SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
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SURFACE VEHICLE RECOMMENDED PRACTICE

Submitted for recognition as an American National Standard

SAE J2001

Issued 1990-09

INTERNAL COMBUSTION ENGINES - PISTON RINGS - HALF KEYSTONE RINGS

This document is equivalent to ISO Standard 6624/2

1. SCOPE AND FIELD OF APPLICATION:

Differences, where they exist, are shown in Appendix A.

This SAE Recommended Practice specifies the essential dimensional features of HK- and HKB- half keystone rings with narrow ring width types.

Dimensional Tables 6 and 7 allow for the use of cast iron (Table 6) or steel (Table 7). Since the modulus of elasticity of steel rings is higher than that of cast iron rings, the fluctuation in the surface pressure will become greater if the free gap is set as the reference for forces. Therefore, forces are set using the surface pressure as the reference in order to minimize the effect of the fluctuation.

The requirements of this document apply to half keystone rings of reciprocating internal combustion engines up to and including 70 mm diameter for cast iron rings and up to and including 100 mm diameter for steel rings.

2. REFERENCES:

SAE DESIGNATION	ISO* 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
J1996	6621/5	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 - COIL SPRING LOADED OIL CONTROL RINGS
J2004	6627 TR	INTERNAL COMBUSTION ENGINES - EXPANDER/SEGMENT OIL CONTROL RINGS
	1101	TECHNICAL DRAWINGS - GEOMETRICAL TOLERANCING - TOLERANCING OF FORM, ORIENTATION, LOCATION AND RUN-OUT - GENERALITIES, DEFINITIONS, SYMBOLS INDICATIONS ON DRAWINGS

*TR refers to Technical Report

3. RING TYPES AND DESIGNATION EXAMPLES:

NOTE: For the angle of half keystone rings, the same definition and measurement apply as for keystone rings: see SAE J1589.

3.1 Type HK - Straight Faced Half Keystone Ring 7 Degrees:

3.1.1 General Features:

NOTE: See Table 6 or 7 for dimensions and forces.

