The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

SURFACE VEHICLE STANDARD

SAE J2000

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Superseding J2000 OCT92

Submitted for recognition as an American National Standard

Internal Combustion Engines—Piston Rings—Keystone Rings

This SAE Standard is equivalent to ISO Standard 6624/1.

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

This SAE Standard specifies the essential dimensional features of T, TB, TM, K, KB, and KM keystone piston ring types.

The requirements of this document apply to compression rings for reciprocating internal combustion engines up to and including 200 mm diameter.

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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

1. TR refers to Technical Report

3. *Ring Types and Designation Examples*

3.1 Type T—Straight Faced Keystone Ring 6 Degrees

3.1.1 GENERAL FEATURES

NOTE—See Table 7 for dimensions and forces.

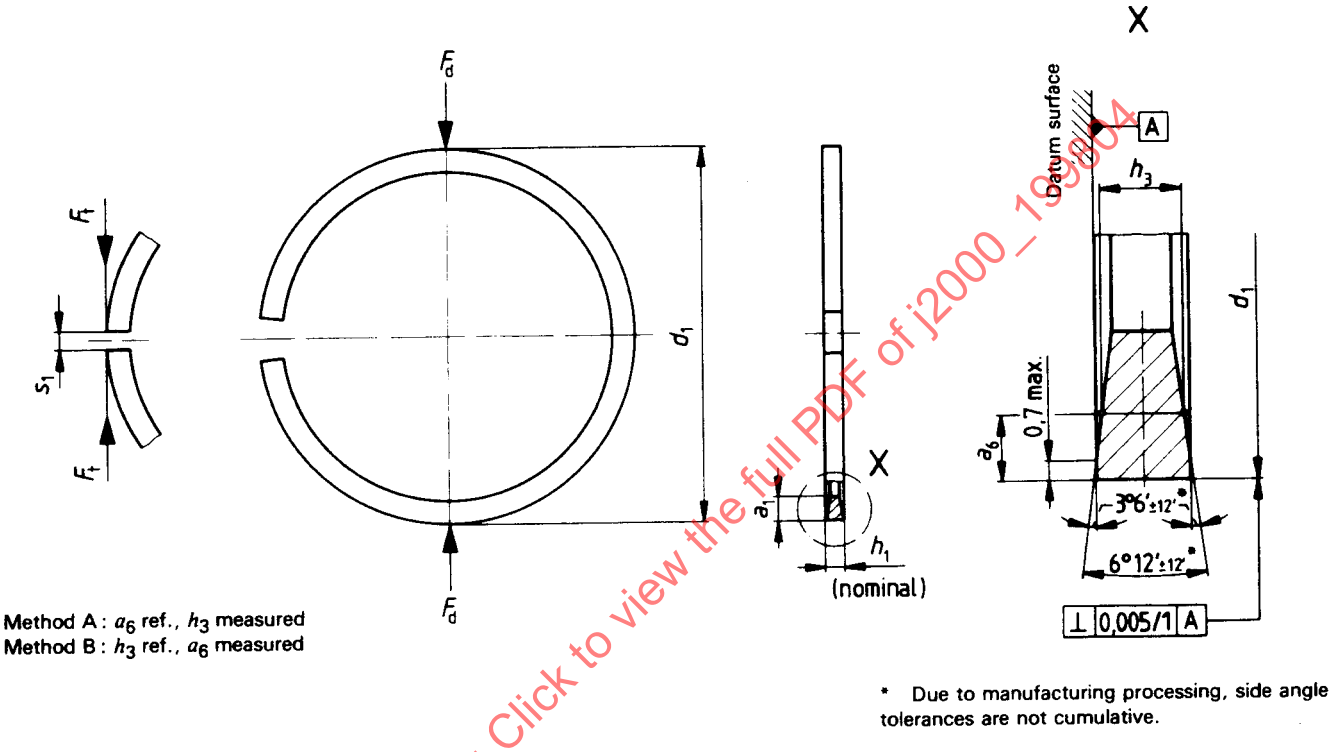


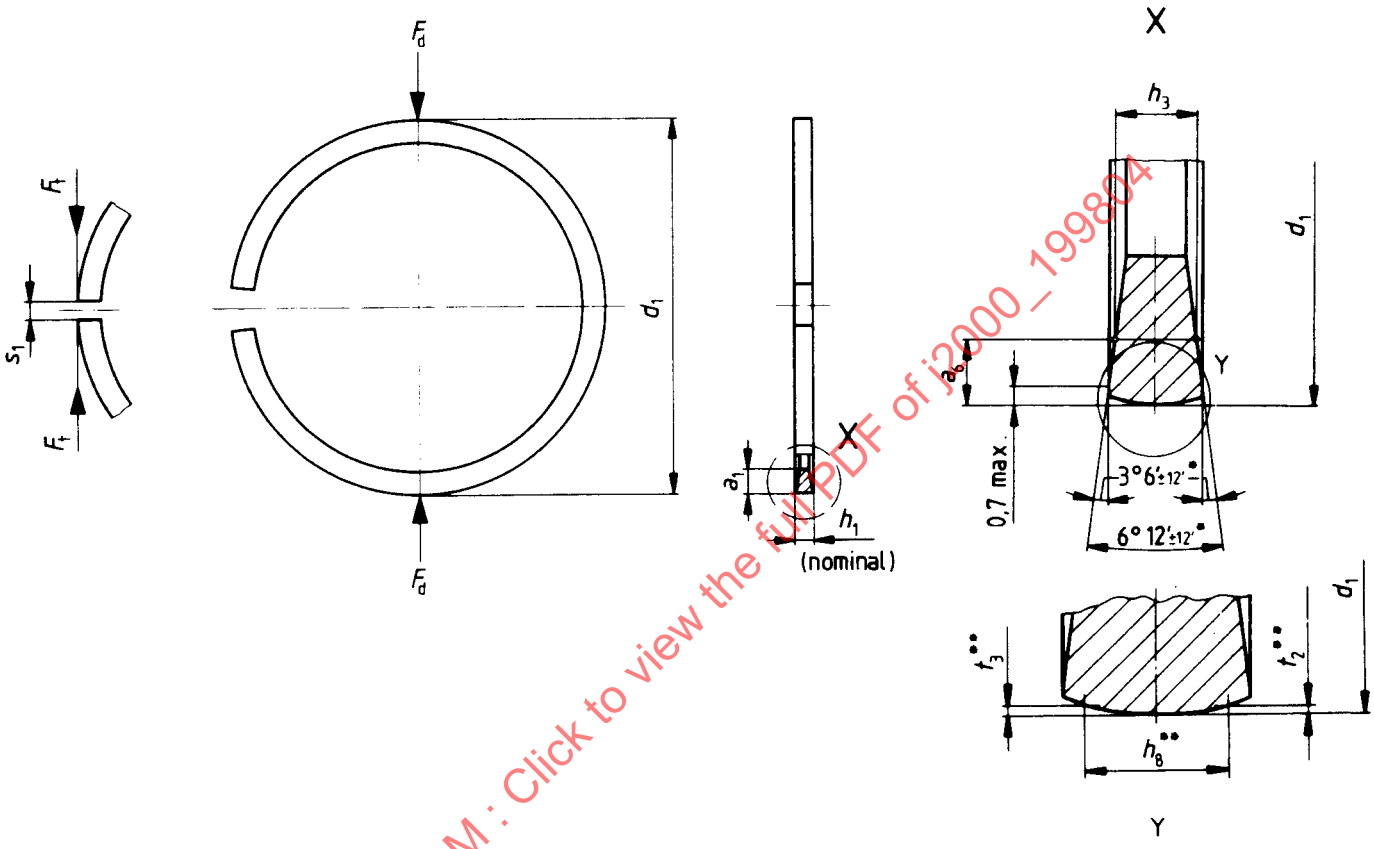
FIGURE 1—TYPE T

