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

SURFACE VEHICLE STANDARD

SAE J1996

REAF. APR1998

Issued 1990-06
Reaffirmed 1998-04

Superseding J1996 OCT92

Submitted for recognition as an American National Standard

Internal Combustion Engines—Piston Rings—Quality Requirements

This SAE Standard is equivalent to ISO Standard 6621/5.

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

1. Scope—Differences, where they exist, are shown in Appendix A.

This SAE Standard specifies the quality aspects that are capable of definition but not normally found on a drawing specification.

The difficulty of trying to define in absolute terms the quality attainable in normal commercial manufacture of piston rings is well known. In this document the commonly encountered aspects of quality in terms of casting defects and other departures from ideal are quantified. Many minor defects are clearly quite acceptable; other defects because of size or numbers are inadmissible.

This document covers the following:

a. Single piece piston rings of grey, carbidic, malleable, spheroidal graphite cast iron or steel
b. Multipiece piston rings (oil control rings) consisting of cast iron parts and spring components
c. Single piece and multipiece rings of steel, i.e., oil control rings in the form of strip steel components or steel segments (rails) with spring expander components

In addition to specifying certain limits of acceptance relating to inspection measuring principles (covered by SAE J1589) this document also covers those features for which no recognized quantitative measurement procedures exist and which are only checked visually with normal eyesight and without magnification. Such features (superficial defects) are additional to the standard tolerances of ring width, radial wall thickness, and closed gap.

The requirements of this document apply to all rings up to and including 200 mm diameter covered by the above classification for both reciprocating internal combustion engines and compressors.

QUESTIONS REGARDING THIS DOCUMENT: (724) 772-8512 FAX: (724) 776-0243
TO PLACE A DOCUMENT ORDER; (724) 776-4970 FAX: (724) 776-0790
SAE WEB ADDRESS http://www.sae.org

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
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
		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—COILSPRING LOADED OIL CONTROL RINGS
J2004	6627 TR	INTERNAL COMBUSTION ENGINES—PISTONRINGS—EXPANDER/SEGMENT OIL CONTROL RINGS
J2226		INTERNAL COMBUSTION ENGINES—PISTON RINGS—STEEL RECTANGULAR RINGS
	2859	SAMPLING PROCEDURES AND TABLES FOR INSPECTION BYATTRIBUTES

3. Definitions—

The terminology used in this document is as given in SAE J1588.

4. Visible Defects

4.1 General—Visible defects are divided into two principle classes as described in 4.2 to 4.5.

The first class covers those defects frequently found in castings and includes such defects as porosity, sand inclusions, cavities, etc.

The second class of defects covers mechanical abrasions which may occur during machining or handling of rings, and includes scratches, dents, chipping, burns, and cracks.

1. TR refers to Technical Report

Inspection of piston rings for such defects is generally carried out visually, without magnification, by inspectors having normal eyesight, corrected if necessary.

It is not intended that every ring be rigorously inspected for size and distribution of defects but rather that the values given in the tables and text be used as a general guide. However, in case of doubt, the values given should be used as the means of judging the quality of the rings.

4.2 Pores, Cavities, and Sand Inclusions—Such defects are permissible on uncoated surfaces and edges provided that the values given in Table 1 for size, number, and spacing are not exceeded.

NOTE—The depth of porosity cannot be checked visually and, therefore, no limiting values are given.

TABLE 1—PERMISSIBLE VALUES OF SIZE, NUMBER AND SPACING OF PORES, CAVITIES AND SAND INCLUSIONS

Dimensions are millimeters

Nominal diameter d_1	Defect size max on periphery(1)	Defect size max on other surfaces(1)	Defect size max on peripheral edges	Defect size max on other edges(2)	Number per ring max	Spacing(3) min
$30 \le d_1 < 60$	0.1	0.3	0.1	0.1	2	4
$60 \le d_1 < 100$	0.15	0.5	0.1	0.2	4	4
$100 \le d_1 < 150$	0.2	0.5	0.1	0.3	6	8
$150 \le d_1 \le 200$	0.2	0.8	0.1	0.4	6	8

1. The defects should not be closer to an edge than one-half of the maximum permissible size of the defect, with a minimum of 0.2 mm.
2. Not on inside gap edges of piston rings with internal notch.
3. Spacing includes defects on adjacent or opposite surfaces.

4.3 Scratches, Indentations, Depressions, and Cracks

4.3.1 SCRATCHES—Isolated scratches are permissible provided that:

a. No burrs are produced exceeding the permissible values given in 4.4.1.1
b. On the periphery with turned surface they are not deeper than the tool marks or, for peripheries without a turned surface, not deeper than 0.004 mm
c. On the side faces they are not deeper than 0.01 mm
d. On other surfaces they are not deeper than 0.06 mm

4.3.2 INDENTATIONS AND DEPRESSIONS—Indentations and Depressions are permissible provided that:

a. The values given in Table 11 for number and spacing of defects are met
b. No burrs are produced exceeding the permissible values given in 4.4.1.1
c. They do not exceed the values for size and depth given in Table 2

Rings of a coated/inlaid type shall not have indentations or depressions on the periphery.

NOTE—Indentations arising from hardness measurements on the side faces are acceptable provided that they do not exceed the limits given in Tables 2 and 11.

