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AEROSPACE INFORMATION REPORT

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V-Couplings, Application of

FOREWORD

Changes in this reaffirm are format/editorial only.

1. SCOPE:

This SAE Aerospace Information Report is intended to inform users of the proper use, application, and installation of V-couplings. V-couplings will perform only if they are properly installed. This document informs the user of the correct manner of applying and installing V-couplings and also cautions against improper use.

2. REFERENCES:

2.1 Applicable Documents:

The following documents provide information relating to specific V-coupling design criteria and to military standard couplings:

2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

ARP699	High Temperature Pneumatic Duct Systems for Aircraft
AS1895	Coupling Assembly, V-Retainer, High Pressure, High Temperature, Pneumatic Tube
AS1960	Coupling Assembly, V-Band, Sheet Metal Flange, Pneumatic Tube
AS4108	T-Bolt and Eye Bolt, A-286 Cres, 1000 °F Fatigue Rated

2.1.2 U.S. Government Publications: Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-C-27536	Coupling, Clamp, Grooved, V-band (Established V-band coupling requirements. Various configurations are specified to Standards MS27114 through MS27116.)
MIL-L-46010	Lubricant, Solid Film, Heat-Cured, Corrosion Inhibiting
MIL-N-25027	Nut, Self-Locking, 250 °F, 500 °F, and 800 °F

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2.1.2 (Continued):

MIL-N-7873	Nut, Self-Locking, 1200 °F
MIL-W-6858	Welding, Resistance: Spot and Seam
MS 24563	Coupling Flanges, V-Band, Profile Dimensions for

2.2 Definitions:

V-BAND COUPLING: A sheet metal band clamp with sheet metal retainer sections welded or riveted to the band.

V-RETAINER COUPLINGS: Coupling with the V-retainer as an integral part of the coupling segment. V-retainer coupling have no straps. The latch components are attached to lugs on the retainer segments.

V-COUPLING: The family of V-band couplings and V-retainer couplings.

2.3 Symbols:

Ag = Seal load, in psi
B = Bolt nominal diameter, in inches
Df = Flange outside diameter, in inches
Dn = Coupling nominal diameter, in inches
Dpl = Pitch line diameter, in inches (flange to retainer contact point, see Figure 1)
Ds = Diameter at seal line or seal, in inches
H = Hoop or circumferential band load, in pounds
Kb = Number of bolts at each latch location
Ga = Radial apex gap, in inches
E = Axial load, in pounds
H = Seal height, in inches
Ls = Axial load to preload seal, in pounds
M = Bending moment, in pounds-inches
Na = Axial tension load, in pounds per inch of circumference
Nb = Axial force as a result of bending moments, in pounds per inch of circumference
Np = Axial force due to internal pressure, in pounds per inch of circumference
N = Design load, in pounds per inch of circumference
Ns = Seal seating load, in pounds per inch of circumference
P = Internal pressure, psig
T = Approximate nut design torque, in pounds-inches
ϕ = V-Retainer angle, in degrees (commonly 40 degrees)

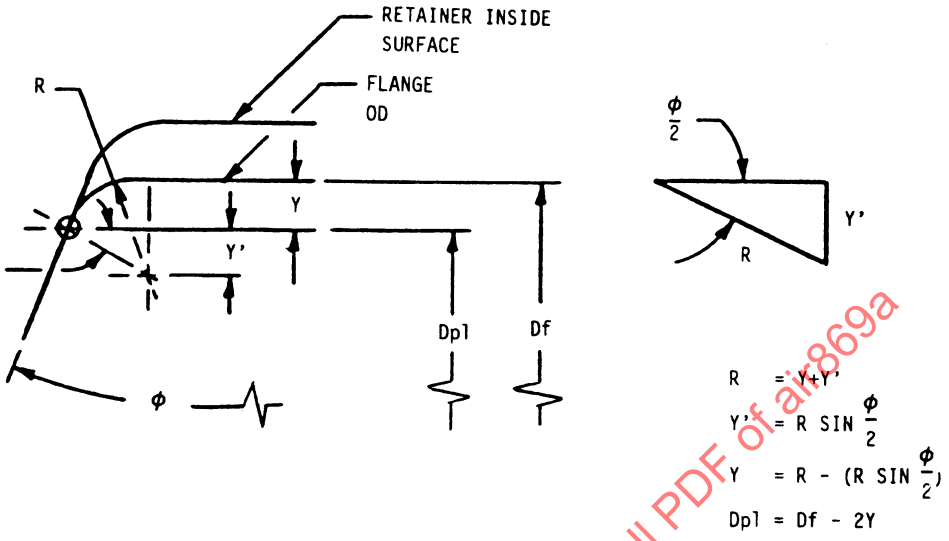


FIGURE 1 - Location of Flange to Retainer Contact Point (Dpl)

2.3.1 Subscripts:

a. c = coupling
b. f = flange
c. g = gasket
d. b = bending moment
e. pl = pitch line
f. n = nominal
g. p = pressure
h. s = seal line or seal

3. V-COUPLING AND DESIGN FACTORS:

V-couplings are used to join two flanges together forming a V-coupling joint. The coupling is tightened by applying torque to a nut which tightens a circumferential band or an integral retainer and lugs exerting an inward radial force onto V-shaped retainer segments. These retainer segments then exert an axial clamping force onto the flanges, joining or pressing them together. V-couplings consist of V-band couplings (Figures 2 and 3) and V-retainer couplings (Figure 4).