3.1.2 DESIGNATION EXAMPLE—Designation of a straight faced keystone ring 6 degrees, of d_1 = 90 mm nominal diameter, h_1 = 2.5 mm ring width, made of grey cast iron, nonheat-treated (material subclass 12), general features as shown in Figure 1, and periphery coated fully faced with chromium, 0.10 mm minimum thickness.

3.2 Type TB — Barrel Faced Keystone Ring 6 Degrees

3.2.1 General Features

NOTE—See Table 7 for dimensions and forces.



Method A : a_6 ref., h_3 measured
Method B : h_3 ref., a_6 measured

* Due to manufacturing processing, side angle tolerances are not cumulative.

** See Table 1.

FIGURE 2—TYPE TB

TABLE 1—GAUGE WIDTH (H_8) AND BARREL DIMENSIONS

Dimensions in millimeters

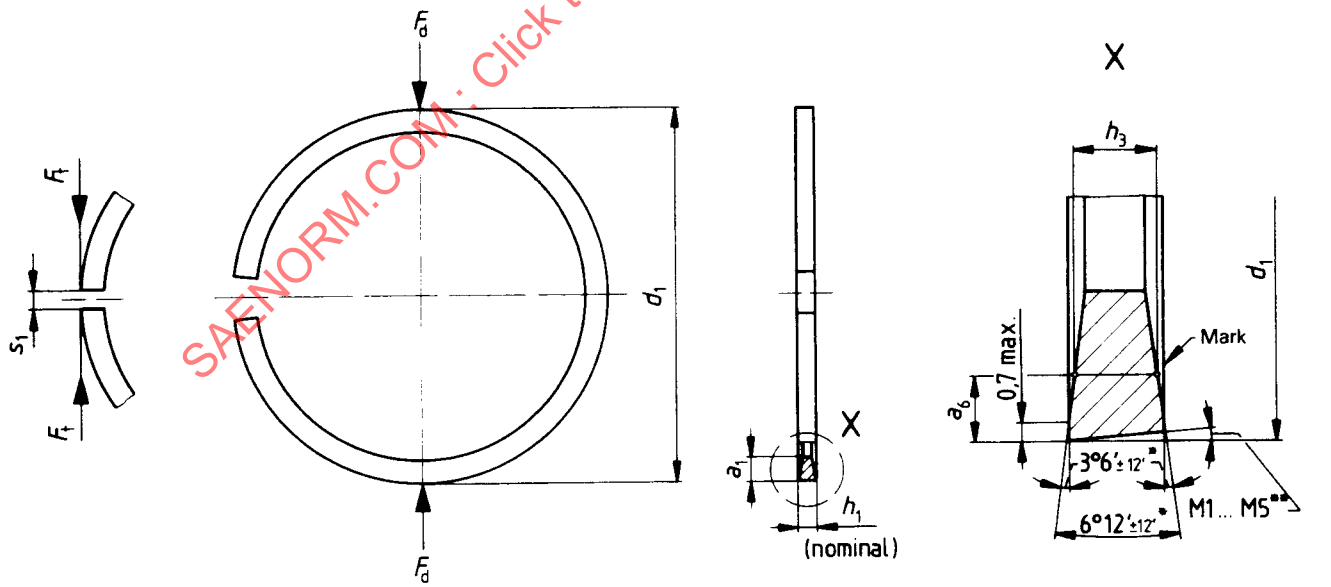
(h_1)	h_8	t_2 , t_3	Maximum Peak Off Center
2.0	1.2		0.30
		0.002/0.016	
2.5	1.6		0.40
3.0	2.0		
		0.005/0.020	0.50
3.5	2.4		
4.0	2.8		
		0.005/0.023	0.60
4.5	3.2		

3.2.2 DESIGNATION EXAMPLE—Designation of a barrel faced keystone ring 6 degrees, of d_1 = 90 mm nominal diameter, h_1 = 2.5 mm ring width, made of spheroidal graphite cast iron, heat-treated martensitic (material subclass 53), general features as shown in Figure 2, and periphery semi-inlaid coated with molybdenum, 0.2 mm minimum thickness.

3.3 Type TM — Taper Faced Keystone Ring 6 Degrees

3.3.1 GENERAL FEATURES

NOTE—See Table 7 for dimensions and forces.