TABLE 2—PERMISSIBLE SIZE OF INDENTATIONS AND DEPRESSIONS

Dimensions are millimeters

Nominal diameter d_1	Defect size max on periphery	Defect size max on side face	Depth max
$30 \le d_1 < 100$	0.3	0.6	10% of corresponding
$100 \le d_1 < 200$	0.5	1	max defect size surface

4.3.3 CRACKS—No cracks are permissible.

See also 4.5.4 for chromium-plated peripheries.

4.4 Edges

4.4.1 EDGE CONFIGURATION—All edges of the piston ring shall be sharp; ideally they should be free from burrs and from ragged edges whether arising from crumbling of material or from deburring. Such conditions are almost impossible to achieve regularly in volume production and, hence, both burrs and removal of edge material is permitted up to the maximum sizes given in 4.4.1.1 and 4.4.1.2.

4.4.1.1 *Burrs*—Burrs are permitted up to the maximum values given in Table 3. The orientation and direction of burrs shall relate to the functional surfaces of the piston ring, that is to say any burr present should point in the direction of sliding motion of the ring and not normal to the direction of sliding.

Any burrs remaining on the edges of rings should be firmly adherent, forming an integral part of the edge.

TABLE 3—MAXIMUM SIZE OF BURRS FOR ALL SIZES OF RING

Dimensions are millimeters

Location of burr	Size of burr[(1)] max
On edges adjacent to	
the peripheral surface and side faces	0.006
the butt ends (gap surfaces)	0.04
the outside groove face (oil rings)	0.2
the inside surface and the ends of the slots (oil rings)	0.5
all other surfaces	0.1

1. Maximum values of burrs on steel rings are to be agreed on between manufacturer and purchaser.

4.4.1.2 *Edge Material Removal*—To eliminate protruding burrs in any direction, it is permissible to remove material from the edges to the values given in Table 4.

TABLE 4—EDGE MATERIAL REMOVAL IN DEBURR OPERATIONS

Dimensions are millimeters

Location of edge	Removal of material max
On peripheral edges	0.08
On peripheral edges of the gap(1)	0.15
On other edges	0.25

1. Does not apply to rings coated on the periphery that have gap edge chamfers.

4.4.2 CHIPPING AND SIMILAR DEFECTS ON PERIPHERAL EDGES, PERIPHERAL EDGES AT THE GAP, OUTSIDE GAP CORNERS AND ON PERIPHERAL CHAMFERS

4.4.2.1 Chipping and similar defects are permitted on these points provided that:

a. They are free of loosely adhering particles
b. No burrs are produced exceeding the values permitted in 4.4.1.1
c. They do not exceed half the width of any witness land on, for example, taper-faced rings
d. They do not exceed the values given in the following tables:
    1. Table 5 for uncoated rings
    2. Table 6 for plated, coating rings
    3. Table 7 for spray-coated rings
    4. Table 8 for chamfers on all rings

Typical defects are illustrated in Figures 1 to 6.

(See 4.4.2.2 for explanations of F and K.)

TABLE 5—PERMISSIBLE SIZE OF CHIPPING AND DEFECTS ON UNCOATED RINGS ON PERIPHERAL EDGES, PERIPHERAL EDGES OF THE GAP AND OUTSIDE GAP CORNERS(1)

Dimensions are millimeters

Ring width h_1	Land width h_4 or h_5	Defect in direction normal to periphery(2) on peripheral edge of gap F_1, F_3	Defect in direction normal to periphery(2) on peripheral edge F_2, F_3	Defect in direction along edge(2) on peripheral edge of gap(3) K_1, K_3	Defect in direction along edge(2) on peripheral edge K_2, K_3
$h_1 < 2$	-	0.2	0.2	0.5	0.5
$2 \le h_1 < 4$	-	0.2	0.2	0.6	0.6
$4 \le h_1 \le 6$	-	0.3	0.3	0.8	0.8
-	h_4, $h_5 < 0.5$	0.1	0.1	0.1	0.6
-	h_4, $h_5 \ge 0.5$	0.2	0.2	0.2	0.8

1. Number and spacing of defects to be in accordance with Table 1.
2. See Figures 1, 2, 3, 4, and 5.
3. Subject to a maximum of one-third of peripheral width of ring or land.

TABLE 6—PERMISSIBLE SIZE OF CHIPPING AND DEFECTS ON UNCOATED RINGS WITH CHROMIUM PLATED PERIPHERY, ON PERIPHERAL EDGES, PERIPHERAL EDGES OF THE GAP AND OUTSIDE GAP CORNERS(1)

Dimensions are millimeters

Ring width h_1	Land width h_5	Defect in direction normal to periphery(2) on peripheral edge of gap F_1, F_3	Defect in direction normal to periphery(2) on peripheral edge F_2, F_3	Defect in direction along edge(2) on peripheral edge of gap(3) K_1, K_3	Defect in direction along edge(2) on peripheral edge K_2, K_3
$h_1 < 2$	-	0.2	0.2	0.3	0.3
$2 \le h_1 < 4$	-	0.2	0.2	0.4	0.3
$4 \le h_1 \le 6$	-	0.3	0.3	0.4	0.4
-	$h_5 < 0.5$	0.1	0.1	0.1	0.6
-	$h_5 \ge 0.5$	0.2	0.1	0.2	0.6

1. Number and spacing of defects to be in accordance with Table 1.
2. See Figures 1, 2, 3, 4, and 5.
3. Subject to a maximum of one-third of peripheral width of ring or land.

