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Valve Seat Insert Information Report

RATIONALE

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Foreword—This Document has not changed other than to put it into the new SAE Technical standards Board format.

Valve seat inserts are installed in internal combustion engine heads or blocks to provide a seating surface for poppet valves. Inserts are usually metallic rings; however, other geometries are also employed. Other materials such as ceramics and ceramic-coated metals have been used on an experimental basis and copper beryllium inserts are used in some racing applications.

Inserts are used for two fundamental reasons. First, and most important, insert alloys are more wear and heat resistant than the block or head material, making them better suited for the harsh environment encountered during valve seating. Engine durability can thus be improved. Second, the use of inserts permits easier field repair or rebuild of engines.

The most common installation practice is to retain the insert through an interference fit between it and the mating counterbore. In addition to retaining the insert, the fit promotes efficient heat transfer from the insert to the mating material. In special applications, the valve seat insert is held in place by mechanical means such as threads or retaining rings. Inserts may also be cast in place.

1. Scope—This SAE Information Report provides engineers and designers with:

- a. Types of valve seat inserts and their nomenclature
- b. Valve seat insert alloy designations and their chemistries
- c. Valve seat insert alloy metallurgy
- d. Typical mechanical and physical properties of insert alloys
- e. Recommended interference fits
- f. Installation procedures
- g. Application considerations

2. References—There are no referenced publications specified herein.

3. Types of Valve Seat Inserts

3.1 Standard Valve Seat Insert—Figures 1 and 2 show the most common type of insert and counterbore in use today along with their nomenclature. This valve seat insert is a cylindrical, ring-shaped component which is usually pressed into a head or block counterbore.

