2 Calculation

Total force correction factor: 1,6 × 0,85 × 0,96 = 1,306.

Basic values F_t and F_d according to ISO 6624-1: F_t = 29,3 N and F_d = 63 N.

Corrected values: F_t = 1,306 × 29,3 N ± 20 % and F_d = 1,306 × 63 N ± 20 %;

F_t = 38,3 N ± 20 % and F_d = 82,3 N ± 20 %;

F_t = 30,6 N ... 46,0 N and F_d = 65,8 N ... 98,8 N.

7.4.3.4 Fourth example — Selected piston ring type: ISO 6625 G - 120 × 5 - MC11 / KI

7.4.3.4.1 Multiplying factors

These are

- 0,9 for material subclass 11, and
- 0,98 for inside chamfered edges, KI.

7.4.3.4.2 Calculation

Total force correction factor: 0,9 × 0,98 = 0,882.

Basic values F_t and F_d according to ISO 6625: F_t = 24,7 N and F_d = 53,1 N.

Corrected values: F_t = 0,882 × 24,7 N ± 20 % and F_d = 0,882 × 53,1 N ± 20 %;

F_t = 21,8 N ± 20 % and F_d = 46,8 N ± 20 %;

F_t = 17,4 N ... 26,2 N and F_d = 37,4 N ... 56,2 N.

7.5 Tangential force F_t of multipiece oil control rings as specified in ISO 6626 and ISO 6626-2

7.5.1 General

The tangential force of a coil spring loaded oil control ring depends on

- piston ring type,
- class of nominal contact pressure, and
- specific tangential force F_{tc} for unit contact pressure of forces, tabulated in ISO 6626 and ISO 6626-2.

NOTE The formula for calculating the actual tangential force is also given in ISO 6626 and ISO 6626-2.

7.5.2 Rounding of values

Actual values of tangential force should be rounded up or down as follows:

— $F_t < 50$ N, to the nearest 0,5 N;

— $F_t > 50$ N, to the nearest 1 N, where 0,5 N is rounded up.

7.5.3 Examples for calculating tangential force F_t

7.5.3.1 First example — Selected piston ring type: ISO 6626 DSF-C - 100 × 4 - MC11 / CR1 CSG PNM

7.5.3.1.1 Pressure class and specific tangential force

Class of nominal contact pressure: PNM = 1,49 N/mm^2.

Specific tangential force for unit contact pressure of 1 N/mm^2: F_{tc} = 40,4 N.

7.5.3.1.2 Calculation

Tangential force: F_t = 1,49 N × 40,4 N ± 20 %;

F_t = 60,2 N ± 20 %;

F_t = 48 N ... 72 N.

7.5.3.2 Second example — Selected type of piston ring: ISO 6626 SSF - 175 × 6 MC11/CSG PNE

7.5.3.2.1 Pressure class and specific tangential force

Class of nominal contact pressure: PNE = 0,59 N/mm^2.

Specific tangential force for unit contact pressure of 1 N/mm^2: F_{tc} = 192,5 N.

7.5.3.2.2 Calculation

Tangential force: F_t = 0,59 × 192,5 N ± 20 %;

F_t = 113,6 N ± 20 %;

F_t = 91 N ... 136 N.

7.6 Tangential force F_t of expander/segment oil control rings as specified in ISO 6627

7.6.1 General

The tangential force of an expander/segment oil control ring depends on

— nominal contact pressure, p_o,

— segment width h_{12}, and

— specific tangential force F_{tc} for a unit contact pressure of 1 N/mm^2.

The values for nominal contact pressure and specific tangential forces are tabulated in ISO 6627.

7.6.2 Example for calculating the tangential force F_t — Selected type of piston ring: ISO 6627 - ES3 - 85 × 3 - MC67 MC68 / CR1 PNH

7.6.2.1 Pressure class and specific tangential force

Class of nominal contact pressure: p_o = 1,2 N/mm^2; multiplying factor = 1,2.

Specific tangential force F_{tc} for unit contact pressure of p_{ou} = 1 N/mm^2 and segment width 0,45 (e.g. F_{tc} = 38,2).

7.6.2.2 Calculation

Tangential force: F_t = 1,2 × 38,2 N ± 20 %;

F_t = 45,8 N ± 20 %;

F_t = 36,5 N ... 55 N.