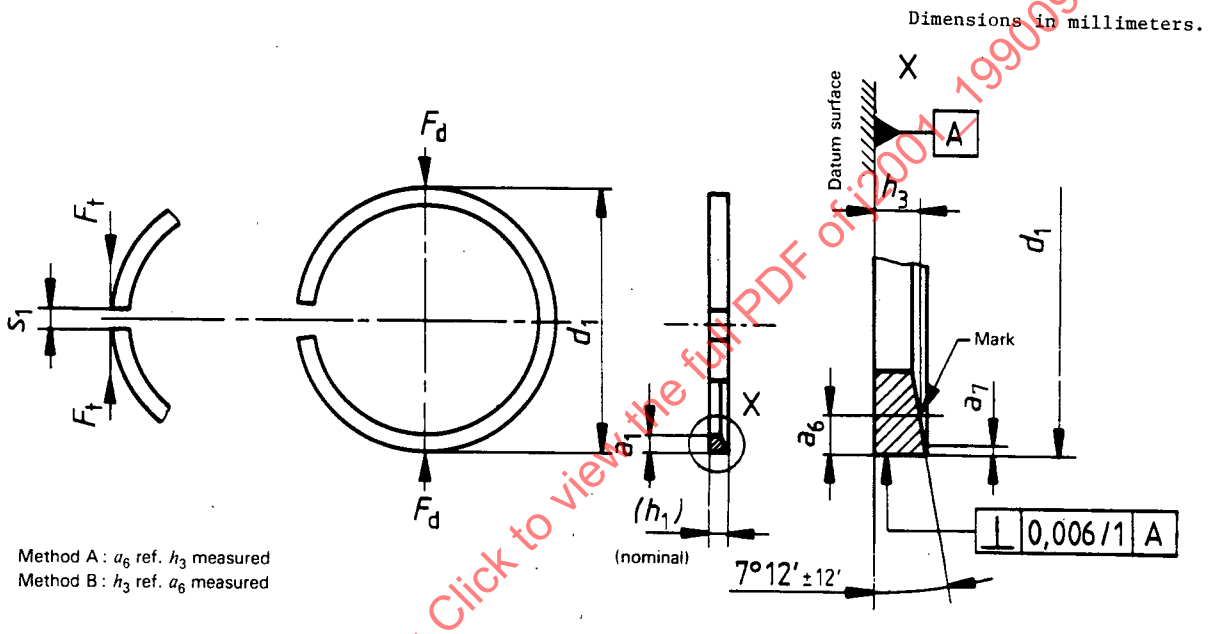


FIGURE 1 - Type HK

3.1.2 Designation Example: Designation of a straight faced half keystone ring 7 degrees of d_1 = 60 mm nominal diameter, h_1 = 1.25 mm ring width, made of steel (material subclass 62), general features as shown in Figure 1, and periphery chromium coated fully faced design 0.1 mm minimum thickness:

a. Piston ring SAE J2001 HK-60 x 1.25-MC62/CR2

3.2 Type HKB - Barrel Faced Half Keystone Ring 7 Degrees:

3.2.1 General Features:

NOTE: See Table 6 or 7 for dimensions and forces.

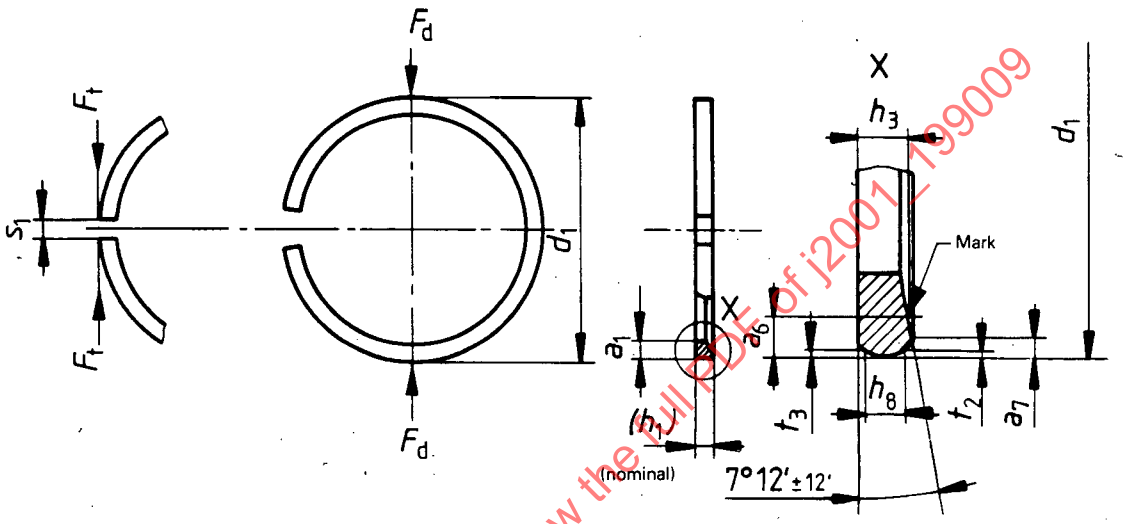


FIGURE 2 - Type HKB

TABLE 1 - Gauge Width (h_8) and Barrel Dimensions

Dimensions in millimeters

h_1	h_8	t_2, t_3		Maximum peak off center
1.25	0.6	0.001	0.013	0.2
1.55	0.8	0.002	0.016	0.25