TABLE 7—PERMISSIBLE SIZE OF CHIPPING AND DEFECTS ON SPRAY COATED RINGS ON PERIPHERAL EDGES, PERIPHERAL EDGES OF THE GAP AND OUTSIDE GAP CORNERS(1)

Dimensions are millimeters

Ring width h_1	Defect in direction normal to periphery(2) on peripheral edges of the gap F_1, F_3	Defect in direction normal to periphery(2) on peripheral on edges(3) F_2, F_3	Defect in direction along edge(2) on peripheral edge of the gap(4) K_1, K_3	Defect in direction along edge(2) on peripheral edge(3) K_2, K_3
$h_1 < 2$	0.3	0.3	0.5	0.5
$2 \le h_1 < 4$	0.3	0.3	0.6	0.6
$4 \le h_1 \le 6$	0.4	0.4	0.8	0.8

1. Number and spacing of defects to be in accordance with Table 1.
2. See Figures 1, 2, 3, 4, and 5.
3. Only for fully faced and semi-inlaid design.
4. Subject to a maximum of one-third of peripheral width of ring or land.

TABLE 8—PERMISSIBLE SIZE OF CHIPPING AND DEFECTS ON CHAMFERS AT THE PERIPHERAL EDGE AND PERIPHERAL EDGE OF THE GAP(1)

Dimensions are millimeters

Ring width h_1 $h_1 < 2$	Size of defect L_1/L_2 max 0.5
$2 \le h_1 < 4$	0.8
$4 \le h_1 \le 6$	1.2

1. Number and spacing of defects to be in accordance with Table 1.

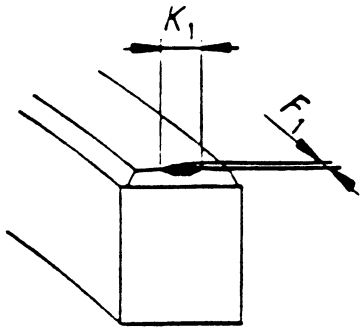

FIGURE 1—CHIPPING ON PERIPHERAL EDGES OF THE GAP

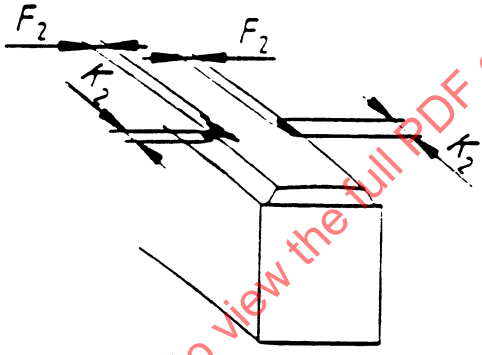

FIGURE 2—CHIPPING ON PERIPHERAL EDGES

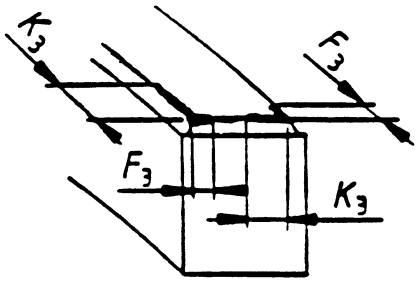

FIGURE 3—CHIPPING ON OUTSIDE GAP CORNERS

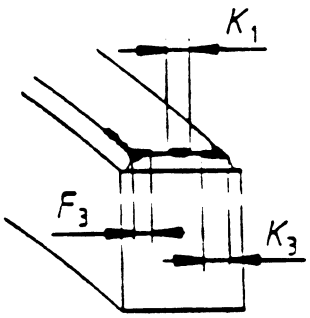

FIGURE 4—COMBINATION OF Figures 1 AND 3

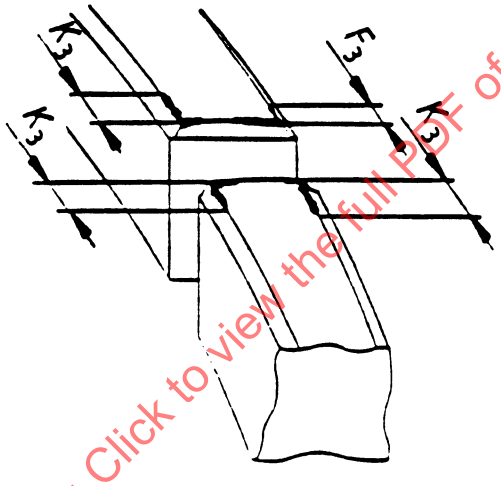

FIGURE 5—CHIPPING ON OPPOSITE GAP CORNERS

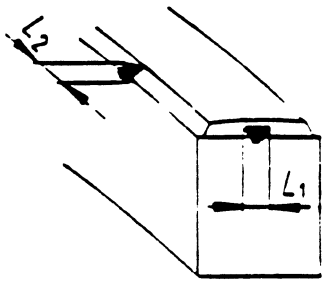

FIGURE 6—CHIPPING ON CHAMFERS

4.4.2.2 *K_1, K_2, K_3, F_1, F_2, and F_3 Dimensions (See Figures 1 to 6)*—K_1, K_2, K_3 are always the dimensions of the defect measured along the edge cut by the defect.