8 Notches for preventing ring rotation

8.1 Ring joint with internal notch (only for compression rings as specified in ISO 6622 and ISO 6624)

See Figures 1 and 2 and Tables 7 and 8.

Dimensions in millimetres

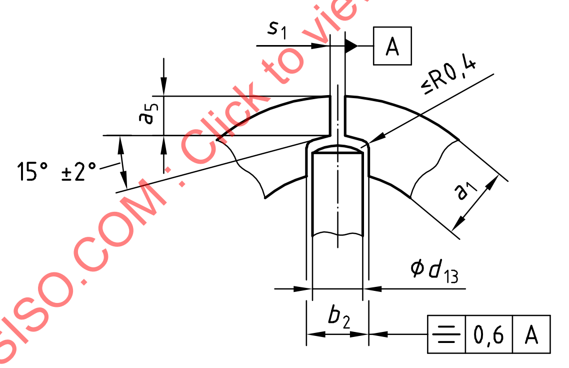


Figure 1 — Internal notch

Table 7 — Dimensions of internal notch

Dimensions in millimetres

Code	Pin diameter d_{13}	Notch [a] b_2	tol.	r_6	tol.
NH1	1,5	2	$^{+0,2}_{-0,1}$	0,8	± 0,1
NH2	2	2,5		0,9	
NH3	2,5	3		1	

r_6 applies only to notch design according to Figure 2.

[a] $b_2 - d_{13} > s_1$ nom.

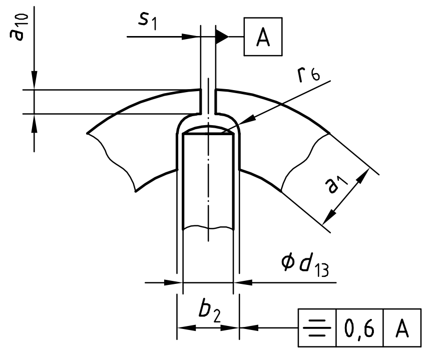


Figure 2 — Internal notch — Option for piston rings with radial wall thickness a_1 > 2,1

Table 8 — Width of overlap a_5 and optional a_{10} for internal notch

Dimensions in millimetres

Radial wall thickness	**Overlap**			
a_1	a_5	tol.	a_{10}	tol.
$1,5 \leqslant a_1 < 2,1$	0,6	± 0,1	—	± 0,1
$2,1 \leqslant a_1 < 2,7$	0,7		0,6	
$2,7 \leqslant a_1 < 3,1$	1		0,7	
$3,1 \leqslant a_1 < 3,5$	1,2		0,8	
$3,5 \leqslant a_1 < 3,9$	1,4		0,9	
$3,9 \leqslant a_1 < 4,1$	1,6		1	

8.2 Ring joint with side notch (only for compression rings as specified in ISO 6622)

See Figure 3 and Table 9.

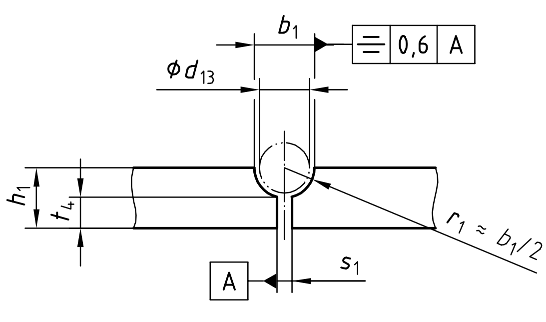


Figure 3 — Side notch

Table 9 — Dimensions of side notch

Dimensions in millimetres

Code	Ring width h_1	Pin diameter d_{13}	Notch [a]			
			b_1	tol.	t_4	tol.
NE1	1,2[b]	1,5	2	+0,2 −0,1	0,5	0 −0,15
	1,5				0,7	
	1,75				0,95	
	2				1,2	
	2,5				1,7	
NE2	1,5	2	2,3		0,7	
	2		2,5		0,9	
	2,5		2,5		1,4	
	3		2,5		1,9	
NE3	2,5	2,5	3		1	
	3	2,5	3		1,5	

[a] $b_1 - d_{13} > s_1$ nom.

[b] Not applicable for material Class 10 according to ISO 6621-3.