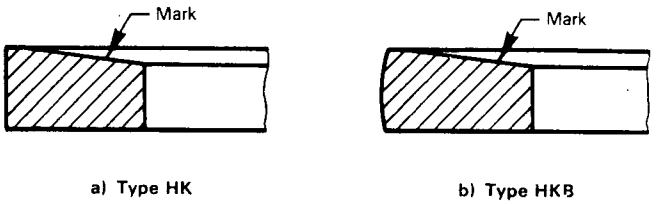
3.2.2 Designation Example: Designation of a barrel faced half keystone ring 7 degrees of d_1 = 60 mm nominal diameter, h_1 = 1.25 mm ring width, made of steel (material subclass 62), general features as shown in Figure 2 and Table 1, and periphery molybdenum coated inlaid design 0.1 mm minimum thickness:

a. Piston ring SAE J2001 HKB-60 x 1.25-MC62/MO2

4. COMMON FEATURES:

4.1 Types HK and HKB - Half Keystone Ring: (See Figures 3 to 6.)

4.1.1 Uncoated Rings:

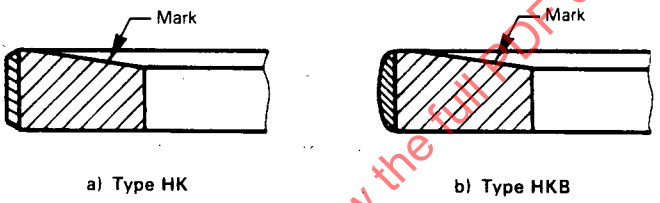


a) Type HK b) Type HKB

FIGURE 3 - Uncoated Rings

4.1.2 Coated Rings (Chromium or Molybdenum):

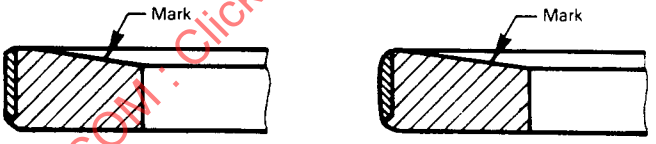
4.1.2.1 Fully Faced:



a) Type HK b) Type HKB

FIGURE 4 - Fully Faced Coated Rings

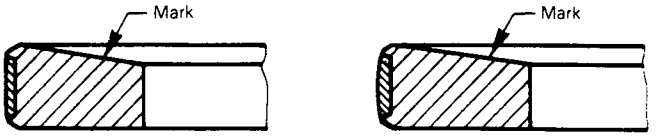
4.1.2.2 Semi-Inlaid:



a) Type HK b) Type HKB

FIGURE 5 - Semi-Inlaid Coated Rings

4.1.2.3 Inlaid:



a) Type HK b) Type HKB

FIGURE 6 - Inlaid Coated Rings

4.2 Chamfered Edges (Cast Iron Rings):

4.2.1 HK and HKB Rings - Outside Chamfered Edges (KA): (See Figures 7 to 9.) See Table 2 for dimensions.

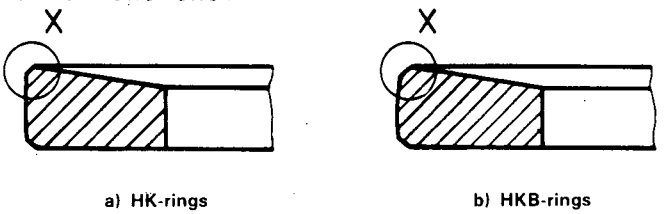


FIGURE 7 - Outside Chamfered Edges (KA)

4.2.2 HK and HKB Rings - Inside Chamfered Edges (KI):

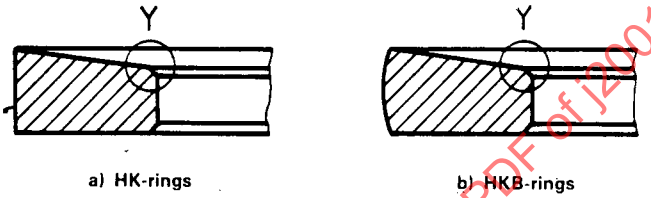


FIGURE 8 - Inside Chamfered Edges (KI)