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

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

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

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

4.4.2.3 The limitations for chipping and similar defects on peripheral edges, peripheral edges of the gap and opposite gap corners are given in a to c.

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

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

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

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

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

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

c. Opposite gap corners—Defects at outside gap corners are accounted for in the assessments shown in a and b either as peripheral edge defects or as peripheral edge of the gap defects.

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

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

4.4.2.4 The limitations for chipping and similar defects on the chamfers at the peripheral edge and at the peripheral edge of the gap are as follows:

This type of defect is illustrated in Figure 6 and is more likely to occur on chromium plated chamfers (machined or unmachined), on machined chamfers on metal sprayed rings (fully coated), and on machined chamfers on grey iron rings. The maximum values of the defects allowable are given in Table 8 and are the same for all rings with chamfers on peripheral edge and peripheral edge of the gap.

Defects counted as on the chamfers shall not cut peripheral edges or peripheral edges of the gap but may just cut side faces or gap faces.

4.4.3 CHIPPING AND DEFECTS ON INNER EDGES AND OTHER EDGES—Chipping and defects on inner edges and other edges are permissible provided that:

a. No burrs are produced exceeding the values given in 4.4.1.1
b. They do not exceed the maximum established values given in Table 1 for pores, cavities, and sand inclusions

4.4.4 CHIPPING AND DEFECTS ON INSIDE GAP CORNERS—Chipping and defects on inside gap corners are permitted provided that:

a. No burrs are produced exceeding the values given in 4.4.1.1
b. The rings do not have an internal notch
c. They do not exceed 0.3 mm in the radial direction and 0.5 mm in the circumferential and axial directions for coil-spring-loaded oil control rings
d. They do not exceed the values given in Table 9 for remaining ring designs

TABLE 9—PERMISSIBLE SIZE OF CHIPPING AND DEFECTS ON INSIDE GAP CORNERS

Dimensions are millimeters

Nominal diameter d_1	Size of defect measured axially(1)	Size of defect measured radially(1)	Size of defect measured circumferentially
$30 \le d_1 < 100$	0.6	0.8	1
$100 \le d_1 \le 200$	0.8	1	1.5

1. Subject to a maximum of one-third of the ring width or radial wall thickness.

4.5 Other Characteristics Subject to Visual Inspection Only

4.5.1 DISCOLORING OR STAINING OF SURFACE—Discoloring or staining spread evenly or unevenly over the ring surfaces is permissible. This does not include rust.

4.5.2 CASTING SKIN AND DEPOSITS ON INSIDE SURFACE—The following defects are permitted:

a. Unmachined (NCU) areas within 5 degrees of the gap ends
b. Firmly adherent deposits arising from processing of the ring

4.5.3 CHIPPING ON UNCOATED SURFACES—This is permissible provided the chip sizes do not exceed the maximum values established in Table 1 for pores, cavities, and sand inclusions.

4.5.4 CHROMIUM PLATED PERIPHERY—The chromium plating shall be fully coherent, i.e., there shall be no visible macro cracks, pores, blisters, chromium beads (undercut bulge in the surface), or pin holes.

Exceptions with regard to pin holes may be agreed on between manufacturer and purchaser.

4.5.5 SPRAY COATINGS—Spray coatings are not homogeneous. The acceptance conditions may be agreed on between manufacturer and purchaser; otherwise, manufacturer's specifications apply.

5. Material

5.1 Specifications—The basic material specifications are given in SAE J1590.

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

5.2 Loss of Tangential Force Under Temperature Effects—Some loss of tangential force at engine operating conditions is acceptable. For the purposes of establishing quality, test conditions, and loss of tangential force with the ring closed to nominal diameter are given in Table 10.

TABLE 10—TEST CONDITIONS TO MEASURE TANGENTIAL FORCE LOSS

SAE reference	Material class	Loss of tangential force max %	Test conditions (ring closed to nominal diameter) Temperature °C	Test conditions (ring closed to nominal diameter) time h
J1997, J1998, J1999, J2000, J2001, J2002, and J2003	10, 20, 30	12	300	3
	40, 50, 60	8	300	3
Rings with cast iron parts WF[1]	10, 20, 30, 40, 50	25	250	5
	10, 20, 30, 40, 50	12	250	5
Single and multipiece steel oil control rings WF[1]	60	30	220	5
	-	15	220	5

1. WF = reduced heat set.

6. Raised Material Caused by Marking of Rings—Raised material is permitted subject to the values given in Table 11.

TABLE 11—MAXIMUM PERMITTED RAISED MATERIAL

Dimensions are millimeters

Nominal diameter d_1	Value above surface max
$30 \le d_1 < 100$	0.008
$100 \le d_1 \le 200$	0.01

7. Machining of Periphery and Sides—Unintentional Departure From Ideal Profile and Flatness— Machining operations are not perfect and the peripheral and side faces cannot be machined precisely to profiles and dimensions given or implied in the general specifications (see Section 3).