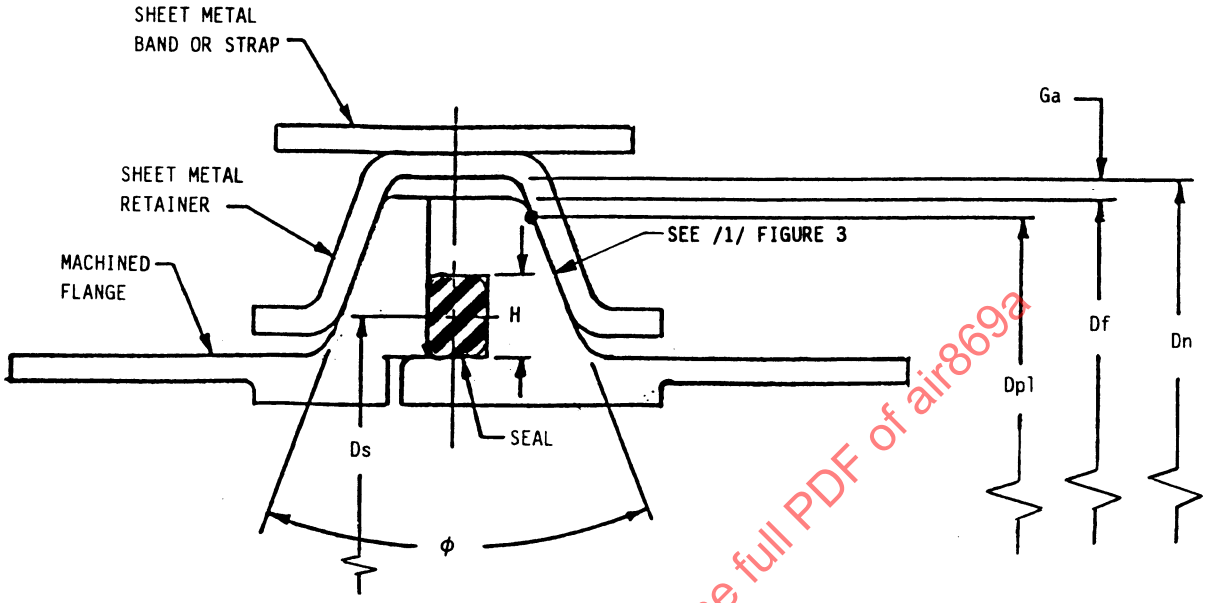
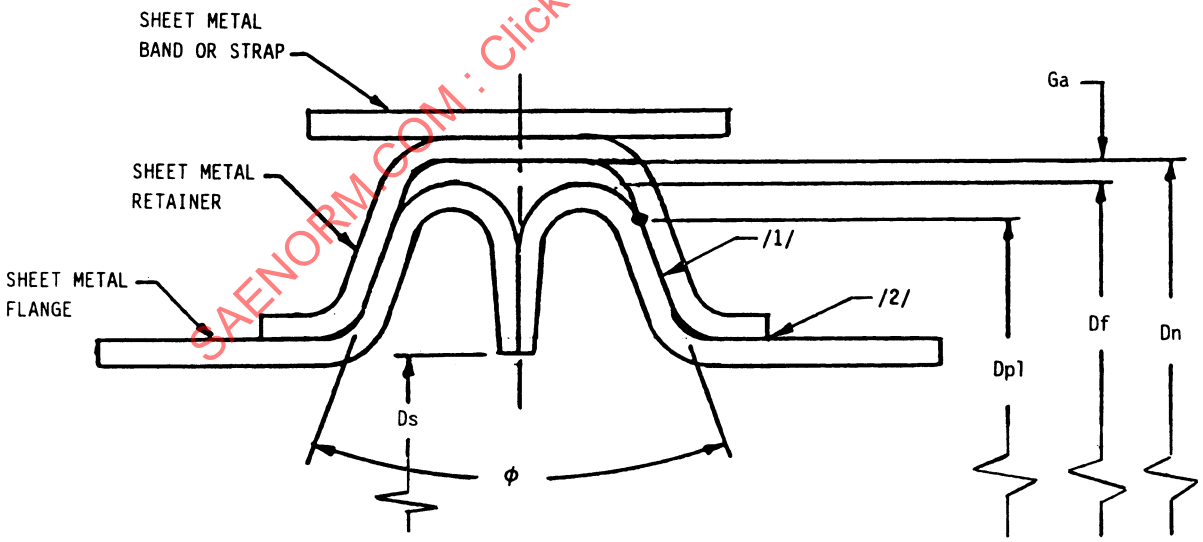


FIGURE 2 - V-Band Coupling Joint and Machined Flanges



NOTES:

/1/ Retainers may spread in the installed condition causing a gap between the flange and retainer.