4.2.3 HK and HKB Rings - Outside and Inside Chamfered Edges (KA + KI):

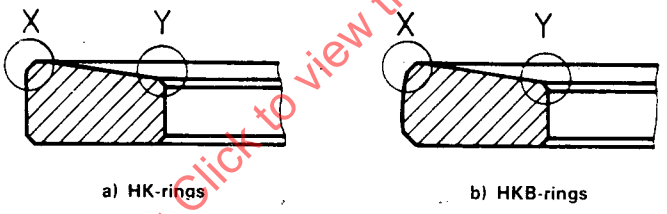


FIGURE 9 - Outside and Inside Chamfered Edges (KA + KI)

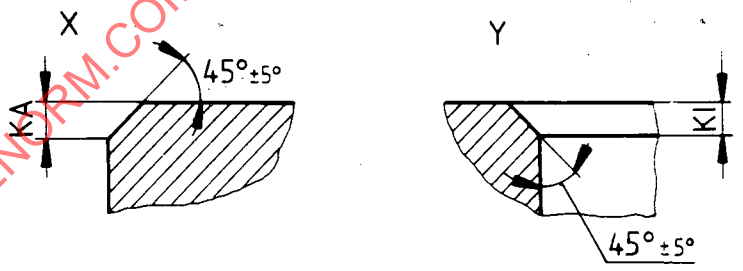


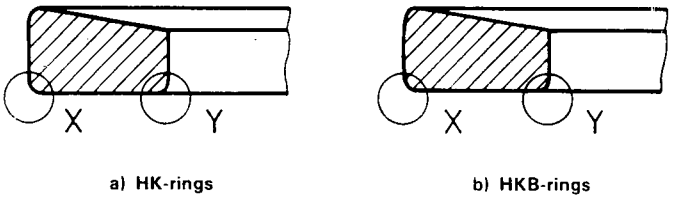
FIGURE 10 - Details of Figures 7, 8, and 9

TABLE 2 - KA and KI Dimensions

Dimensions in millimeters

KA	KI
0.15 ± 0.1	max 0.2

4.3 HK and HKB Steel Rings - Outside and Inside Rounded Edges: (See Figure 11.)



a) HK-rings b) HKB-rings

FIGURE 11 - Outside and Inside Rounded Edges

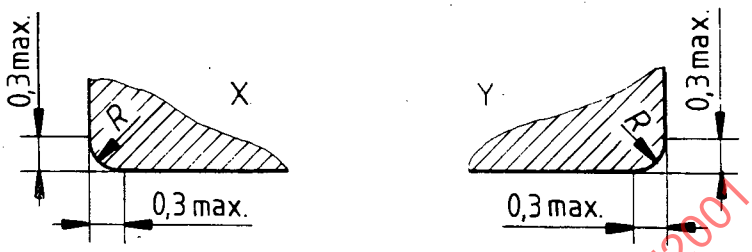
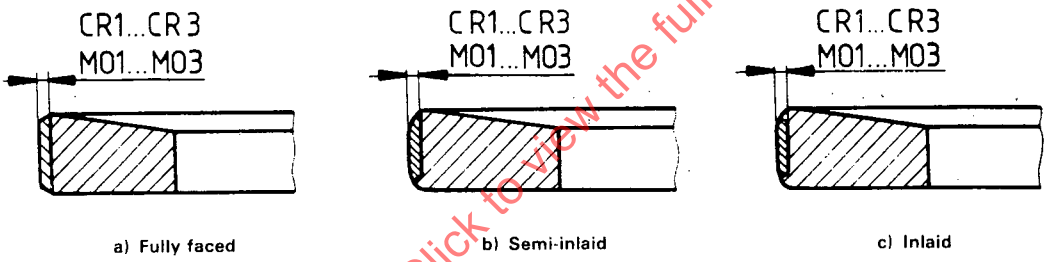


