SAE International™ **SURFACE VEHICLE STANDARD**

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Superseding J1591 APR1998

Internal Combustion Engines—Piston Rings—General Specifications

This SAE Standard is equivalent to ISO Standard 6621/4.

Foreword—This Reaffirmed Document has been changed only to reflect the new SAE Technical Standards Board Format.

1. *Scope and Field of Application*—Differences, where they exist, are shown in Appendix A.

This SAE Standard specifies the general characteristics of piston rings and individual dimensional criteria, which are specified as appropriate in the documents in Section 2.

This document also provides a system for coding, designation, and marking of piston rings.

This document applies to the manufacture of piston rings up to and including 200 mm diameter for reciprocating internal combustion engines. It also applies to piston rings for compressors working under similar conditions.

1.1 Rationale—SAE J1591 is being discontinued because the content of this standard is also contained in ISO 6621-4. Therefore, to eliminate duplication and confusion in coordinating the standards between ISO and SAE, this document will be discontinued. The SAE Piston and Ring Standards Committee will now continue to support ISO in updating the standards as appropriate.

2. *References*

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the latest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE DESIGNATION	ISO[1] EQUIVALENT	
		INTERNAL COMBUSTION ENGINES—PISTON RINGS
J1588	6621/1	Vocabulary
J1589	6621/2	Measuring principles
J1590	6621/3	Material specifications
J1591	6621/4	General specifications
J199	66621/5	Quality requirements
		INTERNAL COMBUSTION ENGINES—PISTON RINGS
J1997	6622/1	Rectangular rings
J1998	6622/2 TR	Rectangular rings with narrow ring width
J1999	6623	INTERNAL COMBUSTION ENGINES—PISTON RINGS—SCRAPER RINGS
		INTERNAL COMBUSTION ENGINES—PISTON RINGS
J2000	6624/1	Keystone rings
J2001	6624/2 TR	Half keystone rings
J2002	6625	INTERNAL COMBUSTION ENGINES—PISTON RINGS—OIL CONTROL RINGS
J2003	6626	INTERNAL COMBUSTION ENGINES—PISTON RINGS—COIL SPRING LOADED OIL CONTROL RINGS
J2004	6627 TR	INTERNAL COMBUSTION ENGINES—PISTON RINGS—EXPANDER/SEGMENT OIL CONTROL RINGS
J2226		INTERNAL COMBUSTION ENGINES—PISTON RINGS—STEEL RECTANGULAR RINGS
	6507/3	METALLIC MATERIALS—HARDNESS TEST—VICKERS TEST—PART 3: LESS THAN HV 0.2

3. ***Terminology***—The terminology used in this document is as given in SAE J1588.

1. TR refers to Technical Report

4. ***Piston Ring Codes***—Codes used for piston rings shall be as given in Table 1 with their explanatory descriptions.

TABLE 1—CODES AND DESCRIPTIONS

Code	Description	Relevant SAE Standard
R	Straight faced rectangular ring	J1997/J1998
B	Barrel faced rectangular ring	J1997/J1998
M1 to M5	Taper faced rectangular ring	J1997/J1998
N	Scraper ring (Napier)	J1999
NM1 to NM4	Taper faced scraper ring (Napier)	J1999
E	Scraper ring (stepped)	J1999
EM1 to EM4	Scraper ring (stepped), taper faced	J1999
T	Straight faced keystone ring 6 degrees	J2000
TB	Barrel faced keystone ring 6 degrees	J2000
TM1 to TM5	Taper faced keystone ring 6 degrees	J2000
K	Straight faced keystone ring 15 degrees	J2000
KB	Barrel faced keystone ring 15 degrees	J2000
KM1 to KM5	Taper faced keystone ring 15 degrees	J2000
HK	Straight faced half keystone ring 7 degrees	J2001
HKB	Barrel faced half keystone ring 7 degrees	J2001
S	Slotted oil control ring	J2002
G	Double bevelled oil control ring	J2002
D	Bevelled edge oil control ring	J2002
DV	Bevelled edge V-groove oil control ring	J2002
DSF-C	Coil spring loaded bevelled edge oil control ring, chromium plated and profile ground	J2003
DSF-CNP	Coil spring loaded bevelled edge oil control ring, chromium plated, not profile ground	J2003
SSF	Coil spring loaded slotted oil control ring	J2003
GSF	Coil spring loaded double bevelled oil control ring	J2003
DSF	Coil spring loaded bevelled edge oil control ring	J2003
DSF-NG	Coil spring loaded bevelled edge oil control ring (face geometry similar type DSF-C or DSF-CNP)	J2003
SSF-L	Coil spring loaded slotted oil control ring with 0.6 mm nominal land width	J2003
D22	Radial wall thickness $a_1 = d_1/22$	J1997/J1999
MC11 to MC63	Material subclasses	J1590
MR	Ratio m/d_1 reduced	J1591, 7.4
Z	Ring shape round	
Y	Ring shape negative ovality	J1591, 7.1
S00 to S10	Closed gap (minimum values)	J1591, 7.3