Method A : a_6 ref., h_3 measured
Method B : h_3 ref., a_6 measured

* Due to manufacturing processing, side angle tolerances are not cumulative.

** See Table 2.

FIGURE 3—TYPE TM

TABLE 2—TAPER

Taper	Uncoated and Coated Rings (Molybdenum or Chrome)	Uncoated and Coated Rings (Molybdenum or Chrome) Tolerance(1)
M1	10′	+50′ 0
M2	30′	
M3	60′	+60′ 0
M4	90′	
M5	120′	

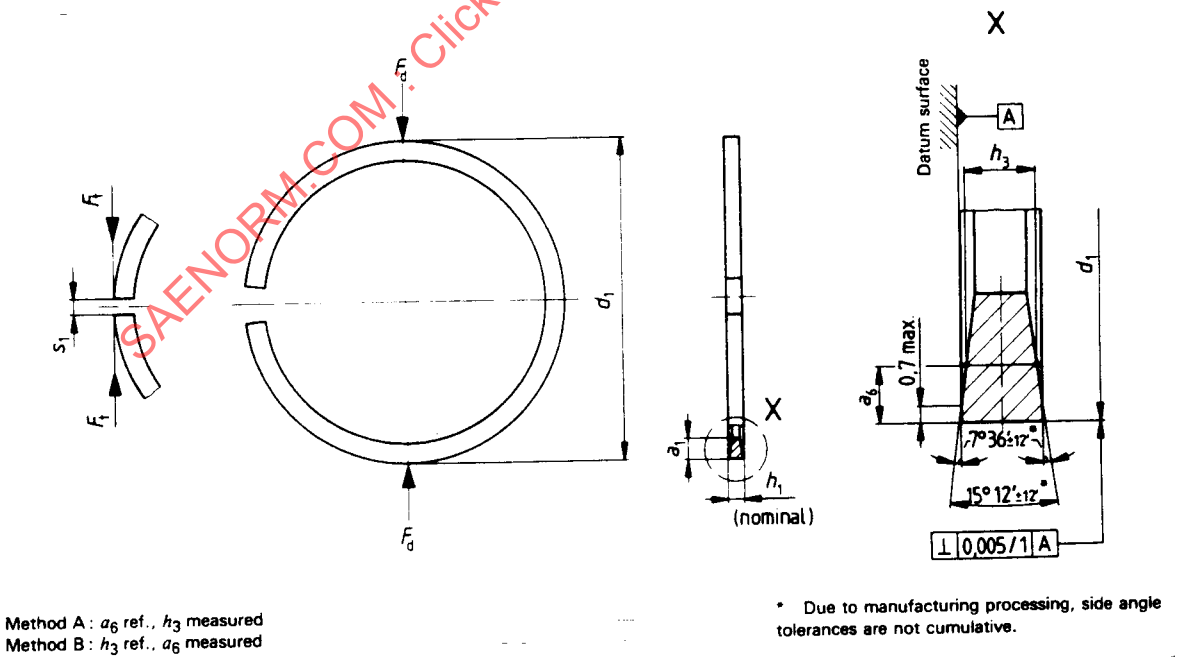
1. For coated rings with tapered periphery not ground, the tolerance shall be increased by 10′ (for example: M3 = 60′ : +70′ 0).

3.3.2 DESIGNATION EXAMPLE—Designation of a taper faced M1 = 10' keystone ring 6 degrees, of d_1 = 90 mm nominal diameter, h_1 = 2.5 mm ring width, made of grey cast iron, heat-treated (material subclass 22), general features as shown in Figure 3, and phosphated all over.

3.4 Type K — Straight Faced Keystone Ring 15 Degrees

3.4.1 GENERAL FEATURES

NOTE—See Table 8 for dimensions and forces.



Method A : a_6 ref., h_3 measured
Method B : h_3 ref., a_6 measured

* Due to manufacturing processing, side angle tolerances are not cumulative.

FIGURE 4—TYPE K

3.4.2 DESIGNATION EXAMPLE—Designation of a straight faced keystone ring 15 degrees, of d_1 = 90 mm nominal diameter, h_1 = 2.5 mm ring width, made of carbidic cast iron, heat-treated martensitic (material subclass 32), general features as shown in Figure 4, and ferroxide coated.

3.5 Type KB—Barrel Faced Keystone Ring 15 Degrees

3.5.1 GENERAL FEATURES

NOTE—See Table 8 for dimensions and forces.