/2/ Retainer foot may bottom on flange skirt as shown or may have a gap equal to or greater than Ga.

FIGURE 3 - V-Band Coupling Joint and Sheet Metal Flanges

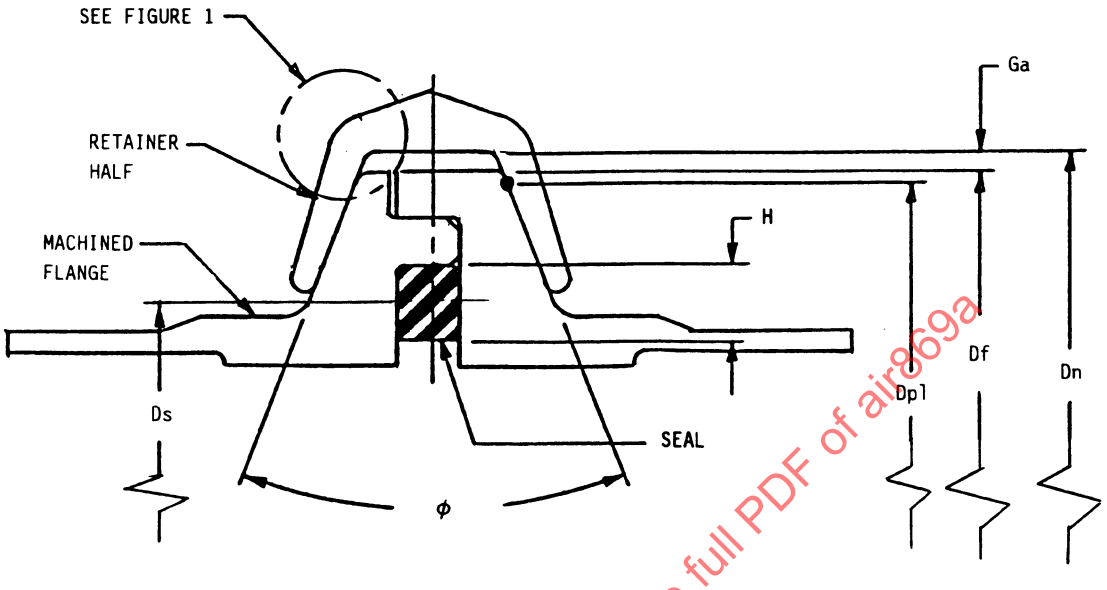


FIGURE 4 - V-Retainer Coupling Joint and Machined Flanges

3.1 Design Loads and Torque:

The axial compressive clamping load that is generated by the application of nut torque must be sufficient to withstand design loads and the required seal load if used. These loads can be resolved into a load per unit of circumferential length at the flange to retainer contact point (Dpl Figures 2, 3, 4) by the following formulas:

3.1.1 Seal Seating Load (Ns):

a. Load-per-unit circumferential length, Ns, at pitch diameter, Dpl, may be given by the seal manufacturer.

b. Or if total axial load, E, required to seal joint is given, then:

$$Ns = \frac{E}{\pi Dpl} \qquad \text{(Eq. 1)}$$

c. Or with seal load per unit area Ag given:

$$Ns = Ag\,H \qquad \text{(Eq. 2)}$$

(No consideration is given to the difference between actual diameter of seal and pitch diameter since it is relatively minor as diameters increase. The designer may account for it in the calculations if desired.)

3.1.2 Design Load (N):

a. As a result of internal pressure:

$$Np = \frac{P(Ds)^2}{4Dpl} \quad \text{(Eq. 3)}$$

b. As a result of bending moment:

$$Nb = \frac{4M}{\pi(Dpl)^2} \quad \text{(Eq. 4)}$$

c. As a result of axial tension load:

$$Na = \frac{E}{\pi Dpl} \quad \text{(Eq. 5)}$$

d. As a result of seal seating load, see 3.1.1.

NOTE: N is a result of any one or the sum of all the preceding loads.

$$N = Np + Na + Nb + Ns \quad \text{(Eq. 6)}$$

N aids in the use of published clamp manufacturers "pressure curves" which rate V-couplings according to diameter and internal pressure loading only. If such curves are unavailable, consult the clamp manufacturer.