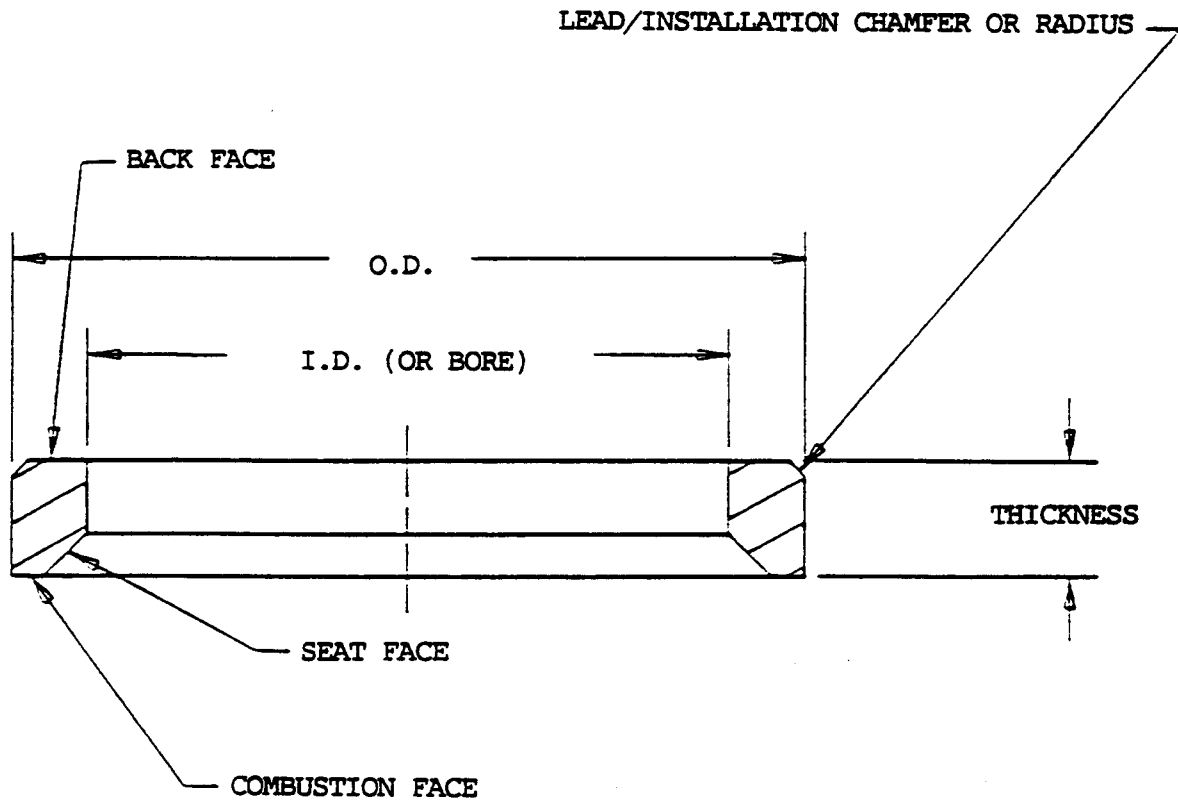
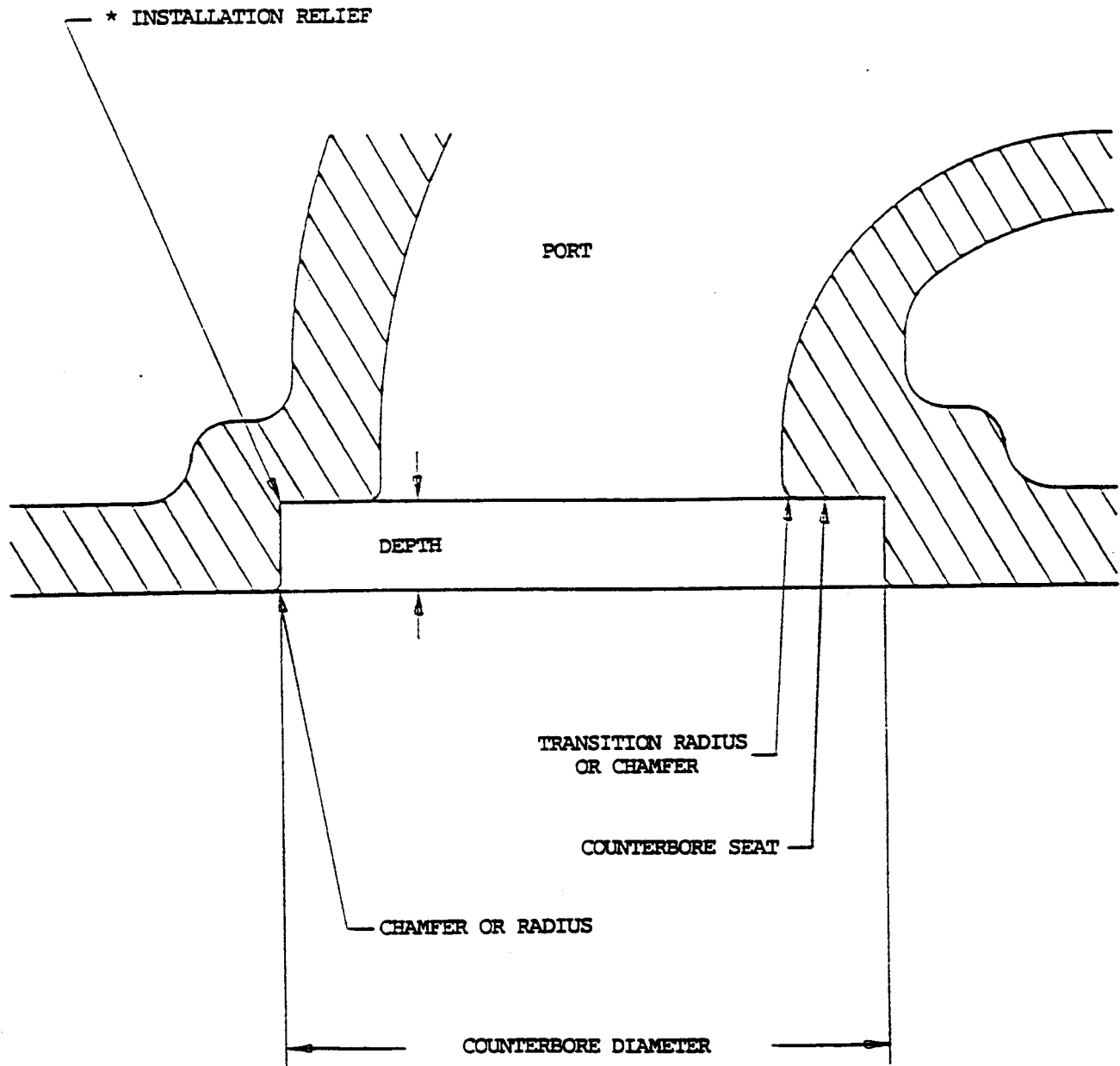