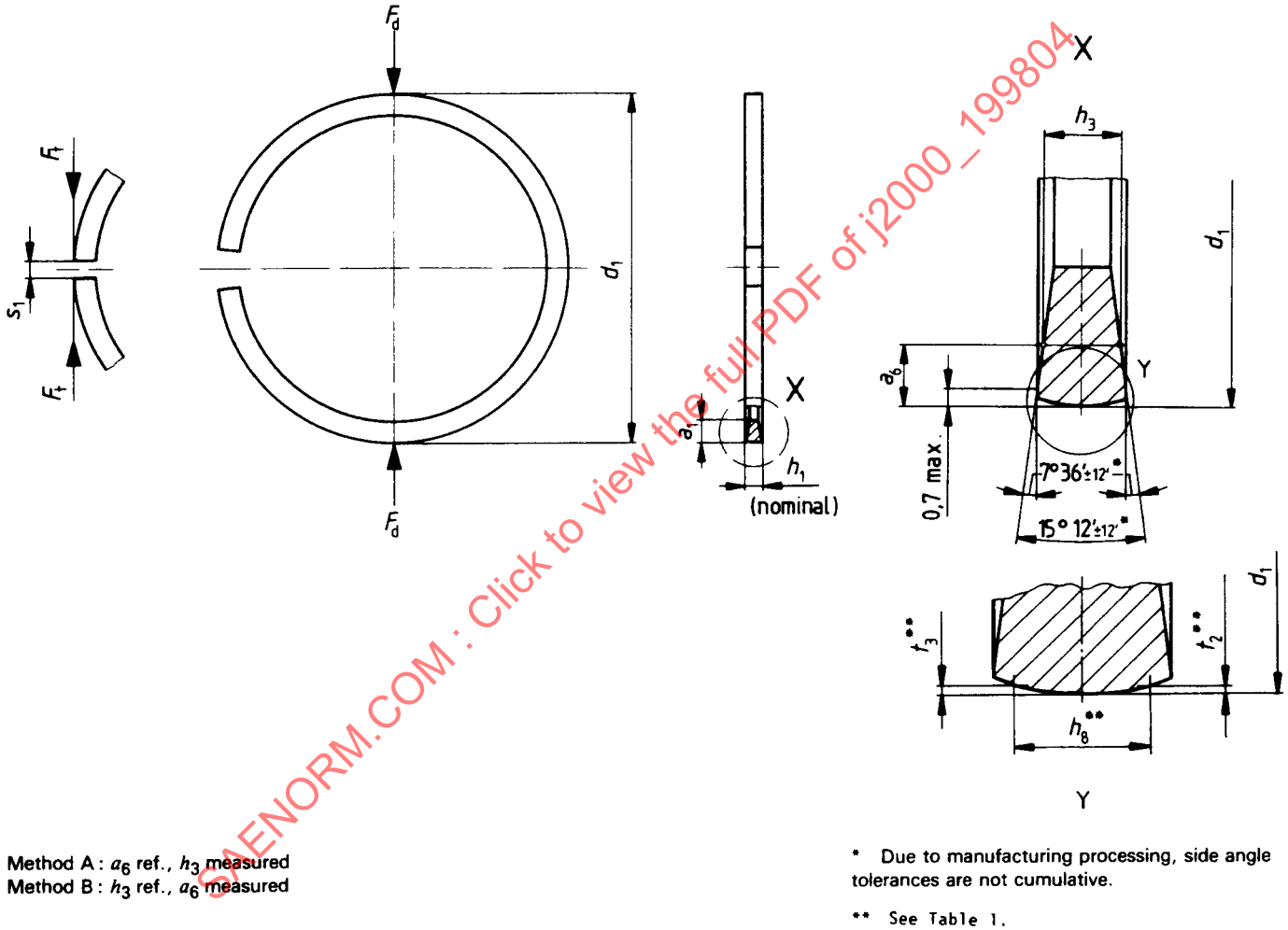


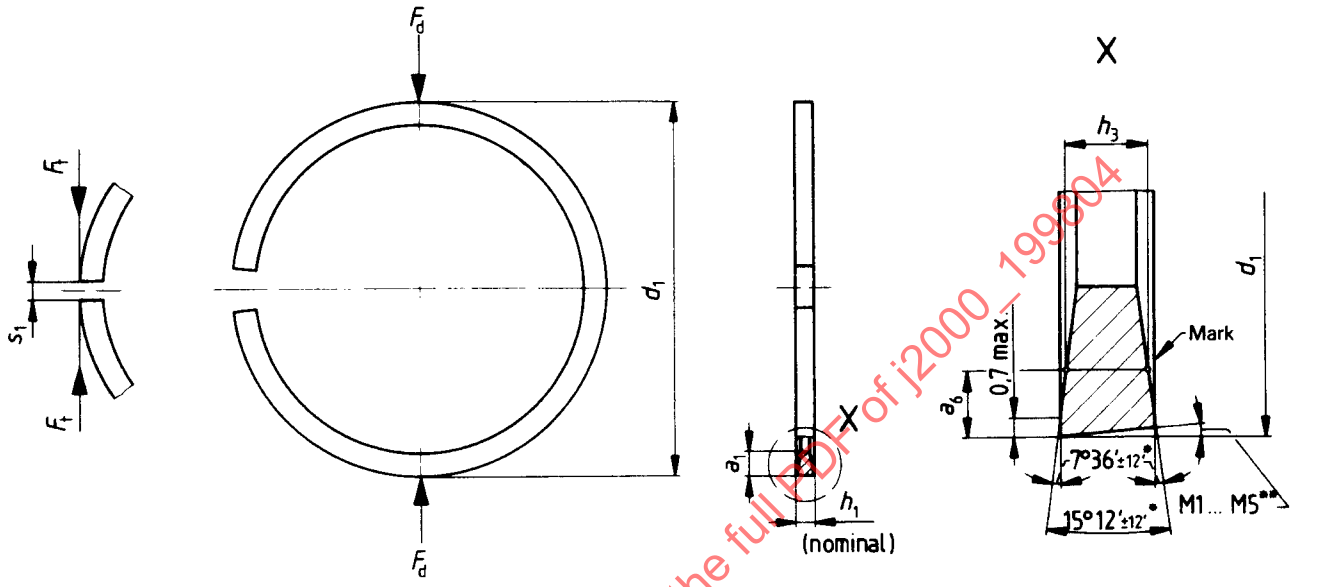
FIGURE 5—TYPE KB

3.5.2 DESIGNATION EXAMPLE—Designation of a barrel faced keystone ring 15 degrees, of d_1 = 90 mm nominal diameter, h_1 = 2.5 mm ring width, made of malleable cast iron, heat-treated pearlitic (material subclass 41), general features as shown in Figure 5, and periphery fully faced, coated with molybdenum, 0.2 mm minimum thickness.

3.6 Type KM—Taper Faced Keystone Ring 15 Degrees

3.6.1 GENERAL FEATURES

NOTE—See Table 8 for dimensions and forces.



Method A : a_6 ref., h_3 measured
Method B : h_3 ref., a_6 measured

* Due to manufacturing processing, side angle tolerances are not cumulative.