FIGURE 12 - Details of Fig. 11

4.4 HK and HKB Rings (Fully Faced, Semi-Inlaid and Inlaid) - Layer Thickness: (See Figure 13.) See Table 3 for dimensions.



a) Fully faced b) Semi-inlaid c) Inlaid

FIGURE 13 - Layer Thickness

TABLE 3 - Layer Thickness

Dimensions in millimeters

Chromium	Molybdenum	Thickness min
CR1	MO1	0.05
CR2	MO2	0.1
CR3[1]	MO3[1]	0.15

[1]CR3 and MO3 apply to rings with nominal diameters of 50 mm or greater.

5. FORCE FACTORS:

The tangential and diametral forces given in Table 6 shall be corrected when additional features and/or materials other than grey cast iron with a modulus of elasticity of 100 000 MPa are being used.

For common features, multiplier correction factors given in Tables 4 and 5 and the force correction factors given in SAE J1591 shall be used. Also, the tangential and diametral forces given in Table 7 shall be corrected when additional features are being used.

TABLE 4 - Force Correction Factors for HK and HKB Rings With Features KA and KI

Factor		
KA	KI	KA and KI
0.98	0.98	0.96

TABLE 5 - Force Correction Factors for Coated HK and HKB Rings (Fully Faced, Semi-Inlaid, and Inlaid Types)

d_1 (reference coating) mm	Factor				
	CR1	CR2/MO1	CR3	MO2	MO3
$38 < d_1 < 50$	0.81	0.7	-	0.64	-
$50 < d_1 < 100$	0.9	0.85	0.81	0.81	0.75

TABLE 6 - Dimensions of HK and HKB Half Keystone Rings With Narrow Ring Width Made of Cast Iron

Dimensions in millimeters.

Nominal diameter d_1	Radial wall thickness a_1	Tolerance	Ring width nominal value For h_1 shown in column 1	2	Method A a_6 (ref.)	a_7	Measured value For h_3 shown in column 1	Tolerance	2	Tolerance	Method B h_3 (ref.) Column 1	2	Measured value a_6	Tolerance	a_7	Closed gap s_1	Tolerance	Tangential force F_t, N For h_1 shown in column 1	2	Tolerance	Diametral force F_d, N For h_1 shown in column 1	2	Tolerance
38	1,6	± 0,15 Within a ring: 0,15 max.	1,25	1,55	0,8	0,5 max.	1,143	0 -0,024 For phosphated PO surface: +0,01 -0,024	1,393	0 -0,024 For phosphated PO surface: +0,01 -0,024	1,13	1,41	0,91	0 -0,19 For phosphated PO surface: +0,08 -0,19	0,5 max.	0,15	+0,2 0			± 30 %	7,2		± 30 %
39	1,65																				7,6		
40	1,65				1		1,118		1,418		1,11	1,41	1,06								7,2		
41	1,7																				7,6		
42	1,75																				7,8		
43	1,8																				8,2	10,5	
44	1,85																				8,3	10,8	
45	1,9																				8,5	11,2	
46	1,9																				8,3	10,6	
47	1,95																				8,5	10,9	
48	2																				8,9	11,4	
49	2,05																				9	11,8	
50	2,1				1,2		1,093		1,393		1,08	1,38	1,3					4,4	5,6		9,4	12,1	
51	2,15																	4,5	5,8		9,6	12,5	
52	2,15																	4,3	5,5		9,2	11,9	
53	2,2																	4,5	5,7		9,6	12,3	
54	2,25																	4,6	5,9		9,7	12,7	
55	2,3																	4,7	6		10,1	13	
56	2,35																	4,9	6,2		10,4	13,4	
57	2,4																	4,9	6,4		10,5	13,8	
58	2,4																	4,7	6,2		10,1	13,4	
59	2,45																	4,9	6,4		10,5	13,8	
60	2,5																	5	6,5		10,7	14	
61	2,55																	5,1	6,7		10,9	14,4	
62	2,6																	5,3	6,9		11,3	14,8	
63	2,65																	5,4	7		11,7	15	
64	2,65																	5,3	6,7		11,3	14,4	
65	2,7					0,6 max.	1,09		1,39		1,08	1,38	1,28		0,6 max.	0,2		5,3	6,9		11,5	14,8	
66	2,75																	5,5	7,1		11,7	15,3	
67	2,8																	5,5	7,3		11,9	15,6	
68	2,85																	5,7	7,5		12,3	16	
69	2,9																	5,7	7,6		12,4	16,2	
70	2,9				1,5		1,053		1,353		1,04	1,34	1,6					5,6	7,3		12	15,7	