9 Machining of surfaces

9.1 Peripheral surfaces

Standard machined: no code required.

See Table 10.

9.2 Side faces

The standard method of machining is by grinding of side faces: no code required.

The standard side face finish is Rz 4 or Ra 0,8, and for steel nitrided, Rz 3,2 or Ra 0,6

In the case of piston rings with treated surfaces (FE, PO, PR), the roughness shall be measured before surface treatment.

Segments for expander/segment oil control rings made of steel are without machining.

9.3 Other surfaces

See Table 11.

Table 10 — Standard machined peripheral surfaces

Ring Type	Ring description	Standard machining methods of peripheral surfaces
All Types	All unplated/uncoated rings made of cast iron	Fine turned
R; B; BA; N; E; T; TB; TBA; K; KB; KBA HK; HKB	Plated/spray coated peripheral surface Straight or barrel faced On rectangular, napier/scraper or keystone rings Made of cast iron or steel	Machined (i.e. ground, lapped or polished) over full face
R; B; BA; T; TB; TBA; K; KB; KBA; HK; HKB	Nitrided peripheral surface on straight or barrel faced rectangular or keystone rings made of steel	Machined (i.e. ground, lapped or polished) over full face
M; NM, EM; TM; KM	Plated/spray coated or nitrided peripheral surface on taper faced rings made of cast iron or steel	Witness machined (i.e. ground, lapped or polished) on part of the width of the peripheral surface only
ES1 ... ES4	Plated or nitrided peripheral surfaces on segments for expander/segment oil control rings made of steel	Machined (= lapped) over part of the width Or machined (= polished) over full face of the peripheral surface
DSF-C; DSF-CNP	Plated lands on oil control rings made of cast iron	Machined (i.e. ground, lapped or polished) over full face
Roughness values and measurement method may be agreed between manufacturer and client as there is no standard method available which is applicable in all cases.		

Table 11 — Standard machined other surfaces

Surface description	Standard machining methods
Inside surface: rings made of cast iron rings made of steel	 Turned Without machining
Gap faces	Ground or milled
Oil control rings OD profile	Turned or ground (DSF-C)
Coil spring	Ground or without machining
Expander	Without machining
Other surfaces	Turned, ground or milled
Roughness values and measurement method may be agreed between manufacturer and client as there is no standard method available which is applicable in all cases.	

10 Plated, coated and treated surfaces

10.1 Chromium plating on peripheral surfaces

10.1.1 General

Codes are required for chromium plated surfaces as specified in the dimensional standards.

10.1.2 Chromium plating thickness

See Table 12.

Table 12 — Chromium plating thickness

Dimensions in millimetres

Code	Thickness min	Tolerance guideline [a]	
		$d_1 < 160$	$160 \leqslant d_1 \leqslant 200$
CRF	0,005	—	—
CR1	0,05	$^{+0,15}_{0}$	$^{+0,2}_{0}$
CR2	0,1		
CR3	0,15		
CR4	0,2		

[a] Usually a minimum specification does not call for tolerances. If a tolerance is required on the plating thickness this guideline is recommended.

10.1.3 Chromium plated rings of fully faced design

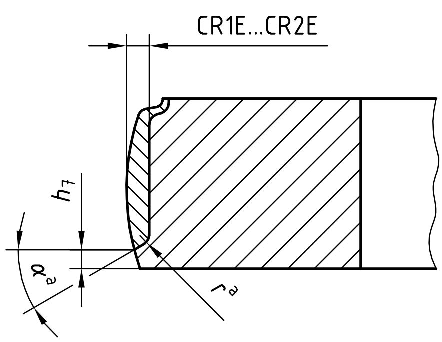
Code: CRF ... CR4.

Piston rings with plated peripheral surfaces are normally designed fully faced.

10.1.4 Chromium plated rings of semi-inlaid design

Code: CR1E ... CR2E.

See Figure 4 and Table 13.



[a] At the manufacturer's discretion.