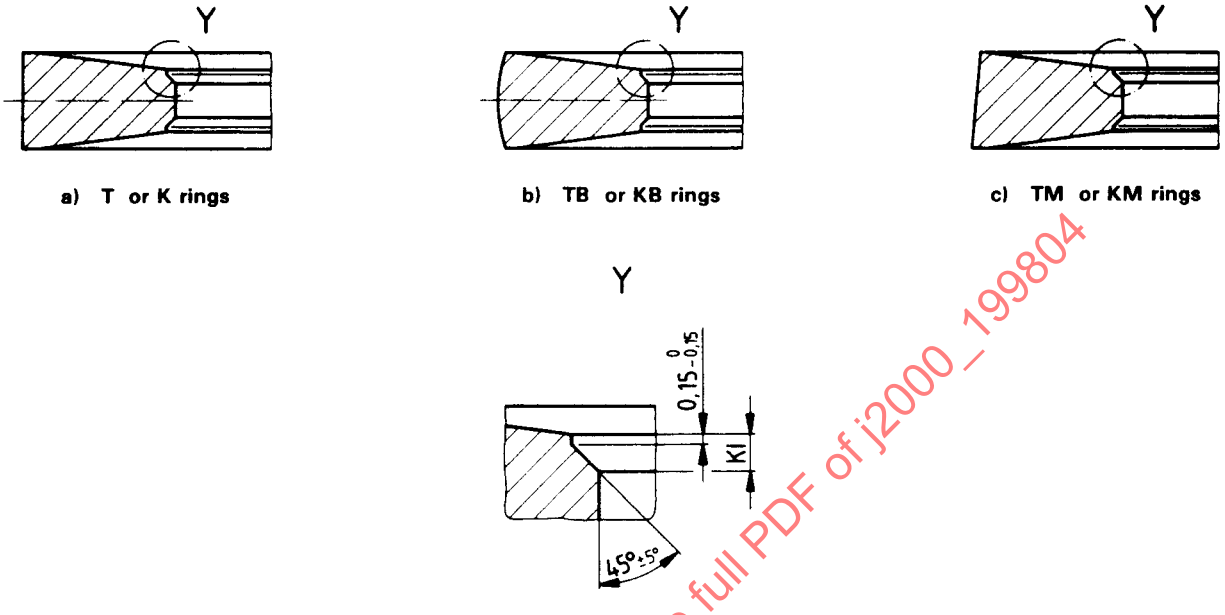
** See Table 2.

FIGURE 6—TYPE KM

3.6.2 DESIGNATION EXAMPLE—Designation of a taper faced M1 = 10' keystone ring 15 degrees, of d_1 = 90 mm nominal diameter, h_1 = 2.5 mm ring width, made of grey cast iron, nonheat-treated (material subclass 12); general features as shown in Figure 6.

4. *Common Features*

4.1 T, TB, TM or K, KB, KM Rings—Inside Chamfered Edges (KI)



a) T or K rings

b) TB or KB rings

c) TM or KM rings

FIGURE 7—INSIDE CHAMFERED EDGES (KI)

TABLE 3—INSIDE CHAMFERED EDGES (KI)

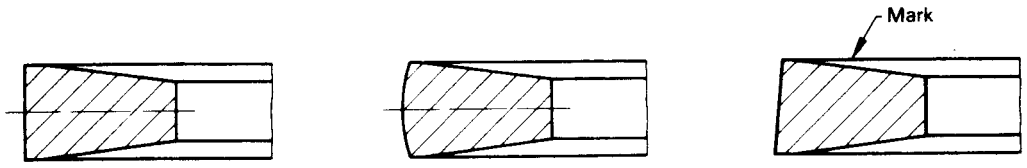
Dimensions in millimeters

d_1	KI
$70 \le d_1 < 125$	0.3 ± 0.15
$125 \le d_1 < 175$	0.4 ± 0.15
$175 \le d_1 \le 200$	0.6 ± 0.20

4.2 T, TB, TM or K, KB, KM Rings—Coating Configuration

NOTE—See Table 4 for dimensions.