FIGURE 1—STANDARD VALVE SEAT INSERT



* MUST BE SMALLER RADIUS THAN INSERT LEAD/INSTALLATION CHAMFER OR RADIUS

FIGURE 2—STANDARD INSERT COUNTERBORE

- 3.2 Skirted Insert**—The flexible or skirted insert shown in Figure 3 is used in some air-cooled engine applications. The clearance between the flange diameter and the cylinder head allows slight movement of the cylinder head to occur without distorting the seating surface. Insert retention is accomplished by an interference fit between the skirt diameter and the head. This puts the insert head interface farther away from the port in a relatively cooler area, thus aiding retention. Insert retention is also aided by a nominal 1/4 degree reverse taper on the skirt outside diameter.

4. Valve Seat Insert Alloy Designations—Table 1 describes the valve seat insert chemical compositions. Table 2 enumerates the valve seat insert materials, manufacturers, and usage. All tabularized data is submitted by the manufacturers as typical.

5. Valve Seat Insert Alloy Metallurgy

5.1 General—Valve seat inserts are manufactured using cast, wrought, or sintered powder metallurgy processes. Wear resistance is generally related to the volume fraction of hard phases such as martensite, carbides, nitrides, and oxides. The major alloy categories in each of these three groups follows along with a brief metallurgical description of each category.

Table 3 lists the typical microstructural constituents of the valve seat materials identified in the document.

6. Cast Alloys

6.1 Grey Cast Iron—Low alloy grey iron is used for light- to moderate-duty intake applications and light-duty exhaust applications. It is sometimes used in the as-cast condition, but may also be heat treated for improved strength and hardness. Grey iron offers low alloy cost and good machinability. For certain applications, it is also less abrasive to the mating valve.

6.2 Ductile Cast Iron—Ductile iron finds limited use in high performance applications seating against titanium valves. It is usually supplied in the hardened and tempered condition.

6.3 White Cast Iron—White iron is employed primarily in heavy-duty intake applications for wear resistance. White irons used for inserts normally have significant additions of carbide formers such as chromium, tungsten, vanadium, or molybdenum. They are also normally heat treated so that the final microstructure consists of alloy carbides in a martensitic matrix.

6.4 Austenitic Cast Iron Alloys—UNS¹ (Ni-resist™) is a typical example of these alloys and is used in some aluminum head applications. It is a highly alloyed austenitic iron which possesses a high coefficient of thermal expansion.

6.5 Cast Martensitic Alloys—Martensitic alloys find application in moderate- to heavy-duty intake inserts and moderate-duty exhaust inserts. They have a temperature capability of approximately 430 to 600 °C (800 to 1100 °F). These alloys are based on tool steel or martensitic stainless steel compositions and are supplied in the hardened and tempered condition. Their microstructures typically consist of alloy carbides in a martensitic matrix. Alloys possessing in excess of 12% chromium generally exhibit excellent hot corrosion resistance.