7.1 Permissible Deviations for Peripheral Surface Profile

7.1.1 Straight faced rings, coated or uncoated, according to SAE J1997, J1998, and J2000:

a. Permissible barrel—0.002 mm per millimeter of ring width h_1 (measuring points: see SAE J1997, J1998, and J2000)

7.1.2 Straight faced rings, coated or uncoated, according to SAE J1997 and J1998 without IW/IF and J2000:

a. Permissible taper—0.005 mm per millimeter of ring width h_1

7.1.3 Straight faced rings, coated or uncoated, according to SAE J1997 and J1998 with IW/IF and J2001:

a. Permissible taper—0.006 mm per millimeter of ring width h_1

7.1.4 S, G, D, and DV type oil control rings:

a. Permissible radial land offset—0.015 mm

7.1.5 SF type, coil spring loaded oil control rings, coated or uncoated:

a. Permissible radial land offset:
   1. Ring width $h_1 < 6$ mm : 0.015 mm
   2. Ring width $h_1 > 6$ mm : 0.025 mm

7.2 Permissible Side Face Unevenness—In the radial direction—50% of h_1 - tolerance.

NOTE—This does not apply to twist rings, scraper rings, half keystone rings, and keystone rings.

In the circumferential direction, see Table 12.

TABLE 12—PERMISSIBLE SIDE FACE UNEVENNESS IN THE CIRCUMFERENTIAL DIRECTION(1)

Dimensions are millimeters

Nominal diameter d_1	Permissible unevenness
$30 \le d_1 < 125$	0.02
$125 \le d_1 < 175$	0.03
$175 \le d_1 \le 200$	0.04

1. This does not apply to twist rings, scraper rings, and oil control rings.

7.3 Permissible Helix—See Table 13.

TABLE 13—PERMISSIBLE HELIX

Dimensions are millimeters

Nominal diameter d_1	Permissible helix	Ring width h_1
$30 \le d_1 < 80$	0.5	$h_1 \le 1.5$
	0.3	$h_1 > 1.5$
$80 \le d_1 < 125$	0.5	-
$125 \le d_1 < 175$	0.7	-
$175 \le d_1 \le 200$	1	-

PREPARED BY THE SAE PISTON RING STANDARDS COMMITTEE 7

SAE J1996 Reaffirmed APR1998

Rationale—Not applicable.

Relationship of SAE Standard to ISO Standard—This SAE Standard is equivalent to ISO Standard 6621/5.

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

This SAE Standard specifies the quality aspects that are capable of definition but not normally found on a drawing specification.

The difficulty of trying to define in absolute terms the quality attainable in normal commercial manufacture of piston rings is well known. In this document the commonly encountered aspects of quality in terms of casting defects and other departures from ideal are quantified. Many minor defects are clearly quite acceptable; other defects because of size or numbers are inadmissible.

This document covers the following:

a. Single piece piston rings of grey, carbidic, malleable, spheroidal graphite cast iron or steel
b. Multipiece piston rings (oil control rings) consisting of cast iron parts and spring components
c. Single piece and multipiece rings of steel, i.e., oil control rings in the form of strip steel components or steel segments (rails) with spring expander components

In addition to specifying certain limits of acceptance relating to inspection measuring principles (covered by SAE J1589) this document also covers those features for which no recognized quantitative measurement procedures exist and which are only checked visually with normal eyesight and without magnification. Such features (superficial defects) are additional to the standard tolerances of ring width, radial wall thickness, and closed gap.

The requirements of this document apply to all rings up to and including 200 mm diameter covered by the above classification for both reciprocating internal combustion engines and compressors.

Reference Section

SAE J1588—Internal Combustion Engines—Piston Rings—Vocabulary

SAE J1589—Internal Combustion Engines—Piston Rings—Measuring Principles

SAE J1590—Internal Combustion Engines—Piston Rings—Material Specifications

SAE J1591—Internal Combustion Engines—Piston Rings—General Specifications

SAE J1996—Internal Combustion Engines—Piston Rings—Quality Requirements

SAE J1997—Internal Combustion Engines—Piston Rings—Rectangular Rings

SAE J1998—Internal Combustion Engines—Piston Rings—Rectangular Rings with Narrow Ring Width

SAE J1999—Internal Combustion Engines—Piston Rings—Scraper Rings

SAE J2000—Internal Combustion Engines—Piston Rings—Keystone Rings

SAE J2001—Internal Combustion Engines—Piston Rings—Half Keystone Rings

SAE J2002—Internal Combustion Engines—Piston Rings—Oil Control Rings

SAE J2003—Internal Combustion Engines—Piston Rings—Coil Spring Loaded Oil Control Rings

SAE J2004—Internal Combustion Engines—Piston Rings—Expander/Segment Oil Control Rings

SAE J2226—Internal Combustion Engines—Piston Rings—Steel Rectangular Rings

ISO 2859—Sampling procedures and tables for inspection by attributes

ISO 6621/1—Internal combustion engines—Piston rings—Vocabulary

ISO 6621/2—Internal combustion engines—Piston rings—Measuring principles

ISO 6621/3—Internal combustion engines—Piston rings—Material specifications

ISO 6621/4—Internal combustion engines—Piston rings—General specifications

ISO 6621/5—Internal combustion engines—Piston rings—Quality requirements

ISO 6622/1—Internal combustion engines—Piston rings—Rectangular rings

ISO 6622/2 TR—Internal combustion engines—Piston rings—Rectangular rings with narrow ring width

ISO 6623—Internal combustion engines—Piston rings—Scraper rings

ISO 6624/1—Internal combustion engines—Piston rings—Keystone rings

ISO 6624/2 TR—Internal combustion engines—Piston rings—Half keystone rings

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

ISO 6627 TR—Internal combustion engines—Piston rings—Expander/segment oil control rings

Developed by the SAE Piston Ring Standards Committee 7

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

SURFACE VEHICLE STANDARD

SAE J1996

REAF. APR1998

Issued 1990-06
Reaffirmed 1998-04

Superseding J1996 OCT92

Submitted for recognition as an American National Standard

Internal Combustion Engines—Piston Rings—Quality Requirements

This SAE Standard is equivalent to ISO Standard 6621/5.