4.2.1 UNCOATED RINGS



a) T or K rings

b) TB or KB rings

c) TM or KM rings

FIGURE 8—UNCOATED RINGS

4.2.2 COATED RINGS (CHROMIUM OR MOLYBDENUM)

4.2.2.1 Fully Faced

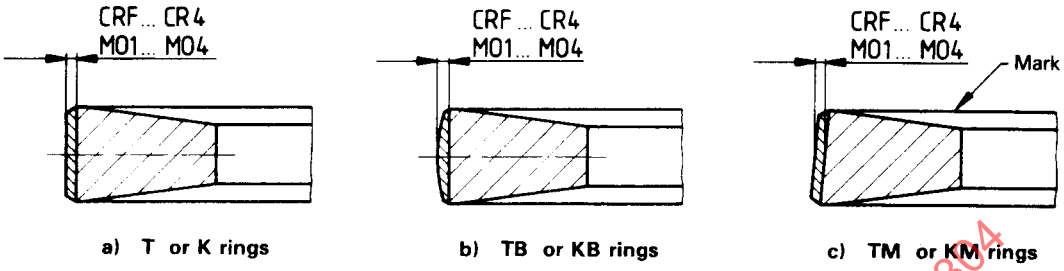


FIGURE 9—FULLY FACED RINGS

4.2.2.2 Semi-Inlaid

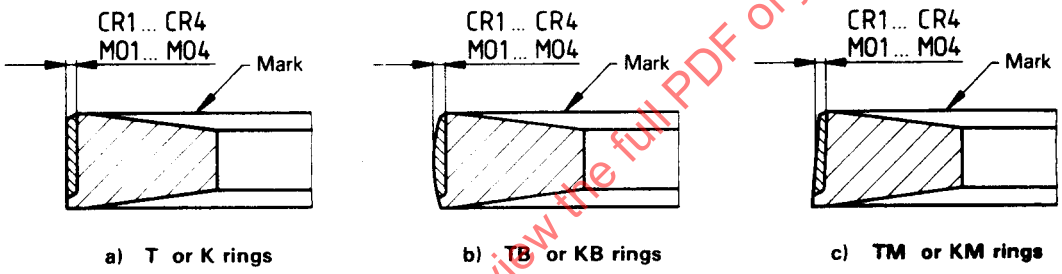


FIGURE 10—SEMI-INLAID RINGS

4.2.2.3 Inlaid

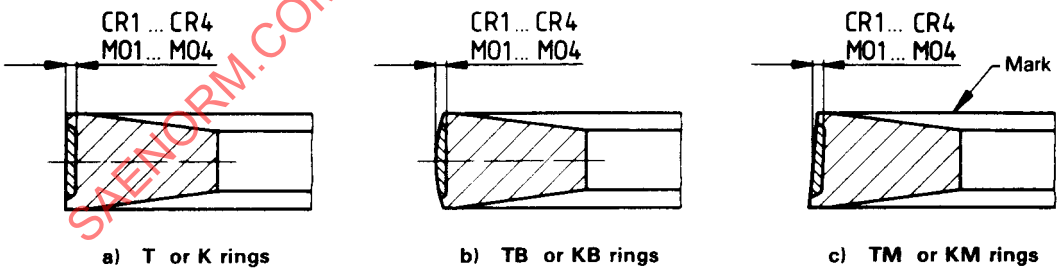


FIGURE 11—INLAID RINGS

TABLE 4—LAYER THICKNESS

Dimensions in millimeters

Chromium	Molybdenum	Thickness Minimum
CRF	—	0.005
CR1	MO1	0.05
CR2	MO2	0.10
CR3	MO3	0.15
CR4	MO4	0.20

5. ***Force Factors—***The tangential and diametral forces given in Tables 7 and 8 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, the multiplier correction factors given in Tables 5 and 6 and the force correction factors given in SAE J1591 shall be used.

The factors of Table 6 have been calculated with mean coating thickness.

TABLE 5—FORCE CORRECTION FACTORS FOR T, TB, TM, K, KB, AND KM RINGS WITH FEATURE KI

KI	Taper M2 or M3	Taper M4 or M5	KI and Taper M2 or M3	KI and Taper M4 or M5
0.96	0.98	0.96	0.94	0.92

TABLE 6—FORCE CORRECTION FACTORS FOR COATED T, TB, TM, K, KB, AND KM RINGS (FULLY FACED, SEMI-INLAID, AND INLAID TYPES)

CRF	CR1	CR2/MO1	CR3/MO2	CR4/MO3	MO4
1	0.94	0.91	0.88	0.85	0.83

6. Dimensions

TABLE 7—DIMENSIONS OF T, TB, TM KEYSTONE RINGS 6 DEGREES

Dimensions in millimeters

Nominal diameter d_1	Radial wall thickness "regular" a_1	Tolerance	Nominal value of ring width Column (h_1) Column 1	Column 2	Method A a_6 (ref.)	Method A Measured value h_3 Column 1	Column 2	Method B h_3 Column 1	Column 2	Method B Measured value a_6	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
70	2.90	±0.15 Within a ring: 0.15 max.	2.0	2.5	1.5	1.832 0 –0.024 For phos-phated PO surface: +0.01 –0.024	2.332 0 –0.024 For phos-phated PO surface: +0.01 –0.024	1.82	2.32	1.61 0 -0.22 For phos-phated PO surface: +0.09 -0.22	0.20	+0.20 0	9.9	12.6	±30 % if F_t lt; 10N ±20 % if $F_t \geq$ 10N	21.3	27.1	±30 % if F_d lt; 21,5N ±20 % if $F_d \geq$ 21.5N
71	2.95												10.1	12.9		21.7	27.7	
72	3.00												10.3	13.2		22.1	28.4	
73	3.05												10.5	13.4		22.6	28.8	
74	3.10												10.7	13.7		23.0	29.5	
75	3.15												10.9	13.9		23.4	29.9	
76	3.15												10.6	13.6		22.8	29.2	
77	3.20												10.8	13.9		23.2	29.9	
78	3.25												11.0	14.1		23.7	30.3	
79	3.30												11.3	14.4		24.3	31.0	
80	3.35												11.5	14.7		24.7	31.6	
81	3.40												11.7	15.0		25.2	32.3	
82	3.40										0.25		11.4	14.6		24.5	31.4	
83	3.45												11.6	14.9		24.9	32.0	
84	3.50												11.8	15.2		25.4	32.7	
85	3.55												12.0	15.4		25.8	33.1	
86	3.60												12.2	15.7		26.2	33.8	
87	3.65												12.5	16.0		26.9	34.4	
88	3.65												12.2	15.6		26.2	33.5	
89	3.70												12.4	15.9		26.7	34.2	
90	3.75											+0.25 0	16.1	19.6		34.6	42.1	
91	3.80												16.3	20.0		35.0	43.0	
92	3.85												16.6	20.3		35.7	43.6	
93	3.90												16.9	20.6		36.3	44.3	
94	3.90												16.5	20.2		35.5	43.4	
95	3.95												16.8	20.5		36.1	44.1	
96	4.00												17.1	20.9		36.8	44.9	
97	4.05												17.3	21.2		37.2	45.6	
98	4.10												17.6	21.5		37.8	46.2	
99	4.15												17.9	21.9		38.5	47.1	
100	4.15										0.30		17.5	21.4		37.6	46.0	
101	4.20												17.7	21.7		38.1	46.7	
102	4.25												18.0	22.0		38.7	47.3	
103	4.30												18.2	22.3		39.1	47.9	
104	4.30												17.9	21.9		38.5	47.1	
105	4.35												18.1	22.2		38.9	47.7	
106	4.40												18.3	22.5		39.3	48.4	
107	4.40												18.0	22.0		38.7	47.3	
108	4.45												18.2	22.3		39.1	47.9	
109	4.50												18.4	22.6		39.6	48.6	
110	4.55												18.6	22.8		40.0	49.0	
111	4.55												18.2	22.4		39.1	48.2	
112	4.60												18.5	22.7		39.8	48.8	
113	4.65												18.7	22.9		40.2	49.2	
114	4.70										0.35	+0.30 0	18.9	23.2		40.6	49.9	
115	4.70												18.6	22.8		40.0	49.0	
116	4.75												18.8	23.1		40.4	49.7	
117	4.80												19.0	23.4		40.9	50.3	
118	4.80												18.7	22.9		40.2	49.2	
119	4.85												18.9	23.2		40,6	49,9	