NOTES

[1]For intermediate sizes (for example repair sizes), the radial wall thickness of the next smaller nominal diameter shall be applied.

[2]The values for F_t and F_d, given in Table 6, apply to as-cast grey cast iron with a typical modulus of elasticity (E_n) of 100 000 MPa. Multiplying factors for materials having a different modulus of elasticity (E_n) are given in ISO 6621/4. Mean forces are calculated for nominal radial wall thickness (a_1) and mean ring width (h_1).

[3]For the sole purpose of this document, the assumed average ratio F_d/F_t is 2.15. However, for rings up to 50 mm the ratio F_d/F_t shall be determined between manufacturer and client.

TABLE 7 – Dimensions of HK and HKB Half Keystone Rings With Narrow Ring Width Made of Steel

Dimensions in millimeters.

Nominal diameter d_1	Radial wall thickness a_1		Ring width nominal value For h_1 shown in column		Method A					Method B				Closed gap s_1		Tangential force F_t, N			Diametral force F_d, N		
					a_6 (ref.)	a_7	Measured value For h_3 shown in column 1		Measured value For h_3 shown in column 2		h_3 (ref.) Column		Measured value a_6		a_7			For h_1 shown in column			For h_1 shown in column		
		Tolerance	1	2				Tolerance		Tolerance	1	2		Tolerance			Tolerance	1	2	Tolerance	1	2	Tolerance
38	1,5	± 0,15 Within a ring: 0,15 max.	1,25	1,55	0,8	0,5 max.	1,143	0 −0,024	1,393	0 −0,024	1,13	1,08	0,91	0 −0,19	0,5 max.	0,15	+0,2 0	5,3	6,7	± 30 % if F_t < 10 N ± 20 % if F_t > 10 N	8,8		± 30 % if F_d < 21,5 N ± 20 % if F_d > 21,5 N
39																		5,4	6,8		9,1		
40					1		1,118		1,418		1,11	1,38	1,06					5,5	6,9		9,3		
41																		5,6	7,1		9,5		
42	1,7																	5,7	7,1		9,7		
43																		5,8	7,2		9,8	12,6	
44																		5,9	7,4		10	12,8	
45																		6	7,5		10,5	13	
46																		6	7,6		10,6	13,4	
47	1,9																	6,1	7,7		10,8	13,6	
48																		6,2	8		10,9	13,9	
49																		6,3	8,1		11,1	14,1	
50					1,2		1,093		1,393		1,08	1,38	1,3					6,4	8,2		11,3	14,3	
51																		6,5	8,3		11,6	14,7	
52	2,1																	6,6	8,4		11,8	14,9	
53																		6,6	8,6		12	15,1	
54																		6,7	8,6		12,2	15,3	
55																		6,8	8,7		12,4	15,6	
56																		6,8	8,8		12,6	16	
57																		7	8,9		12,8	16,2	
58																		7,1	9,1		12,9	16,4	
59	2,3																	7,2	9,2		13,1	16,6	
60						0,6 max.	1,09		1,39		1,08	1,38	1,28		0,6 max.	0,2		7,3	9,3		13,2	17,2	
61																		7,3	9,4		13,6	17,4	
62																		7,4	9,5		13,9	17,6	
63	2,5																				13,9	17,8	
64																					14,1	18	
65																					14,3	18,4	
66																					14,5	18,6	
67																					14,7	18,8	
68																					14,7	19	
69	2,7																				15,1	19,2	
70					1,5		1,053		1,353		1,04	1,34	1,6								15,3	19,6	
71																					15,5	19,8	
72																					15,7	20	
73	2,9																				15,7	20,1	
74																					15,8	20,4	

TABLE 7 (Concluded)

Dimensions in millimeters.

