

Guide to the Application and Use of Passenger Car Air-Conditioning Compressor Face Seals

- 1. Scope**—This SAE Recommended Practice is intended as a guide in the usage of mechanical face seals for the passenger car air-conditioning compressor application. Included in this guide is a compilation of present practices; for example, a description of various type seals, material combinations, design data, tolerances, drawing format, qualification testing, inspection information, and quality control data. The terminology used is recommended to promote uniformity in seal nomenclature.
- 2. References**
 - 2.1 Applicable Publication**—The following publication forms a part of this specification to the extent specified herein.
 - 2.1.1 ANSI PUBLICATION**—Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002.

ANSI B46.1
- 3. Seal and Mating Ring Types**—The mechanical face seal assemblies utilized in passenger car air-conditioning compressors consist of a seal head and a mating ring. Although many variations of face seal designs exist, two basic concepts are predominantly applied with respect to both seal head and mating rings.
 - 3.1 Seal Head**—The two basic design classifications are pusher and nonpusher. By definition, pusher seals are mechanical seals employing a secondary sealing element (such as O-rings, V-rings, U-cups, wedges, etc.) that are pushed along the respective sealing surfaces while the primary sealing function at the faces is being performed. A typical pusher seal is shown in Figure 1B. Nonpusher seals shown in Figures 1A, 1C, and 1D employ a bellows or diaphragm as a secondary sealing element. Axial displacement of the seal components caused by wear at the seal faces and/or shaft movement causes sliding or “pushing” of the secondary seals in the pusher seals. This same displacement in nonpusher seals is taken up by flexing of the bellows. The selection of seal head design is based primarily on seal environmental conditions.

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SEAL HEADS									
IA	IB	IC	ID						
MATING RINGS									
IE	IF	IG	IH	IJ					
SEAL ASSEMBLY FIG'S IA, IB, IC, & ID	MATING RINGS FIG'S IE, IF, IG, IH & IJ	APPLICATION PASSENGER OR NON PASS	A MIN./MAX. BORE I.D.	B MAX. OUTSIDE DIA.	C1 MIN./MAX. FREE LENGTH	C2 MAX. SOLID LENGTH	C3 MIN. OPERATING LENGTH	C4 NCM. OPERATING LENGTH	
C5 MAX. OPERATING LENGTH	D MAX. SHELL LENGTH	E MAX. LOAD AT C3	E2 NCM. LOAD AT C4	E3 MIN. LOAD AT C5	F MIN./MAX. MATING RING ASS'Y I.D.	G MIN./MAX. MATING RING ASS'Y O.D.	H MIN./MAX. MATING RING ASS'Y THICKNESS	J MIN./MAX. MATING RING BOLT CIRCLE	
HOUSINGS & SHAFTS									
IK	IL	IM							
A SEAL HOUSING BORE DIA.	B SHAFT DIA.	C SEAL CAVITY LENGTH	D SEAL BORE LEAD IN CHAMFER	SURFACE ROUGHNESS A	SURFACE ROUGHNESS B	SHAFT END PLAY	CONCEN- TRICITY A-B	SQUARE -NESS B-E	SQUARE -NESS B-F
FLUID COMPOSITION _____						DRWN. _____		COMPANY NAME _____	
R.P.M. _____ MIN. _____ MAX.						CHKD. _____			
TEMPERATURE _____ MIN. _____ MAX.						APPD. _____			
PRESSURE _____ MIN. _____ MAX.						BY _____		DATE _____	
OIL VISCOSITY _____						SCALE _____		PART NO. _____	
REMARKS _____				REV. _____	DESCR _____	BY _____	DATE _____		

FIGURE 1—DRAWING FORMAT

Independent of classification, the seal head is the rotating element of the seal assembly and is comprised of the following components:

- a. Primary Ring (see Item 1, Figure 2) which is in rubbing contact with the stationary mating ring (see Item 5, Figure 2). This interface forms the primary seal.
- b. Secondary Seal (see Item 2, Figure 2) as defined in 3.1.
- c. Spring (see Item 3, Figure 2) which provides mechanical load to the primary faces.
- d. Hardware consisting of retaining and drive devices (see Item 4, Figure 2) which provide reactionary support for the spring and transmit shaft rotation drive to the primary ring. Secondary seal support function is also provided by these components. On some nonpusher seal designs, seal head drive is provided via a positive interference of the elastomeric secondary seal element with the compressor shaft and hardware components.