1. No UNS number assigned.

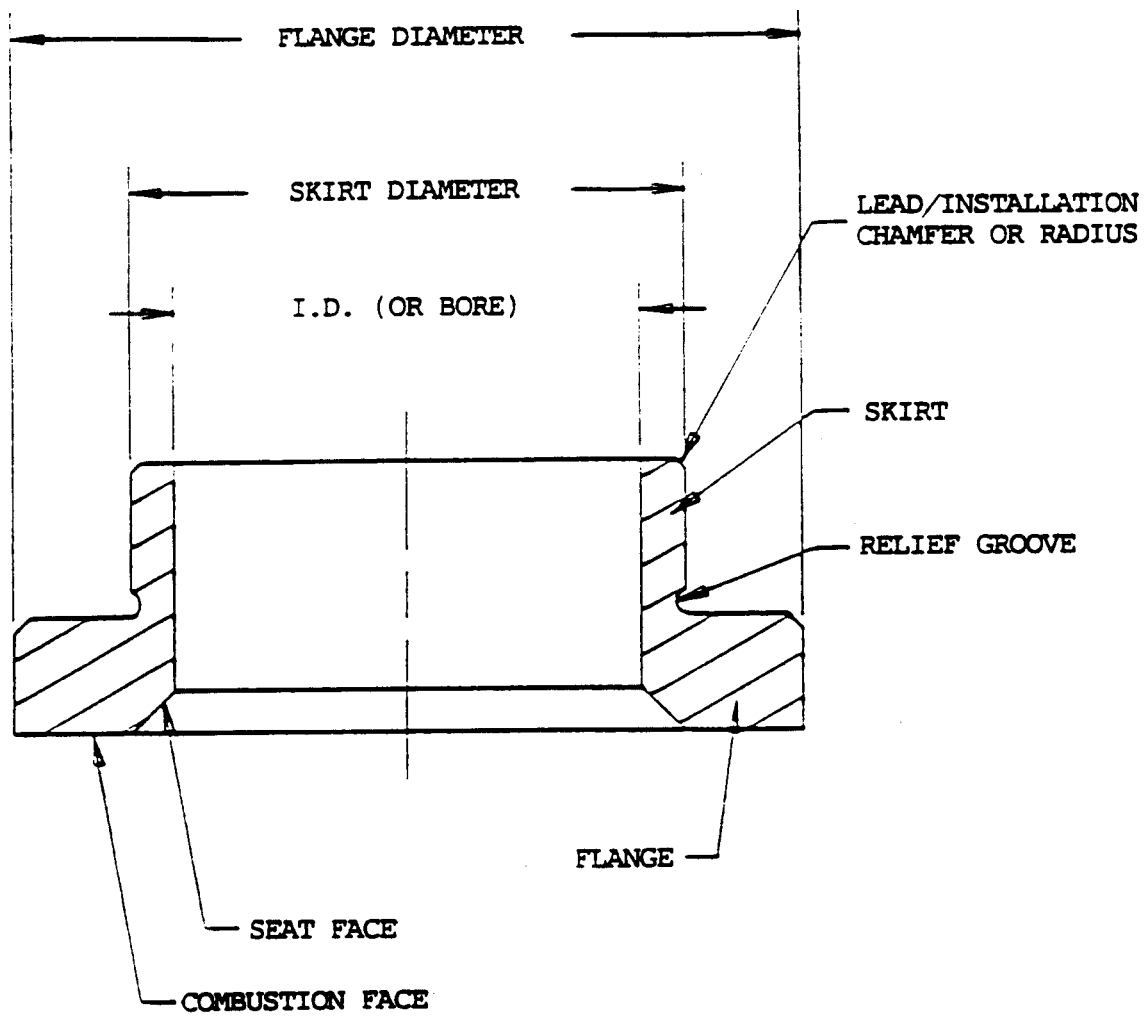


FIGURE 3—FLEXIBLE OR SKIRTED VALVE SEAT INSERT

TABLE 1—⁽¹⁾ VALVE SEAT INSERT MATERIAL CHEMICAL COMPOSITIONS (MINIMUM/MAXIMUM - WEIGHT %)