TABLE 1—CODES AND DESCRIPTIONS (CONTINUED)

Code	Description	Relevant SAE Standard
CRF to CR4	Periphery chromium coated fully faced design	
CR1E to CR4E	Periphery chromium coated semi-inlaid design	J1591, 9.3
CR1F to CR4F	Periphery chromium coated inlaid design	
MO1 to MO4	Periphery molybdenum coated fully faced design	
MO1E to MO4E	Periphery molybdenum coated semi-inlaid design	J1591, 9.3
MO1F to MO4F	Periphery molybdenum coated inlaid design	
LF	Uncoated ring periphery or uncoated land periphery, fully lapped	J1591, 7.2
LP	Taper faced piston ring with lapped land over the whole circumference but not over the whole width of the periphery	J1591, 7.2
FE	Ferrox coated	J1591, 10.1
PO	Phosphate coated (0.002 mm min)	
PR	Phosphate coated (0.002 mm max)	J1591, 10.2 & 10.3
KA	Peripheral edges chamfered	
KI	Inside edges chamfered	J1997, J1998
IF	Internal bevel (top side)	
IFU	Internal bevel (bottom side)	
IW	Internal step (top side)	J1997, J1998
IWU	Internal step (bottom side)	
IFV	Variable internal bevel (top side)	
IFVU	Variable internal bevel (bottom side)	
NE1 to NE3	Ring joint with lateral stop	
NH1 to NH3	Ring joint with internal stop	J1591, 8.1
WK	Reduced slot length	J2003
WF	Reduced heat set	J1996, J2003
CSN, CSG, CSE	Type of coil spring	J2003
PNE, PNL, PNR, PNM, PNH, PNV	Contact pressure class	J2003
	Additional marking:	
MM	manufacturer's mark	
MZ	mark for required ring shape "round"	
MY	mark for required ring shape "negative ovality"	J1591, 6.2
MX	material mark(1)	
MU	any other additional mark(2)	

1. Material mark (for alternative materials) at the discretion of the manufacturer.
2. Any other additional marking on purchaser's request shall be quoted clearly in the order; it shall be agreed on between manufacturer and purchaser.

5. Designation of Piston Rings

5.1 Designation Elements and Order—To designate piston rings complying with the relevant International Standards and the SAE documents, the following details shall be given in the order shown.

The codes given in Table 1 shall be used.

5.1.1 MANDATORY ELEMENTS—The following mandatory elements shall constitute the designation of a piston ring:

a. Designation, i.e., piston ring
b. Number of SAE Standards
c. Type of piston ring, e.g., R
d. Hyphen
e. Size of piston ring, d_1 x h_1
f. Code D22 if the selected wall thickness, in accordance with SAE J1997 and J1999, is D/22

    1. Hyphen
    2. Material code, e.g., MC11

5.1.2 ADDITIONAL ELEMENTS—The following optional elements may be added to the designation of a piston ring; in this case, they shall be added on the second line beneath the mandatory elements, or separated by a slant (/):

a. Code for reduced ratio m/d_1, MR
b. Code for ring shape, e.g., MZ
c. Code for the selected nominal closed gap if it differs from the closed gap specified in the dimensional tables, e.g., S05
d. Code for the selected coating, e.g., CR3
e. Code for uncoated rings with fully lapped periphery or taper faced rings with partial lapped periphery, e.g., LF or LP
f. Code for the selected surface treatment, e.g., PO
g. Code for the selected peripheral edge feature, e.g., KA
h. Code for the selected inside edge feature, e.g., KI
i. Code for the inside step or bevel, e.g., IWU
j. Code for the selected notch to prevent ring rotation, e.g., NH1
k. Code if reduced slot length is required, WK
l. Code if the coil spring with reduced heat set is required, e.g., WF
m. Code for the selected type of coil spring, e.g., CSG
n. Code for the selected pressure class, e.g., PNM