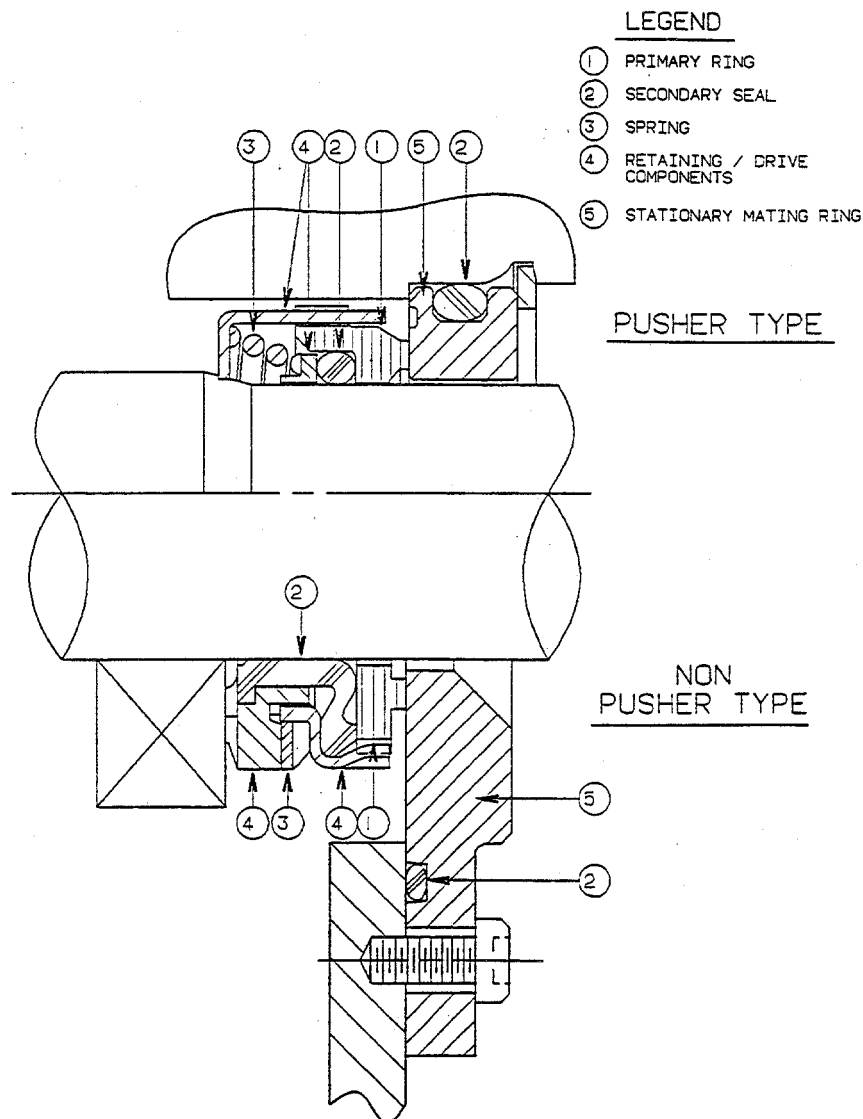


FIGURE 2—SEAL COMPONENTS

3.1.1 NONPUSHER SEAL—Nonpusher seals have been preferred for passenger car air-conditioning compressor seals where one or more of the following conditions exist:

- a. Axial shaft movement with amplitudes greater than 0.203 mm (0.008 in).
- b. Deposition of carbonized oil, foreign material, and/or corrosive products on the compressor shaft in sufficient magnitude to restrict the movement of the pusher-type secondary seal. This restriction prevents the seal from following shaft dynamics or prevents the primary faces from axial movement to accommodate seal face wear. The end result is excess leakage.
- c. Distortion of the primary seal faces caused by excessive volume swell of secondary seal elastomer.
- d. Excessive face loading due to pressure being sealed. Reduced seal balance is required to minimize heat generation in applications where standard balanced seals cannot be accommodated. Nonpusher seals, although classified as unbalanced, can be designed to have a balance of less than one without a stepped-shaft design normally required for a balanced seal. It should be noted that the balance of nonpusher seals will vary with the pressure sealed. The amount of balance variation is a function of the bellows design and materials. The term "seal balance" as used here is the ratio of hydraulic area closing the seal face to that of hydraulic area opening (A_c/A_o).

3.1.1.1 *Advantages*—In addition to the application conditions listed previously, nonpusher seals have the following advantages:

- a. Normally do not require a positive mechanical drive with the compressor shaft
- b. Are more tolerant of out-of-square mating ring face conditions

3.1.1.2 *Disadvantages*

- a. Generally more expensive due to the bellows
- b. Generally more difficult to install into compressor, due to the interference fit between shaft and drive portion of bellows

3.1.2 PUSHER SEALS—Recent passenger car compressor designs have substantially improved the seal environment, particularly with respect to temperature excursions and shaft end play. These improvements have permitted the use of pusher seals.