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

1. Scope—Differences, where they exist, are shown in Appendix A.

This SAE Standard specifies the quality aspects that are capable of definition but not normally found on a drawing specification.

The difficulty of trying to define in absolute terms the quality attainable in normal commercial manufacture of piston rings is well known. In this document the commonly encountered aspects of quality in terms of casting defects and other departures from ideal are quantified. Many minor defects are clearly quite acceptable; other defects because of size or numbers are inadmissible.

This document covers the following:

a. Single piece piston rings of grey, carbidic, malleable, spheroidal graphite cast iron or steel
b. Multipiece piston rings (oil control rings) consisting of cast iron parts and spring components
c. Single piece and multipiece rings of steel, i.e., oil control rings in the form of strip steel components or steel segments (rails) with spring expander components

In addition to specifying certain limits of acceptance relating to inspection measuring principles (covered by SAE J1589) this document also covers those features for which no recognized quantitative measurement procedures exist and which are only checked visually with normal eyesight and without magnification. Such features (superficial defects) are additional to the standard tolerances of ring width, radial wall thickness, and closed gap.

The requirements of this document apply to all rings up to and including 200 mm diameter covered by the above classification for both reciprocating internal combustion engines and compressors.

QUESTIONS REGARDING THIS DOCUMENT: (724) 772-8512 FAX: (724) 776-0243
TO PLACE A DOCUMENT ORDER; (724) 776-4970 FAX: (724) 776-0790
SAE WEB ADDRESS http://www.sae.org

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
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
		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—COILSPRING LOADED OIL CONTROL RINGS
J2004	6627 TR	INTERNAL COMBUSTION ENGINES—PISTONRINGS—EXPANDER/SEGMENT OIL CONTROL RINGS
J2226		INTERNAL COMBUSTION ENGINES—PISTON RINGS—STEEL RECTANGULAR RINGS
	2859	SAMPLING PROCEDURES AND TABLES FOR INSPECTION BYATTRIBUTES

3. Definitions—

The terminology used in this document is as given in SAE J1588.

4. Visible Defects

4.1 General—Visible defects are divided into two principle classes as described in 4.2 to 4.5.

The first class covers those defects frequently found in castings and includes such defects as porosity, sand inclusions, cavities, etc.

The second class of defects covers mechanical abrasions which may occur during machining or handling of rings, and includes scratches, dents, chipping, burns, and cracks.

1. TR refers to Technical Report

Inspection of piston rings for such defects is generally carried out visually, without magnification, by inspectors having normal eyesight, corrected if necessary.

It is not intended that every ring be rigorously inspected for size and distribution of defects but rather that the values given in the tables and text be used as a general guide. However, in case of doubt, the values given should be used as the means of judging the quality of the rings.

4.2 Pores, Cavities, and Sand Inclusions—Such defects are permissible on uncoated surfaces and edges provided that the values given in Table 1 for size, number, and spacing are not exceeded.

NOTE—The depth of porosity cannot be checked visually and, therefore, no limiting values are given.

TABLE 1—PERMISSIBLE VALUES OF SIZE, NUMBER AND SPACING OF PORES, CAVITIES AND SAND INCLUSIONS

Dimensions are millimeters

Nominal diameter d_1	Defect size max on periphery(1)	Defect size max on other surfaces(1)	Defect size max on peripheral edges	Defect size max on other edges(2)	Number per ring max	Spacing(3) min
$30 \le d_1 < 60$	0.1	0.3	0.1	0.1	2	4
$60 \le d_1 < 100$	0.15	0.5	0.1	0.2	4	4
$100 \le d_1 < 150$	0.2	0.5	0.1	0.3	6	8
$150 \le d_1 \le 200$	0.2	0.8	0.1	0.4	6	8

1. The defects should not be closer to an edge than one-half of the maximum permissible size of the defect, with a minimum of 0.2 mm.
2. Not on inside gap edges of piston rings with internal notch.
3. Spacing includes defects on adjacent or opposite surfaces.

4.3 Scratches, Indentations, Depressions, and Cracks

4.3.1 SCRATCHES—Isolated scratches are permissible provided that:

a. No burrs are produced exceeding the permissible values given in 4.4.1.1
b. On the periphery with turned surface they are not deeper than the tool marks or, for peripheries without a turned surface, not deeper than 0.004 mm
c. On the side faces they are not deeper than 0.01 mm
d. On other surfaces they are not deeper than 0.06 mm

4.3.2 INDENTATIONS AND DEPRESSIONS—Indentations and Depressions are permissible provided that:

a. The values given in Table 11 for number and spacing of defects are met
b. No burrs are produced exceeding the permissible values given in 4.4.1.1
c. They do not exceed the values for size and depth given in Table 2

Rings of a coated/inlaid type shall not have indentations or depressions on the periphery.