5.1.3 ELEMENTS FOR ADDITIONAL MARKING—Any additional marking shall follow the additional elements specified in 5.1.2:

a. Code if manufacturer's mark is required, MM
b. Code for marking of required ring shape, e.g., MZ
c. Code for material, MX (see Table 1, footnote 1)
d. Code for any other marking, MU (see Table 1, footnote 2)

5.2 Designation Examples

5.2.1 Designation of a piston ring complying with the requirements of SAE J1997,

a. A straight faced rectangular ring (R)
b. Of nominal diameter d_1 = 90 mm (90)
c. And a nominal ring width h_1 = 2.5 mm (2.5)
d. Made of grey cast iron, nonheat-treated, material subclass 11 (MC11):
    1. Piston ring SAE J1997 R - 90 x 2.5 - MC11

5.2.2 Designation of a piston ring complying with the requirements of SAE J2000,

a. A keystone ring 6 degrees, taper faced (TM1)
b. Of nominal diameter d_1 = 105 mm (105)
c. And nominal ring width h_1 = 2.5 mm (2.5)
d. Made of spheroidal graphite cast iron, martensitic type, material subclass 51 (MC51)
e. Ring shape round (MZ)
f. With selected closed gap of 0.3 mm (S03)
g. Inside edges chamfered (KI)
h. Periphery chromium plated, with layer thickness 0.1 mm min (CR2):
    1. Piston ring SAE J2000 TM1 - 105 x 2.5 - MC51
    2. Z S03 KI CR2

5.2.3 Designation of a piston ring complying with the requirements of SAE J2003,

a. A coil spring loaded, bevelled edge oil control ring, chromium plated and profile ground (DSF-C)
b. Of nominal diameter d_1 = 125 mm (125)
c. And nominal ring width h_1 = 5 mm (5)
d. Made of grey cast iron, nonheat-treated, material subclass 11 (MC11)
e. A selected closed gap of 0.2 mm (S02)
f. A chromium layer thickness on the lands of 0.15 mm min (CR3)
g. Phosphated on all cast iron surfaces to a depth of 0.002 mm min (PO)
h. Reduced slot length (WK)
i. Coil spring with reduced heat set (WF)
j. And variable pitch with coil diameter d_1 ground (CSE)
k. Tangential force F_t according to the medium nominal contact pressure class (PNM)
l. And the ring marked with manufacturer's mark (MM):

    1. Piston ring SAE J2003 DSF-C-125 x 5 - MC11
    2. S02 CR3 PO WK WF CSE PNM MM

6. Marking of Piston Rings—The requirements and recommendations for piston ring marking in 6.1 and 6.2 apply to piston rings of 1.6 mm radial wall thickness and above. Marking of piston rings below 1.6 mm is at the choice of the manufacturer.

6.1 Mandatory Top Side Marking—All rings requiring orientation shall be marked to indicate the top side only, i.e., the side nearest to the combustion chamber.

In the absence of any other mark agreed on between manufacturer and purchaser, the mark TOP should be used.

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

a. All taper faced rings
b. All internally bevelled or stepped rings
c. All semi-inlaid rings
d. All scraper rings
e. All half keystone rings
f. All directional oil control rings

All such rings requiring marking are shown in the "common features" clause of the appropriate SAE Standards: J1997, J1998, J1999, J2000, J2001, J2002, and J2003.

6.2 Additional Marking—Additional marking of piston rings is optional or at the purchaser's request.

Such additional marking comprises the following:

a. Manufacturer's mark
b. Mark for required ring shape
c. Material mark (for alternative materials)
d. Any other additional mark agreed on between manufacturer and purchaser

7. General Characteristics

7.1 Ring Shape—Degrees of ovality only apply to rectangular rings (SAE J1997, J1998), scraper rings (SAE J1999), and keystone rings (SAE J2000, J2001). The forms of ovality are:

a. Positive ovality, i.e., standard without a code
b. Round, code MZ
c. Negative ovality, code MY

Values are given in Table 2.