3.1.2.1 *Advantages*

- a. Generally lower cost due to the O-ring
- b. Generally reduced exposure of the elastomeric member to interfacial frictional heat
- c. Closer primary ring-to-shaft concentricity

3.1.2.2 *Disadvantages*

- a. Require positive shaft drive
- b. More vulnerable to seal "hang-up"
- c. More vulnerable to primary ring face distortion caused by secondary seal volume change

3.2 **Mating Ring**—Two basic mating ring designs are incorporated in air-conditioning compressor seals:

- a. End-plate designs as shown in Figure 1G which are an integral part of the compressor
- b. Separate secondary seal-mounted mating rings as shown in Figures 1E, 1F, 1H, and 1J

The selection of the mating ring design is based principally on compressor design, seal operating conditions, and mating ring material.

3.2.1 **END PLATE DESIGNS**—End plate designs are generally machined from fine-grained cast iron with a precision-lapped seal mating surface.

3.2.1.1 *Advantages*

- a. Requires less axial space
- b. Provides better frictional heat transfer capabilities

3.2.1.2 *Disadvantages*

- a. Geometry generally limits material selection
- b. Subject to face distortion due to bolt stresses. Distortion can be minimized by use of a clamping ring which eliminates localized bolt stresses.
- c. More difficult to lap primary seal face due to size and shape

3.2.2 **SEPARATE MATING RINGS**—Separate mating rings are fabricated from various materials and are precision lapped.

3.2.2.1 *Advantages*

- a. Due to relatively simple shape, rings can be produced from various materials such as cast iron, sintered iron, high alumina ceramics, etc.
- b. Lower cost due to simpler configuration and smaller size
- c. Less face distortion when installed
- d. Easier to lap

3.2.2.2 *Disadvantages*

- a. Reduced frictional heat dissipation
- b. Secondary seal is often subjected to higher temperatures due to closer proximity to the primary seal faces
- c. More potential for installation damage or misassembly of secondary seals

3.3 **Secondary Seals**—Three basic secondary seals are employed. The most universal is an O-ring. Flat gaskets and molded or lathe-cut rings are also incorporated in conjunction with end-plate designs and mating rings. In end-plate designs, the O-ring, molded or lathe-cut ring is preferred over flat gaskets for control of flatness and to improve heat transfer from the end plate.

O-ring configurations are also preferred for separate mating rings, again primarily for simplicity and cost.

4. **Seal Materials**—Environmental conditions dictate the type of material which should be used in a specific application. Seal materials can be fully evaluated only in terms of specific operating conditions and performance requirements. The following paragraphs describe primary seal ring materials, mating ring materials, secondary seals and the elastomeric compounds used to fabricate them, seal hardware, and springs.

4.1 **Primary Ring**—The primary ring material must be impervious to environmental pressure, display adequate friction/wear properties, have good thermal conductivity and remain stable under the temperature, pressure, and fluid conditions in a compressor.

4.1.1 **RESIN BONDED GRAPHITE**—Thermoset materials generally made from phenolic resin, graphite, and varying amounts of mineral fillers. Usually processed in the 149 to 315 °C temperature range.

4.1.1.1 Advantages

- a. Good wear resistance
- b. Readily molded to complex geometry and close tolerances
- c. Good inherent low porosity
- d. Low cost
- e. Good handling characteristics (resists chips and cracks)

4.1.1.2 Disadvantages

- a. Fair thermal stability
- b. Lower maximum operating temperature
- c. Fair thermal conductivity

4.1.2 CARBON-GRAPHITE—A manufactured product of carbon and graphite in a rigid, hard structure produced by firing at high temperatures usually in the range of 900 to 2000 °C. Carbon-graphite is inherently porous after firing and must be made impervious for use as a primary seal ring. Various materials are used to impregnate the carbon-graphite structure.

4.1.2.1 Advantages

- a. Excellent temperature resistance and stability
- b. Excellent compatibility with refrigerants and associated lubricants (impregnant must be properly chosen)
- c. Excellent wear resistance
- d. Good thermal conductivity
- e. Low thermal distortion coefficient

4.1.2.2 Disadvantages

- a. Difficult to mold complex shapes and maintain close tolerances
- b. Fair handling characteristics (vulnerable to chips and cracks)
- c. High cost

4.2 Mating Ring—The mating ring is usually a dissimilar material, and harder than the primary seal ring. The material choice depends upon operating conditions, configuration, costs, and performance requirements.

4.2.1 CAST IRON—Cast iron is used in various forms and grades. Microstructure and hardness are principal criteria for grade selection.

4.2.1.1 Advantages

- a. Low cost for complex shapes
- b. Excellent thermal shock resistance
- c. Good wear resistance
- d. Low thermal distortion coefficient

4.2.1.2 Disadvantages

- a. Control of microstructure and casting defects critical to insure good performance
- b. Fair corrosion resistance
- c. Fair scratch resistance