TABLE 7—DIMENSIONS OF T, TB, TM KEYSTONE RINGS 6 DEGREES

Dimensions in millimeters

Nominal diameter d_1	Radial wall thickness "regular" a_1	Tolerance	Nominal value of ring width Column (h_1) 1	Nominal value of ring width Column (h_1) 2	Method A a_6 (ref.)	Method A Measured value h_3 Column 1	Method A Measured value h_3 Column 2	Method B h_3 Column 1	Method B h_3 Column 2	Method B Measured value a_6	Closed gap s_1	Closed gap Tolerance	Tangential force F_t, N For h_1 shown in column 1	Tangential force F_t, N For h_1 shown in column 2	Tangential force F_t, N Tolerance	Diametral force F_d, N For h_1 shown in column 1	Diametral force F_d, N For h_1 shown in column 2	Diametral force F_d, N Tolerance
						2.278 0 –0.024 For phosphated PO surface: +0.01 –0.024	2.778 0 –0.024 For phosphated PO surface: +0.01 –0.024			2.08 0 –0.022 For phosphated PO surface: +0.09 –0.22								
120	4.90										0.35 +0.30 0		19.1	23.5		41.1	50.5	
121	4.95												19.3	23.8		41.5	51.2	
122	4.95												19.0	23.3		40.9	50.1	
123	5.00												19.2	23.6		41.3	50.7	
124	5.05												19.4	23.9		41.7	51.4	
125	5.05												23.4	27.8		50.3	59.8	
126	5.10												23.7	28.1		51.0	60.4	
127	5.15												24.0	28.5		51.6	61.3	
128	5.20												24.2	28.8		52.0	61.9	
129	5.20												23.8	28.3		51.2	60.8	
130	5.25												24.0	28.5		51.6	61.3	
131	5.30												24.3	28.9		52.2	62.1	
132	5.30												23.9	28.4		51.4	61.1	
133	5.35												24.1	28.7		51.8	61.7	
134	5.40					2.724 0 -0.024 For phosphated PO surface: +0.01 -0.024	3.224 0 -0.024 For phosphated PO surface: +0.01 -0.024			2.63 0 –0.22 For phosphated PO surface: +0.09 –0.22			24.4	29.0		52.5	62.4	
135	5.40												24.0	28.5		51.6	61.3	
136	5.45												24.3	28.8		52.2	61.9	
137	5.50												24.5	29.1		52.7	62.6	
138	5.50												24.1	28.7		51.8	61.7	
139	5.55												24.4	29.0		52.5	62.4	
140	5.60										0.40	+0.35 0	24.6	29.3	±30 % if F_t lt; 10N ±20 % if $F_t \geq$ 10N	52.9	63.0	±30 % if F_d lt; 21,5N ±20 % if $F_d \geq$ 21.5N
141	5.65	±0.20 Within a ring: 0.20 max.											24.9	29.6		53.5	63.6	
142	5.65												24.5	29.1		52.7	62.6	
143	5.70												24.7	29.4		53.1	63.2	
144	5.75		3.0	3.5	2.5			2.71	3.21				25.0	29.7		53.8	63.9	
145	5.75												24.6	29.3		52.9	63.0	
146	5.80												24.9	29.6		53.5	63.6	
147	5.85												25.1	29.9		54.0	64.3	
148	5.85												24.7	29.4		53.1	63.2	
149	5.90												25.0	29.7		53.8	63.9	
150	5.95												25.0	29.8		53.8	64.1	
152	6.00												24.9	29.7		53.5	63.9	
154	6.05					2.724 0 –0.029 For phosphated PO surface: +0.01 –0.029	3.224 0 –0.029 For phosphated PO surface: +0.01 –0.029			2.63 0 –0.026 For phosphated PO surface: +0.09 –0.027			24.8	29.5		53.3	63.4	
155	6.10												25.0	29.8		53.8	64.1	
156	6.15												25.2	30.1		54.2	64.7	
158	6.20												25.1	29.9		54.0	64.3	
160	6.25												25.0	29.8		53.8	64.1	
162	6.35										0.50	+0.40 0	25.4	30.3		54.6	65.1	
164	6.40												25.3	30.2		54.4	64.9	
165	6.40												25.0	29.8		53.8	64.1	
166	6.45												25.2	30.0		54.2	64.5	
168	6.50												25.1	29.9		54.0	64.3	
170	6.60					3.172 3.172 0 –0.029 For phosphated PO surface: +0.01 –0.029	3.672 3.672 0 –0.029 For phosphated PO surface: +0.01 –0.029			3.20 3.20 0 –0.027 For phosphated PO surface: +0.09 –0.027			30.4	35.4		65.4	76.1	
172	6.65												30.3	35.2		65.1	75.7	
174	6.70		3.5	4.0	3.0			3.15	3.65				30.2	35.1		64.9	75.5	
175	6.75												30.3	35.2		65.1	75.7	
176	6.80										0.60	+0.45 0	30.5	35.5		65.6	76.3	
178	6.85												30.4	35.4		65.4	76.1	

TABLE 7—DIMENSIONS OF T, TB, TM KEYSTONE RINGS 6 DEGREES

Dimensions in millimeters

Nominal diameter d_1	Radial wall thickness "regular" a_1	Tolerance	Nominal value of ring width Column (h_1) Column 1	Column 2	Method A a_6 (ref.)	Method A Measured value h_3 Column 1	Column 2	Method B h_3 Column 1	Column 2	Method B Measured value a_6	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
180	6.90	±0.20 Within a ring: 0.20 max.	3.5	4.0	3.0	3.172	3.672	3.15	3.65	3.20	0.60	+0.45 0	30.3	35.2	±30 % if F_t lt; 10N ±20 % if $F_t \geq$ 10N	65.1	75.7	±30 % if F_d lt; 21.5N ±20 % if $F_d \geq$ 21.5N
182	6.95												30.1	35.1		64.7	75.5	
184	7.05												30.6	35.7		65.8	76.8	
185	7.05					0	0			0			30.3	35.2		65.1	75.7	
186	7.10					–0.029	–0.029			–0.027			30.5	35.5		65.6	76.3	
188	7.15					For	For			For			30.4	35.4		65.4	76.1	
190	7.20					phos-	phos-			phos-			30.3	35.2		65.1	75.7	
192	7.25					phated	phated			phated			30.1	35.1		64.7	75.5	
194	7.35					PO	PO			PO			30.6	35.7		65.8	76.8	
195	7.35					surface:	surface:			surface:			30.2	35.2		64.9	75.7	
196	7.40					+0.01	+0.01			+0.09			30.5	35.5		65.6	76.3	
198	7.45					–0.029	–0.029			–0.027			30.45	35.4		65.4	76.1	
200	7.50												30.2	35.2		64.9	75.7	

NOTE 1—For Intermediate sizes (for example repair sizes), the radial wall thickness of the next smaller nominal diameter should be applied.