TABLE 2—OVALITY

Dimensions in millimeters

Nominal Diameter d_1	Positive Ovality	Round(1)	Negative Ovality(2)
$30 \le d_1 < 60$	0 to +0.60	–0.30 to +0.30	–0.60 to 0
$60 \le d_1 < 100$	+0.05 to +0.85	–0.35 to +0.35	–0.70 to 0
$100 \le d_1 < 150$	+0.10 to +1.10	–0.45 to +0.45	–0.95 to –0.05
$150 \le d_1 \le 200$	+0.15 to +1.35	–0.50 to +0.50	–1.10 to –0.10

1. For taper faced coated and uncoated rings with lapped land, the recommended ring shape is round.
2. Not applicable for material class 10 of SAE J1590.

7.2 Light Tightness—At least 90% of the piston ring periphery shall be light tight.

Taper faced rings with coated and ground periphery without lapped land shall be at least 95% light tight.

The following piston ring designs shall be 100% light tight.

a. Uncoated piston rings with periphery fully lapped
b. Taper faced piston rings uncoated or coated with lapped land over the whole circumference but not over the whole width of the periphery
c. Piston rings with periphery chromium plated or molybdenum coated (fully faced, semi-inlaid, or inlaid design) with lapped land over the whole width of periphery

NOTE—In the case of piston rings with 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 defined in SAE J1589.

7.3 Closed Gap—Whenever the selected closed gap differs from that given in the dimensional tables of the specific International Standards, the codes in Table 3 apply and the tolerances remain the same.

TABLE 3—CLOSED GAP

Dimensions in millimeters

Code	Closed Gap
S00	0.05
S01	0.1
S02	0.2
S03	0.3
S04	0.4
S05	0.5
S06	0.6
S07	0.7
S08	0.8
S09	0.9
S10	1.0

7.4 Tangential Force, F_t, and Diametral Force, F_d, of Single Piece Piston Rings—The individual types of piston rings are given in SAE J1997, J1998, J1999, J2000, J2001, and J2002. The definitions of F_t and F_d are given in SAE J1589.

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 documents.

The values are calculated for the following:

a. The basic feature of each piston ring type
b. Nominal radial wall thickness, a_1, and mean ring width, h_1 or h_3
c. Piston ring material with a modulus of elasticity of 100 000 MPa
d. A ratio of total free gap to nominal diameter (m/d_1) according to Table 4

NOTE—The calculation of the tangential forces and diametral forces of the following:

e. Rectangular rings with narrow ring width made of steel (see SAE J1988)
f. Half keystone rings made of steel (see SAE J2001)

is based on a theoretical contact pressure of approximately 0.19 MPa.

The ratio m/d_1 is quite different to the values given in Table 4 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 = 52 to 57 mm).

TABLE 4—REGULAR RATIO OF TOTAL FREE GAP TO NOMINAL DIAMETER

d_1	m/d
$30 \le d_1 < 100$	$15\frac{1}{100}$
$100 \le d_1 \le 200$	$17 - \frac{2d_1}{100}\,\frac{1}{100}$

7.4.2 CORRECTION OF F_t AND F_d VALUES—The F_t and F_d values shall be corrected when:

a. Additional features such as rings with:

1. Coated periphery and/or
2. Inside chamfered edges and/or
3. Outside chamfered edges and/or
4. Taper and/or
5. Internal step or
6. Internal bevel

b. Piston ring materials with a modulus of elasticity other than 100 000 MPa
c. A ratio of total free gap to nominal diameter (m/d_1) other than that given in Table 4

The formula for the regular ratio of total free gap to nominal diameter (m/d_1 regular) is given in Table 4.

7.4.2.1 Multiplier Factors for Common Features—For common features, the necessary multiplier correction factors are tabulated in the dimensional documents SAE J1997, J1998, J1999, J2000, J2001, and J2002 under clause 5 "force factors".

7.4.2.2 Multiplier Force Correction Factors for Materials—For materials specified in SAE J1590, the force correction factors given in Table 5 are recommended.