Figure 4 — Chromium plated ring semi-inlaid

Table 13 — Land dimensions h_7 of peripheral edges for chromium plated rings semi-inlaid

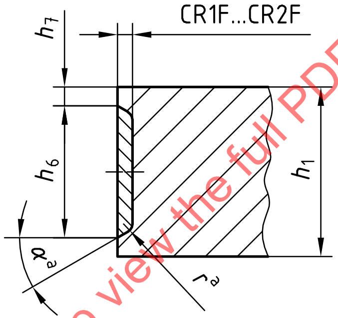
Dimensions in millimetres

Ring width h_1	Land dimension h_7	
	MC 10, 20, 30	MC 40, 50, 60
$\leqslant 2$	0,15 ... 0,45	0,1 ... 0,4
$2 < h_1 < 3,5$	0,15 ... 0,5	0,1 ... 0,45
$3,5 \leqslant h_1 \leqslant 4,5$	0,15 ... 0,55	0,1 ... 0,5

Chromium plated rings of inlaid design

Code: CR1F ... CR2F.

See Figure 5 and Table 14.



a At the manufacturer's discretion.

Figure 5 — Chromium plated ring inlaid

Table 14 — Dimensions of groove and land of peripheral edges for chromium plated rings

Dimensions in millimetres

Ring Width h_1	Groove dim. h_6 min.	Land dimension h_7	
		MC 10, 20, 30	**MC 40, 50, 60**
2	1,3	0,15 ... 0,45	0,1 ... 0,4
2,5	1,7	0,15 ... 0,5	0,1 ... 0,45
3	2,2		
3,5	2,5		
4	3	0,15 ... 0,55	0,1 ... 0,5
4,5	3,5		

10.1.5 Radiusing, chamfering and dimensions of peripheral edges of chromium plated rings

NOTE Values do not apply to chromium plated oil control rings and segments.

Rings of Code CRF to CR4, both peripheral edges, and rings of Code CR1E to CR4E, the upper peripheral edge, may be radiused or chamfered before plating.

See Figures 6 to 8 and Table 15.

Dimensions in millimetres

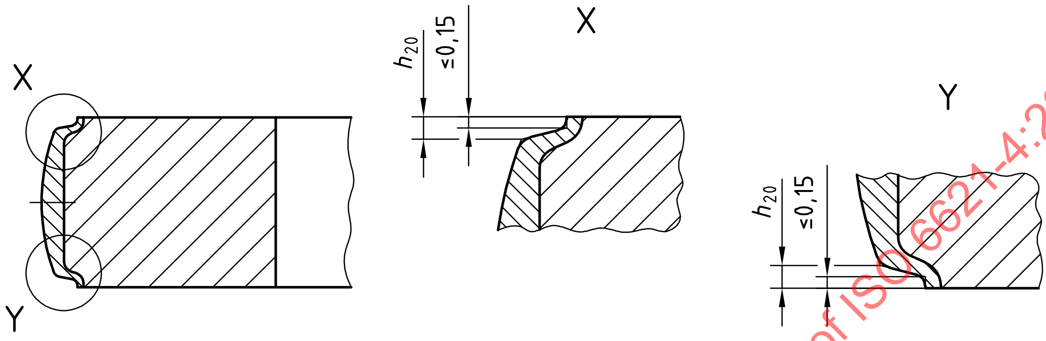


Figure 6 — Chromium plated ring fully faced

Dimensions in millimetres

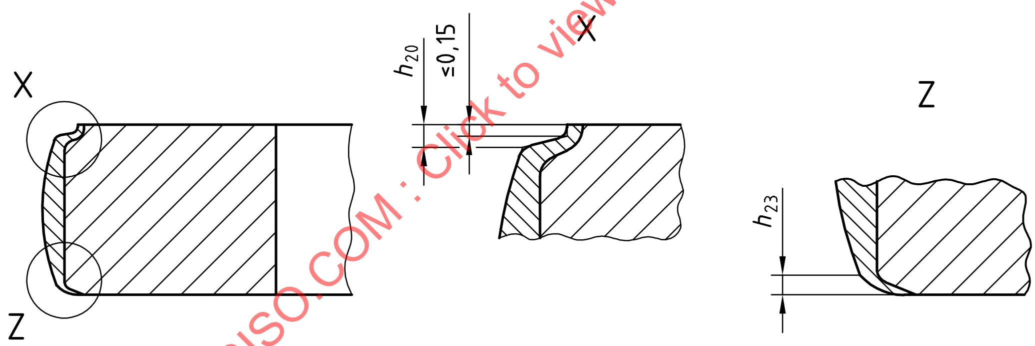


Figure 7 — Chromium plated ring fully faced, reduced peripheral bottom edge — Code: KU