NOTE 2—For values for F_t and F_d, given in Table 7, 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 (E_n) are given in SAE J1591.

Mean forces are calculated for nominal radial wall thickness (a_1) and mean ring width (h_1).

NOTE 3—For the sole purpose of this document, the assumed average ratio F_d/F_t is 2.15.

TABLE 8—DIMENSIONS OF K. KB. KM KEYSTONE RINGS 15 DEGREES

Dimensions in millimeters

Nominal diameter d_1	Radial wall thickness "regular" a_1	Tolerance	Nominal value of ring width Column (h_1) Column 1	Column 2	Method A a_6 (ref.)	Method A Measured value h_3 Column 1	Column 2	Method B h_3 Column 1	Column 2	Method B Measured value a_6	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
80	3.35												12.8	16.0		27.5	34.4	
81	3.40												13.0	16.3		28.0	35.0	
82	3.40												12.7	15.9		27.3	34.2	
83	3.45												12.9	16.2		27.7	34.8	
84	3.50										0.25		13.1	16.5		28.2	35.5	
85	3.55					2.097	2.597			1.49			13.3	16.7		28.6	35.9	
86	3.60					0	0			0			13.5	17.0		29.0	36.6	
87	3.65	+0.15				–0.029	–0.029			–0.11			13.7	17.3		29.5	37.2	
88	3.65	Within			For	For				For			13.4	16.9		28.8	36.3	
89	3.70	a ring:	2.5	3.0	1.5	phos-	phos-	2.10	2.60	phos-			13.6	17.1		29.2	36.8	
90	3.75	0.15				phated	phated			phated			13.7	17.3		29.5	37.2	
91	3.80	max.				PO	PO			PO			13.9	17.6		29.9	37.8	
92	3.85					surface:	surface:			surface:		+ 0.25	14.1	17.8		30.3	38.3	
93	3.90					+0.01	+0.01			+0.04		0	14.3	18.1		30.7	38.9	
94	3.90												14.0	17.7		30.1	38.1	
95	3.95												14.1	17.9		30.3	38.5	
96	4.00												14.3	18.2		30.7	39.1	
97	4.05												14.5	18.5		31.2	39.8	
98	4.10												14.7	18.7		31.6	40.2	
99	4.15										0.30		14.9	19.0		32.0	40.9	
100	4.15												18.5	22.5		39.8	48.4	
101	4.20												18.8	22.8		40.4	49.0	
102	4.25												19.0	23.1		40.9	49.7	
103	4.30												19.2	23.3		41.3	50.1	
104	4.30												18.8	22.9		40.4	49.2	
105	4.35												19.0	23.1	± 30 % if	40.9	49.7	± 30 % if
106	4.40												19.2	23.4	F_t < 10 N	41.3	50.3	F_d < 21.5 N
107	4.40					2.463	2.963			2.05			18.8	22.9	±20% if	40.4	49.2	± 20% if
108	4.45					0	0			0			19.0	23.2	$F_t \geq$ 10 N	40.9	49.9	F_d ³ 21.5 N
109	4.50					For	For			For			19.2	23.5		41.3	50.5	
110	4.55					phos-	phos-			phos-			19.4	23.6		41.7	50.7	
111	4.55					phated	phated			phos-			19.0	23.2		40.9	49.9	
112	4.60		3.0	3.5	2.0	PO	PO	2.45	2.95	phated			19.2	23.4		41.3	50.3	
113	4.65					surface:	surface:			PO			19.4	23.7		41.7	51.0	
114	4.70					+0.01	+0.01			surface:			19.6	24.0		42.1	51.6	
115	4.70	± 0.20				–0.034	–0.034			+0.04			19.2	23.5		41.3	50.5	
116	4.75	Within								–0.13			19.4	23.7		41.7	51.0	
117	4.80	a ring:											19.6	24.0		42.1	51.6	
118	4.80	0.20											19.2	23.5		41.3	50.5	
119	4.85	max									0.35	+0.30	19.4	23.8		41.7	51.2	
120	4.90											0	19.6	24.0		42.1	51.6	
121	4.95												19.8	24.3		42.6	52.2	
122	4.95												19.4	23.8		41.7	51.2	
123	5.00												19.6	24.1		42.1	51.8	
124	5.05												19.8	24.3		42.6	52.2	
125	5.05					2.830	3.330			2.61			23.9	28.3		51.4	60.8	
126	5.10					0	0			0			24.1	28.6		51.8	61.5	
127	5.15					–0.034	–0.034			–0.13			24.3	28.9		52.2	62.1	
128	5.20					For	For			For			24.6	29.2		52.9	62.8	
129	5.20		3.5	4.0	2.5	phos-	phos-	2.80	3.30	phos-			24.1	28.7		51.8	61.7	
130	5.25					phated	phated			phated			24.3	28.9		52.2	62.1	
131	5.30					PO	PO			PO			24.5	29.2		52.7	62.8	
132	5.30					surface:	surface:			surface:	0.40	+0.35 0	24.1	28.7		51.8	61.7	
133	5.35					+0.01	+0.01			+0.04			24.3	28.9		52.2	62.1	
134	5.40					–0.034	–0.034			–0.13			24.5	29.2		52.7	62.8	