7.4.2.3 Multiplier Force Correction Factors for Ratio m/d_1—Piston rings made of materials in classes 30 to 60 increase the tangential force and diametral force in relationship to the modulus of elasticity (see Table 5) when ratio m/d_1 regular is used.

For limitation of such increased forces, it is common to use reduced values of m/d_1. In Table 6 the recommended correction factors for m/d_1 regular and m/d_1 reduced are given.

For calculation of real values of ratio m/d_1 reduced, the factors given in Table 6 apply. Therefore, the values of m/d_1 calculated with the formula given in Table 4 have to be corrected with the correction factors in Table 6.

TABLE 5—MATERIAL FORCE CORRECTION FACTORS

Material Class	Material Force Correction Factor
10	0.9 to 1[1]
20	1.1 to 1.3[1]
30	1.45
40	1.6
50	1.6
60	2.0

1. Force correction factors for materials depend on the modulus of elasticity in the manufacturer's material specification. Equation 1:

$$\text{Correction factor} = \frac{\text{Typical modulus of elasticity in MPa}}{100\ 000\ \text{MPa}} \quad \text{(Eq. 1)}$$

TABLE 6—FORCE CORRECTION FACTORS FOR RATIO m/d_1

Material Class	Factor for m/d_1 Regular	Factor for m/d_1 Reduced[1]
10	1	—
20	1	—
30	1	0.825
40	1	0.75
50	1	0.75
60	—	0.75

1. Ratio m/d_1 reduced is given the code MR.

7.4.3 EXAMPLES FOR CORRECTION OF F_t AND F_d

7.4.3.1 Designation of Piston Ring

a. SAE J1997 B - 95 x 2.5 - MC53
b. MR CR2 IW

7.4.3.1.1 Multiplying Factors

a. 1.6 for material subclass 53
b. 0.75 for ratio m/d_1 reduced
c. 0.85 for periphery chromium plated CR2
d. 0.78 for internal step

7.4.3.1.2 Calculation

Total force correction factor:

$$1.6 \times 0.75 \times 0.85 \times 0.78 = 0.796 \quad \text{(Eq. 2)}$$

Basic values F_t and F_d according to J1997:

$$F_t = 18.5\ \text{N and } F_d = 39.8\ \text{N} \quad \text{(Eq. 3)}$$

Corrected values:

$F_t = 0.796 \times 18.5\ N \pm 20\%$
$F_t = 14.7\ N \pm 20\%$
$F_t = 11.8$ to $17.6\ N$

and

$F_d = 0.796 \times 39.8\ N \pm 20\%$
$F_d = 31.7\ N \pm 20\%$
$F_d = 25.6$ to $38\ N$

7.4.3.2 Designation of Piston Ring

a. SAE J1999 N - 70 x 2 D22 - MC24/MO2

7.4.3.2.1 Multiplying Factors

1.15 for material subclass 24
0.86 for periphery molybdenum coated MO2F (inlaid type)

7.4.3.2.2 Calculation

Total force correction factor:

$$1.15 \times 0.86 = 0.989 \quad \text{(Eq. 4)}$$

Basic values F_t and F_d according to SAE J2000:

$$F_t = 9.2\ \text{N and } F_d = 19.8\ \text{N} \quad \text{(Eq. 5)}$$

Corrected values:

$F_t = 0.989 \times 9.2\ N \pm 30\%$
$F_t = 9.1\ N \pm 30\%$
$F_t = 6.4$ to $11.8\ N$

and

$F_d = 0.989 \times 19.8\ N \pm 30\%$
$F_d = 19.6\ N \pm 30\%$
$F_d = 13.7$ to $25.5\ N$

7.4.3.3 Designation of Piston Ring

a. SAE J2000 KB - 140 x 4 - MC42/MO4 KI

7.4.3.3.1 Multiplying Factors

a. 1.6 for material subclass 42
b. 0.83 for periphery molybdenum coated MO4 (fully faced type)
c. 0.96 for inside chamfered edges KI

7.4.3.3.2 Calculation

Total force correction factor:

$$1.6 \times 0.83 \times 0.96 = 1.275 \quad \text{(Eq. 6)}$$

Basic values F_t and F_d according to SAE J2000:

$$F_t = 29.3 \text{ N and } F_d = 63 \text{ N} \quad \text{(Eq. 7)}$$

Corrected values:

$F_t = 1.275 \times 29.3 \text{ N} \pm 20\%$
$F_t = 37.4 \text{ N} \pm 20\%$
$F_t = 29.9 \text{ to } 44.9 \text{ N}$

and

$F_d = 1.275 \times 63 \text{ N} \pm 20\%$
$F_d = 80.3 \text{ N} \pm 20\%$
$F_d = 64.2 \text{ to } 96.4 \text{ N}$

7.4.3.4 Designation of Piston Ring

a. SAE J2002 G - 120 x 5 - MC11/KI

7.4.3.4.1 Multiplying Factors

a. 0.9 for material subclass 11
b. 0.98 for inside chamfered edges KI

7.4.3.4.2 Calculation

Total force correction factor:

$$0.9 \times 0.98 = 0.882 \quad \text{(Eq. 8)}$$

Basic values F_t and F_d according to SAE J2002:

$$F_t = 24.7\ \text{N and } F_d = 53.1\ \text{N} \quad \text{(Eq. 9)}$$

Corrected values:

$F_t = 0.882 \times 24.7\ \text{N} \pm 20\%$
$F_t = 21.8\ \text{N} \pm 20\%$
$F_t = 17.4$ to $26.2\ \text{N}$

and

$F_d = 0.882 \times 53.1\ \text{N} \pm 20\%$
$F_d = 46.8\ \text{N} \pm 20\%$
$F_d = 37.4$ to $56.2\ \text{N}$

7.5 Tangential Force F_t of Multipiece Oil Control Rings as Specified in SAE J2003—The tangential force of a coil spring loaded oil control ring depends on:

a. Piston ring type
b. Class of nominal contact pressure
c. Specific tangential force F_{tc} for unit contact pressure of 1 MPa

The values for nominal contact pressure and specific tangential forces are tabulated in SAE J2003.

The formula for calculating the actual tangential force is also given in SAE J2003.

7.5.1 EXAMPLES FOR CALCULATING THE TANGENTIAL FORCE F_t

7.5.1.1 Designation of Piston Ring

SAE J2003 DSF-C - 100 x 4 - MC11/CR1 CSG PNM

7.5.1.1.1 Pressure Class and Specific Tangential Force

a. Class of nominal contact pressure:
   1. PNM = 1.49 MPa

b. Specific tangential force for unit contact pressure of 1 MPa:
   1. $F_{tc} = 40.4\ \text{N}$

7.5.1.1.2 Calculation[2]

$$\text{Tangential force, } F_t = 1.49 \times 40.4 \text{ N} \pm 20\%$$
$$F_t = 60.2 \text{ N} \pm 20\% \qquad \text{(Eq. 10)}$$
$$F_t = 48 \text{ to } 72\text{N}$$

7.5.1.2 Designation of Piston Ring

a. SAE J2003 SSF - 175 x 6 MC11/CSG PNE

7.5.1.2.1 Pressure Class and Specific Tangential Force

a. Class of nominal contact pressure:
   1. PNE = 0.59 MPa

b. Specific tangential force for unit contact pressure of 1 MPa:
   1. F_{tc} = 192.5 N

7.5.1.2.2 Calculation[2]

$$\text{Tangential force, } F_t = 0.59 \times 192.5 \text{ N} \pm 20\%$$
$$F_t = 113.6 \text{ N} \pm 20\% \qquad \text{(Eq. 11)}$$
$$F_t = 91 \text{ to } 136 \text{ N}$$

8. Notches to Prevent Ring Rotation

8.1 Ring Joint With Internal Notch (only for compression rings of types R, B, M, T, K, and HK) (see Figure 1)—See Tables 7 and 8 for dimensions.