Trade Name	C	Si	Mn	P	S	Co	Cr	Mo	Ni	V	W	Fe	Others
ALLOY 1H	3.50/3.90	2.20/3.10	0.40/0.80	0.30/0.80	0.00/0.10		0.10/0.20	1.00/1.20	0.20/0.50			BAL	Cu 0.10/0.25 Combined C 0.45/0.75
ALLOY 7	2.50/3.00	1.50/2.50	0.50/0.80	0.00/0.20	0.00/0.10		2.75/3.25	4.00/5.00	1.00/1.60			BAL	
ALLOY 11	1.25/1.75	1.90/2.60	0.20/0.60	0.00/0.15	0.00/0.10		19.00/21.00		1.00/1.60			BAL	
ALLOY 13	1.35/1.75	1.90/2.60	0.20/0.60	0.00/0.03	0.00/0.03		19.00/21.00		BAL			BAL	
ALLOY 79	1.30/1.50	0.00/1.00	0.00/0.75			9.00/11.00	25.00/28.00	9.00/11.00			9.00/11.00	10.50/14.00	
ALLOY 81	2.00/2.75	0.00/1.00					27.00/31.00		46.00/52.00		14.00/16.00	0.00/3.00	
ALLOY 589	2.90/3.40	0.50/1.50	0.00/0.50				15.50/18.50	14.50/17.50		1.65/2.10		BAL	
EH-2	0.70/1.10						2.00/4.00	0.20/0.40		0.20/0.40		BAL	
EH-8	0.60/1.10	0.10/0.30				5.00/10.00	1.00/2.00	1.50/4.00	0.50/1.00	0.10/0.20		BAL	
EH-9	0.60/1.10						1.00/4.00	2.50/8.00	0.50/3.00			BAL	Cu 0.50/2.00
EH-10	0.60/1.10	0.10/0.50				10.00/15.00	2.00/4.00	4.00/7.00	0.50/2.00	0.10/0.20		BAL	
EH-11	0.40/0.80	0.10/0.50				10.00/15.00	0.50/2.00	3.00/7.00	0.50/1.00			BAL	Pb 13.00/23.00
EMS 541	0.70/1.10		3.00/4.70	0.00/0.05	0.10/0.25		8.00/10.75		0.75/1.50			BAL	Cu 1.50/2.50 Mg 0.13/0.30
EMS 542	0.55/0.90		0.20/0.45	0.00/0.05	0.00/0.05			0.65/0.85	0.35/0.55			BAL	Cu 1.50/2.50 Mg 0.13/0.30
EMS 544	0.70/1.10		3.00/5.00		0.04/0.15		8.00/10.75	0.30/0.45	0.75/1.80			BAL	Cu 1.50/2.50 Mg 0.13/0.30
EMS 554	1.60/2.00		1.00/2.70	0.00/0.05	0.03/0.06		4.00/6.50	0.30/0.45	1.60/2.40			BAL	Cu 2.50/4.00 Mg 0.13/0.30
GM 76135	1.20/1.50	0.30/0.60	0.30/0.60	0.00/0.20	0.00/0.10		3.50/4.25	6.00/7.00	0.00/1.00		5.00/6.00	BAL	Cu 0.00/0.25
J3	2.20/2.70	0.00/1.50	0.00/1.00			BAL	29.00/33.00		0.00/3.00		11.00/14.00	0.00/3.00	
J6	0.90/1.40	0.00/1.50	0.00/1.00			BAL	27.00/31.00		0.00/3.00		3.50/5.50	0.00/3.00	
J10	0.00/0.08	2.20/2.60				BAL	7.50/8.50	26.50/29.00				0.00/3.00	(with Ni)
J70	2.20/2.80	0.00/1.25				15.00/18.50	26.50/31.50	1.75/2.75	BAL	1.75/2.75	0.00/1.50	0.00/9.00	
J96	2.00/2.75	0.00/1.50					27.00/31.00		BAL		14.00/16.00	0.00/8.00	
J100	2.00/2.75	0.00/1.00				9.00/11.00	27.00/31.00		BAL		14.00/16.00	0.00/8.00	
J101 H	0.00/3.00	1.00/3.00	1.00/2.00				1.75/3.00		13.50/17.50			BAL	Cu 4.50/7.50
J120	1.20/1.50	0.30/0.60	0.30/0.60	0.00/0.20	0.00/0.10		3.50/4.25	6.00/7.00	0.00/1.00		5.00/6.00	BAL	
J122	2.50/3.00	1.50/2.50	0.50/0.80				2.75/3.25	4.00/5.00				BAL	
J125	1.25/1.75	1.90/2.60	0.20/0.60	0.00/0.15	0.00/0.10		19.00/21.00		1.00/1.75			BAL	
PL 7N	3.10/3.50	1.80/2.40	0.40/0.80	0.40/0.60	0.00/0.08		0.50/0.80	1.00/1.30	0.80/1.20			BAL	
PL 12M	1.80/2.30	0.80/1.20	0.00/0.60	0.00/0.06	0.00/0.04		12.00/14.00	2.00/2.50	0.00/0.50			BAL	