NOTE—Indentations arising from hardness measurements on the side faces are acceptable provided that they do not exceed the limits given in Tables 2 and 11.

TABLE 2—PERMISSIBLE SIZE OF INDENTATIONS AND DEPRESSIONS

Dimensions are millimeters

Nominal diameter d_1	Defect size max on periphery	Defect size max on side face	Depth max
$30 \le d_1 < 100$	0.3	0.6	10% of corresponding
$100 \le d_1 < 200$	0.5	1	max defect size surface

4.3.3 CRACKS—No cracks are permissible.

See also 4.5.4 for chromium-plated peripheries.

4.4 Edges

4.4.1 EDGE CONFIGURATION—All edges of the piston ring shall be sharp; ideally they should be free from burrs and from ragged edges whether arising from crumbling of material or from deburring. Such conditions are almost impossible to achieve regularly in volume production and, hence, both burrs and removal of edge material is permitted up to the maximum sizes given in 4.4.1.1 and 4.4.1.2.

4.4.1.1 *Burrs*—Burrs are permitted up to the maximum values given in Table 3. The orientation and direction of burrs shall relate to the functional surfaces of the piston ring, that is to say any burr present should point in the direction of sliding motion of the ring and not normal to the direction of sliding.

Any burrs remaining on the edges of rings should be firmly adherent, forming an integral part of the edge.

TABLE 3—MAXIMUM SIZE OF BURRS FOR ALL SIZES OF RING

Dimensions are millimeters

Location of burr	Size of burr[(1)] max
On edges adjacent to	
the peripheral surface and side faces	0.006
the butt ends (gap surfaces)	0.04
the outside groove face (oil rings)	0.2
the inside surface and the ends of the slots (oil rings)	0.5
all other surfaces	0.1

1. Maximum values of burrs on steel rings are to be agreed on between manufacturer and purchaser.

4.4.1.2 *Edge Material Removal*—To eliminate protruding burrs in any direction, it is permissible to remove material from the edges to the values given in Table 4.

TABLE 4—EDGE MATERIAL REMOVAL IN DEBURR OPERATIONS

Dimensions are millimeters

Location of edge	Removal of material max
On peripheral edges	0.08
On peripheral edges of the gap(1)	0.15
On other edges	0.25

1. Does not apply to rings coated on the periphery that have gap edge chamfers.

4.4.2 CHIPPING AND SIMILAR DEFECTS ON PERIPHERAL EDGES, PERIPHERAL EDGES AT THE GAP, OUTSIDE GAP CORNERS AND ON PERIPHERAL CHAMFERS

4.4.2.1 Chipping and similar defects are permitted on these points provided that:

a. They are free of loosely adhering particles
b. No burrs are produced exceeding the values permitted in 4.4.1.1
c. They do not exceed half the width of any witness land on, for example, taper-faced rings
d. They do not exceed the values given in the following tables:
    1. Table 5 for uncoated rings
    2. Table 6 for plated, coating rings
    3. Table 7 for spray-coated rings
    4. Table 8 for chamfers on all rings

Typical defects are illustrated in Figures 1 to 6.

(See 4.4.2.2 for explanations of F and K.)

TABLE 5—PERMISSIBLE SIZE OF CHIPPING AND DEFECTS ON UNCOATED RINGS ON PERIPHERAL EDGES, PERIPHERAL EDGES OF THE GAP AND OUTSIDE GAP CORNERS(1)

Dimensions are millimeters

Ring width h_1	Land width h_4 or h_5	Defect in direction normal to periphery(2) on peripheral edge of gap F_1, F_3	Defect in direction normal to periphery(2) on peripheral edge F_2, F_3	Defect in direction along edge(2) on peripheral edge of gap(3) K_1, K_3	Defect in direction along edge(2) on peripheral edge K_2, K_3
$h_1 < 2$	-	0.2	0.2	0.5	0.5
$2 \le h_1 < 4$	-	0.2	0.2	0.6	0.6
$4 \le h_1 \le 6$	-	0.3	0.3	0.8	0.8
-	h_4, $h_5 < 0.5$	0.1	0.1	0.1	0.6
-	h_4, $h_5 \ge 0.5$	0.2	0.2	0.2	0.8

1. Number and spacing of defects to be in accordance with Table 1.
2. See Figures 1, 2, 3, 4, and 5.
3. Subject to a maximum of one-third of peripheral width of ring or land.

TABLE 6—PERMISSIBLE SIZE OF CHIPPING AND DEFECTS ON UNCOATED RINGS WITH CHROMIUM PLATED PERIPHERY, ON PERIPHERAL EDGES, PERIPHERAL EDGES OF THE GAP AND OUTSIDE GAP CORNERS(1)

Dimensions are millimeters

Ring width h_1	Land width h_5	Defect in direction normal to periphery(2) on peripheral edge of gap F_1, F_3	Defect in direction normal to periphery(2) on peripheral edge F_2, F_3	Defect in direction along edge(2) on peripheral edge of gap(3) K_1, K_3	Defect in direction along edge(2) on peripheral edge K_2, K_3
$h_1 < 2$	-	0.2	0.2	0.3	0.3
$2 \le h_1 < 4$	-	0.2	0.2	0.4	0.3
$4 \le h_1 \le 6$	-	0.3	0.3	0.4	0.4
-	$h_5 < 0.5$	0.1	0.1	0.1	0.6
-	$h_5 \ge 0.5$	0.2	0.1	0.2	0.6

1. Number and spacing of defects to be in accordance with Table 1.
2. See Figures 1, 2, 3, 4, and 5.
3. Subject to a maximum of one-third of peripheral width of ring or land.