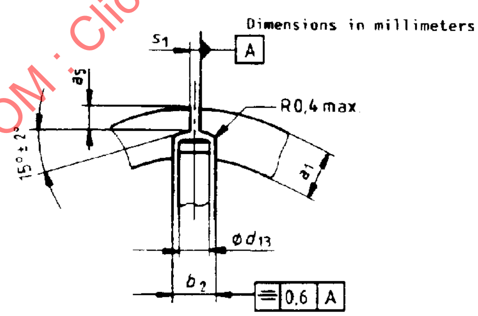

FIGURE 1—INTERNAL NOTCH

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

   $F_t < 50$ N to the nearest 0.5 N
   $F_t \geq 50$ N to the nearest 1 N, where 0.5 N is to be rounded up

TABLE 7—DIMENSIONS OF INTERNAL NOTCH

Dimensions in millimeters

Code	Pin Diameter d_{13}	Notch b_2	Notch Tol.	Notch r_6	Notch Tol.
NH1	1.5	2		0.8	
NH2	2	2.5	+0.2	0.9	±0.1
NH3	2.5	3	−0.1	1	

$b_2 - d_{13} > s_1$ nom.

NOTE—r_6 applies only to notch design according to Figure 2.

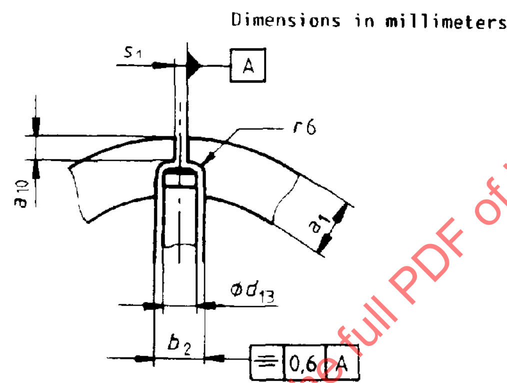

FIGURE 2—INTERNAL NOTCH—OPTION FOR PISTON RINGS WITH RADIAL WALL THICKNESS $a_1 > 2.1$

TABLE 8—WIDTH OF OVERLAP a_5 AND OPTIONAL a_{10} FOR INTERNAL NOTCH

Dimensions in millimeters

Radial Wall Thickness a_1	Overlap a_5	Overlap Tol.	Overlap a_{10}	Overlap Tol.
$1.5 \le a_1 < 2.1$	0.6		—	—
$2.1 \le a_1 < 2.7$	0.7		0.6	
$2.7 \le a_1 < 3.1$	1		0.7	
		±0.1		±0.1
$3.1 \le a_1 < 3.5$	1.2		0.8	
$3.5 \le a_1 < 3.9$	1.4		0.9	
$3.9 \le a_1 \le 4.1$	1.6		1	

8.2 Ring Joint With Side Notch (see Figure 3)—See Table 9 for dimensions.

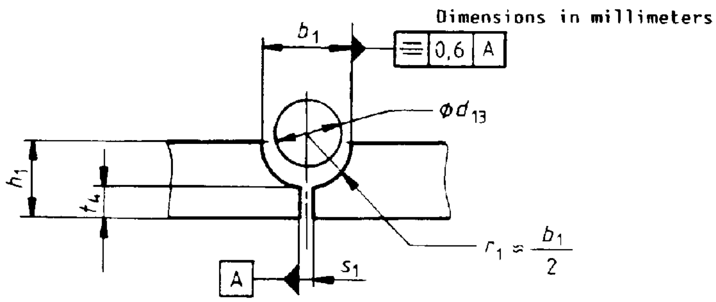

FIGURE 3—SIDE NOTCH

TABLE 9—DIMENSIONS OF SIDE NOTCH

Dimensions in millimeters

Code	Ring Width h_1	Pin Diameter d_{13}	Notch[(1)] b_1	Notch[(1)] Tol.	Notch[(1)] t_4	Notch[(1)] Tol.
	1.2[(2)]				0.5	
	1.5				0.7	
NE1	1.75	1.5	2		0.95	
	2				1.2	
	2.5				1.7	
				–0.2		0
	2			–0.1	0.9	–0.15
NE2	2.5	2	2.5		1.4	
	2.5				1	
NE3	3	2.5	3		1.5	

1. $b_1 - d_{13} > s_1$ nom.
2. Not applicable for material class 10 in SAE J1590.