Nominal diameter d_1	Radial wall thickness a_1		Ring width nominal value For h_1 shown in column		Method A a_6 (ref.)	Method A a_7	Method A Measured value For h_3 shown in column 1		Method A Measured value For h_3 shown in column 2		Method B h_3 (ref.) Column		Method B Measured value a_6		Method B a_7	Closed gap s_1		Tangential force F_t, N For h_1 shown in column			Diametral force F_d, N For h_1 shown in column		
		Tolerance	1	2				Tolerance		Tolerance	1	2		Tolerance			Tolerance	1	2	Tolerance	1	2	Tolerance
75	2,9	± 0,15 Within a ring: 0,15 max.	1,25	1,55	1,5	0,6 max.	1,053	0 −0,024	1,353	0 −0,024	1,04	1,34	1,6	0 −0,19	0,6 max.	0,25	+0,25 0	7,5	9,6	± 30 % if F_t < 10N ± 20 % if F_t > 10N	16,1	20,7	± 30 % if F_d < 21,5N ± 20 % if F_d > 21,5N
76																		7,6	9,7		16,3	20,9	
77																		7,7	9,8		16,6	21,1	
78																		7,7	10		16,6	21,6	
79																		7,8	10,1		16,8	21,7	
80	3,1																	7,9	10,3		17,1	22,1	
81																		8	10,4		17,2	22,3	
82																		8,1	10,6		17,4	22,7	
83																		8,1	10,5		17,4	22,7	
84																		8,2	10,6		17,6	22,9	
85	3,3																	8,4	10,8		17,9	23,2	
86																		8,4	10,9		18,2	23,4	
87																		8,5	11,1		18,4	23,8	
88																		8,5	11		18,3	23,8	
89																		8,6	11,1		18,5	23,9	
90	3,5																		11,3			24,3	
91																			11,4			24,5	
92																			11,6			24,9	
93																			11,5			24,8	
94																			11,6			25	
95	3,7				2				1,289			1,28	2,07			0,3			11,8			25,3	
96																			11,9			25,5	
97																			12,1			26	
98																			12,1			26,1	
99	3,9																		12,2			26,3	
100																			12,4			26,7	

NOTES

[1]For intermediate sizes (for example repair sizes), the radial wall thickness of the next smaller nominal diameter shall be applied.

[2]The values for F_t and F_d, given in Table 7, apply to steel with a typical modulus of elasticity (E_n) of 200 000 MPa. Mean forces are calculated for nominal radial wall thickness (a_1) and mean ring width (h_1).

[3]For the sole purpose of this document, the assumed average ratio F_d/F_t is 2.15. However, for rings up to 50 mm the ratio F_d/F_t shall be determined between manufacturer and client.

APPENDIX A

A.1 This document has been established to harmonize the ISO and SAE piston ring documents. The U.S. Technical Advisory Group, with the support of the National Engine Parts Manufacturers Association, has worked with other national organizations on this worldwide document. Some of the wording and phrasing may differ slightly from U.S. terminology for translation purposes.

In preparing this SAE document, the Scope and Field of Application, and Reference sections of the ISO 6624/2 have been editorially revised and reorganized.

Certain of the barrel drop (Table 1) dimensions were changed to comply with established U.S. standard practice.

The tolerances specified in this document represent a six sigma quality level.