TABLE 7—PERMISSIBLE SIZE OF CHIPPING AND DEFECTS ON SPRAY COATED RINGS ON PERIPHERAL EDGES, PERIPHERAL EDGES OF THE GAP AND OUTSIDE GAP CORNERS(1)

Dimensions are millimeters

Ring width h_1	Defect in direction normal to periphery(2) on peripheral edges of the gap F_1, F_3	Defect in direction normal to periphery(2) on peripheral on edges(3) F_2, F_3	Defect in direction along edge(2) on peripheral edge of the gap(4) K_1, K_3	Defect in direction along edge(2) on peripheral edge(3) K_2, K_3
$h_1 < 2$	0.3	0.3	0.5	0.5
$2 \le h_1 < 4$	0.3	0.3	0.6	0.6
$4 \le h_1 \le 6$	0.4	0.4	0.8	0.8

1. Number and spacing of defects to be in accordance with Table 1.
2. See Figures 1, 2, 3, 4, and 5.
3. Only for fully faced and semi-inlaid design.
4. Subject to a maximum of one-third of peripheral width of ring or land.

TABLE 8—PERMISSIBLE SIZE OF CHIPPING AND DEFECTS ON CHAMFERS AT THE PERIPHERAL EDGE AND PERIPHERAL EDGE OF THE GAP(1)

Dimensions are millimeters

Ring width h_1 $h_1 < 2$	Size of defect L_1/L_2 max 0.5
$2 \le h_1 < 4$	0.8
$4 \le h_1 \le 6$	1.2

1. Number and spacing of defects to be in accordance with Table 1.

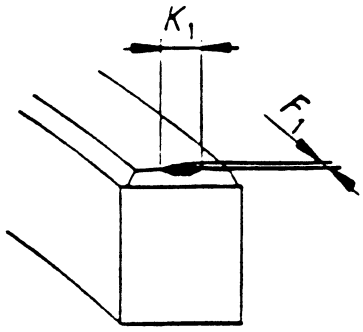

FIGURE 1—CHIPPING ON PERIPHERAL EDGES OF THE GAP

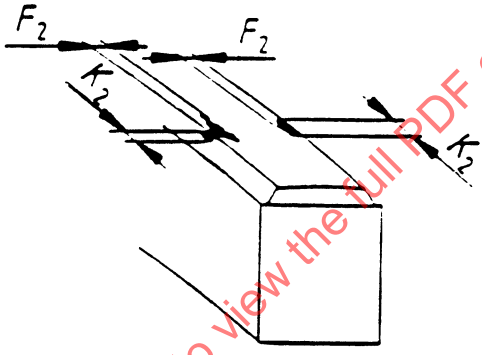

FIGURE 2—CHIPPING ON PERIPHERAL EDGES

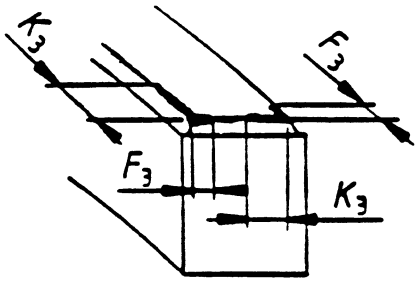

FIGURE 3—CHIPPING ON OUTSIDE GAP CORNERS

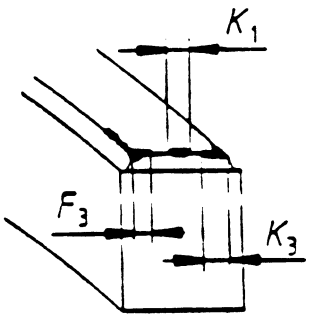

FIGURE 4—COMBINATION OF Figures 1 AND 3

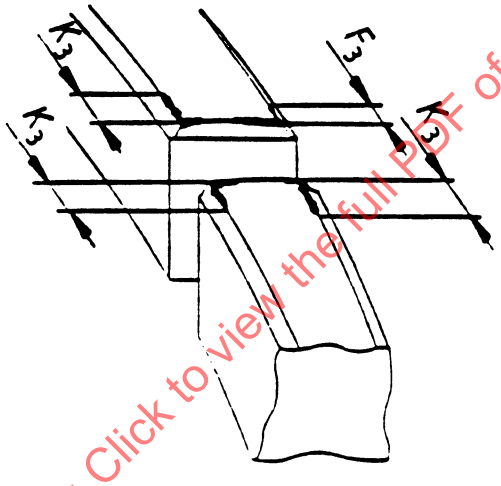

FIGURE 5—CHIPPING ON OPPOSITE GAP CORNERS

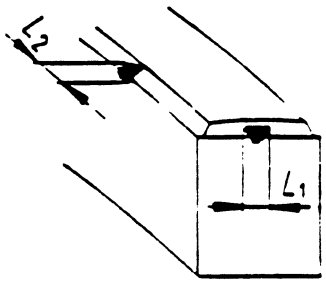

FIGURE 6—CHIPPING ON CHAMFERS