9. Machining and Coating Surfaces

9.1 Machining of Periphery—Where normal standards of machining are required, no code is needed for identification.

These normal standards are:

a. All uncoated rings—periphery fine turned
b. Rectangular or keystone rings with coated periphery, straight or barrel faced and chromium coated oil control rings and chromium plated segments of expander/segment oil control rings—machine (ground or lapped) over full face
c. Rectangular or keystone rings with coated periphery, taper faced—witness machining on part of width only

NOTE—Roughness values and measurement method may be agreed on between manufacturer and purchaser as there is no standard method available that is applicable in all cases.

9.2 Machining of Side Faces—The standard method of machining is by grinding of side faces; no code is required.

The standard side face finish is R_z 4 or R_a 0.8.

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

9.3 Coatings on Periphery—Codes are required when chromium or molybdenum coatings are used as specified in the dimensional documents.

9.3.1 CHROMIUM COATING—LAYER THICKNESS

a. CRF—Thickness 0.005 mm min
b. CR1—Thickness 0.05 mm min
c. CR2—Thickness 0.1 mm min
d. CR3—Thickness 0.15 mm min
e. CR4—Thickness 0.2 mm min

9.3.1.1 Chromium Coated Rings of Fully Faced Design—(See Figure 4.)

a. Code CRF to CR4

Piston rings with chromium coated periphery are normally designed fully faced.

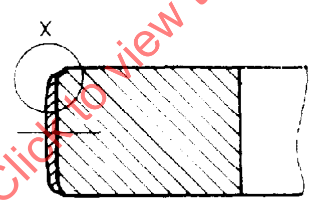

FIGURE 4—CHROMIUM COATED RING OF FULLY FACED DESIGN, CODE CRF TO CR4

9.3.1.2 Chromium Coated Rings of Semi-Inlaid Design—(See Figure 5 and Figure 6.)

a. Code CR1E to CR4E

NOTE—This ring design needs a minimum chromium thickness CR1.

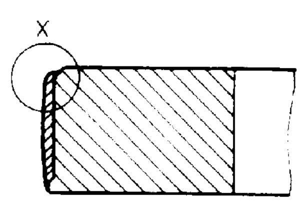

FIGURE 5—CHROMIUM COATED RING OF SEMI-INLAID DESIGN, CODE CR1E TO CR4E

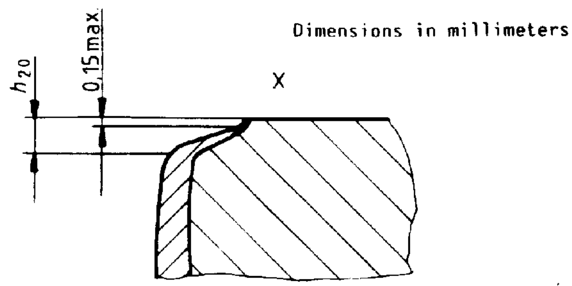

FIGURE 6—DESIGN OF PERIPHERAL EDGE
(DETAIL OF Figures 4 AND 5)

9.3.1.3 Chromium Coated Rings of Inlaid Design

a. Code CR1F to CR4F

NOTE—This ring design needs a minimum chromium thickness CR1.

9.3.2 MOLYBDENUM COATING—LAYER THICKNESS

a. MO1—Thickness 0.05 mm min
b. MO2—Thickness 0.1 mm min
c. MO3—Thickness 0.15 mm min
d. MO4—Thickness 0.2 mm min

9.3.2.1 Molybdenum Coated Rings of Fully Faced Design

a. Code MO1 to MO4

9.3.2.2 Molybdenum Coated Rings of Semi-Inlaid Design

a. Code MO1E to MO4E

9.3.2.3 Molybdenum Coated Rings of Inlaid Design

a. Code MO1F to MO4F

9.4 Designation of Edges of Chromium Coated Rings—See Table 10 for dimensions.

TABLE 10—AXIAL DIMENSIONS, h_{20}, OF PERIPHERAL EDGES OF CHROMIUM PLATED RINGS, FULLY FACED AND UPPER PERIPHERAL EDGE OF CHROMIUM PLATED RINGS, SEMI-INLAID[(1)]

Dimensions in millimeters

Ring Width h_1	Axial Dimension h_{20} max
$1.2 \leq h_1 \leq 3.5$	0.3
$3.5 < h_1 \leq 4.5$	0.4

1. Values do not apply to chromium plated oil control rings.