Dimensions in millimetres

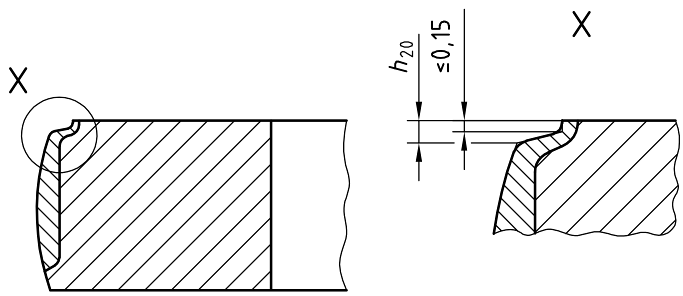


Figure 8 — Chromium plated ring semi-inlaid

Table 15 — Axial dimensions, h_{20} and h_{23} (acc. code KU) of peripheral edges of chromium plated rings

Dimensions in millimetres

Ring width h_1	Axial dimension	
	h_{20} max.	h_{23} max.
$1{,}0 \leqslant h_1 < 3{,}5$	0,3	0,2
$3{,}5 \leqslant h_1 \leqslant 4{,}5$	0,4	0,3

10.1.6 Peripheral edges at the gap of chromium plated rings and segments

After plating, the peripheral edges at the gap shall be radiused or chamfered. See Table 16.

Table 16 — Circumferential dimensions of peripheral edges at gap of chromium plated rings and segments

Dimensions in millimetres

Ring width h_1, h_{12}	Circumferential dimension	
	s_3 max.	reduced s_3 (Code: KG) max.
< 6	0,4	0,15
$\geqslant$ 6	0,6	0,25

10.1.7 Hardness of chromium plating

The hardness of chromium plating shall be 800 HV 0,1 minimum, in accordance with ISO 6507-3.

10.2 Spray coated peripheral surfaces

10.2.1 Codes

Codes are required for spray-coated surfaces as specified in the dimensional standards.

10.2.2 Spray coating thickness (see 10.2.8)

See Table 17.

10.2.3 Spray-coated rings of fully faced design

Code: SC1 to SC4.

10.2.4 Spray coated rings of semi-inlaid design

Code: SC1E to SC4E.

See Figure 9.

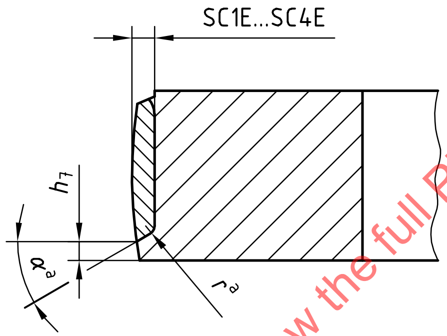
The dimensions of the land at the bottom of the peripheral edge for spray coated rings of semi-inlaid design shall be those given for h_7 in Table 13.

Table 17 — Spray coating thickness

Dimensions in millimetres

Code	Thickness min.	Tolerance guideline[a] $d_1 < 160$	Tolerance guideline[a] $160 \leqslant d_1 \leqslant 200$
SC1	0,05	$^{+0,2}_{\ \ 0}$	$^{+0,25}_{\ \ 0}$
SC2	0,1		
SC3	0,15		
SC4	0,2		

[a] Usually minimum specification does not call for tolerances. If a tolerance is required on the coating thickness, this guideline is recommended.



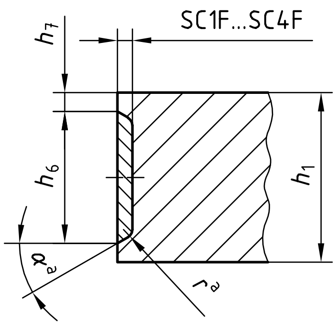
[a] At the manufacturer's discretion.

Figure 9 — Spray coated ring semi-inlaid

10.2.5 Spray-coated rings of inlaid design

Code: SC1F to SC4F.

See Figure 10 and Table 18.



[a] At the manufacturer's discretion.

Figure 10 — Spray coated ring inlaid design