3.1.3 Design Torque (T): The approximate design torque in pound-inches is

$$T = \frac{.2\ HB}{Kb} \quad \text{(Eq. 7)}$$

where the bolt and the circumferential hoop load (H) in the band (retainer to flange friction is neglected) is

$$H = NDpl\ TAN\ \frac{\phi}{2} \quad \text{(Eq. 8)}$$

The recommended torque for the V-coupling should be the approximate design torque given by the above calculation plus an allowance for friction of the threads. Since thread friction is often unpredictable, actual testing and reference to clamp manufacturers recommended torque values is suggested. Locknut designs and thread lubricants will effect the design torque. Locknuts generally increase torque requirements while lubricants tend to decrease torque requirements.

3.1.4 Critical Installation: Most pneumatic duct flange are critical in application because they contain high temperature gaseous fluid media. For such installations, the following are design recommendations.

a. Consider the operating temperature of the V-coupling when selecting materials. The more commonly used materials for the band, retainers, trunnion, and latch are as follows:

(1) 300 series cres: 800 °F max
(2) A286 cres: 1200 °F max
(3) Nickel alloys: 1200 °F max

All sheet metal V-couplings operating over 800 °F should have tangential wraps (see Figure 5) to prevent relaxation of the band tension at elevated temperatures.

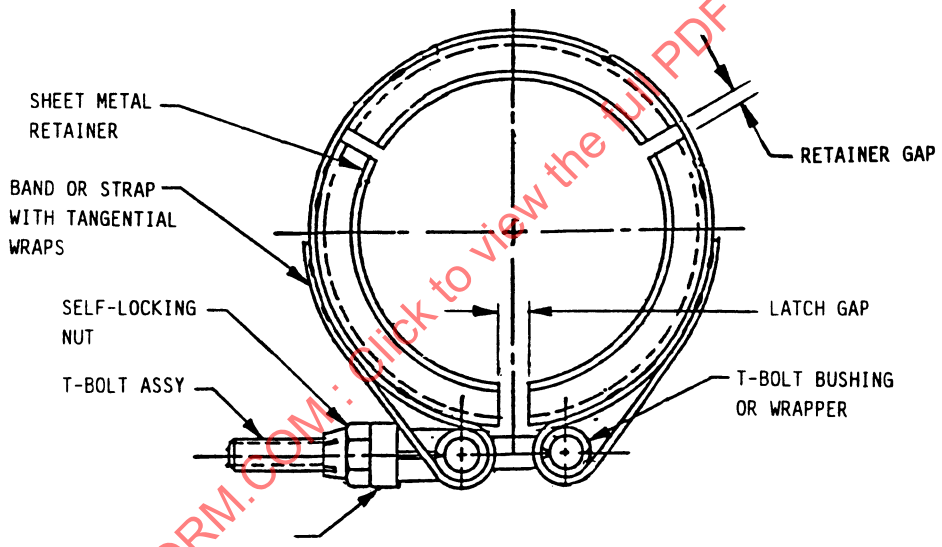


FIGURE 5 - V-Band Coupling

b. Whenever possible use A286 cres bolts. This alloy has been the most widely accepted material for aircraft bolts and has been the specified T-bolt material on all Military Standard V-band couplings per MIL-C-27536 and eye bolts as specified in AS4108 and AS1895.

c. The maximum load capacity of a V-coupling is limited by the yield strength of the retainer segment at its apex. The combined forces of axial load, internal pressure, and bending loads apply a bending load on the retainer apex corners, see Figures 2, 3, and 4. The "burst pressure curves" published by V-coupling manufacturers relates to the yield point of the retainer which is at the maximum pressure only load. The formulas which convert axial and bending loads into equivalent pressure loads to facilitate the use of the published pressure curves are in 3.1.2. Published maximum load curves apply at room temperature only. If the coupling is to be used at elevated temperatures, design load capability must be reduced (see MIL Handbook 5, AS1895, AS1960, or supplier published data).

3.1.4 (Continued):

d. Most V-couplings have bolt latches consisting of a T-bolt or eye bolt, trunnion, and locknut. Some of these bolts are defined in AS4108. The second most used latch is the quick-release latch which adds a hinged and slotted yoke that engages the head of the bolt. Select the quick-release latch only when the coupling is expected to be installed and removed frequently, or when quick installation and removal is necessary. T-bolts can only be replaced on quick-release latches; it cannot be replaced on the basic T-bolt latch. Eyebolts cannot normally be replaced.

Safety latches are in common use on V-retainer couplings (see Figure 6) and occasionally on V-band couplings. This is a redundant latch system and maintains joint integrity in the event of primary latch failure.

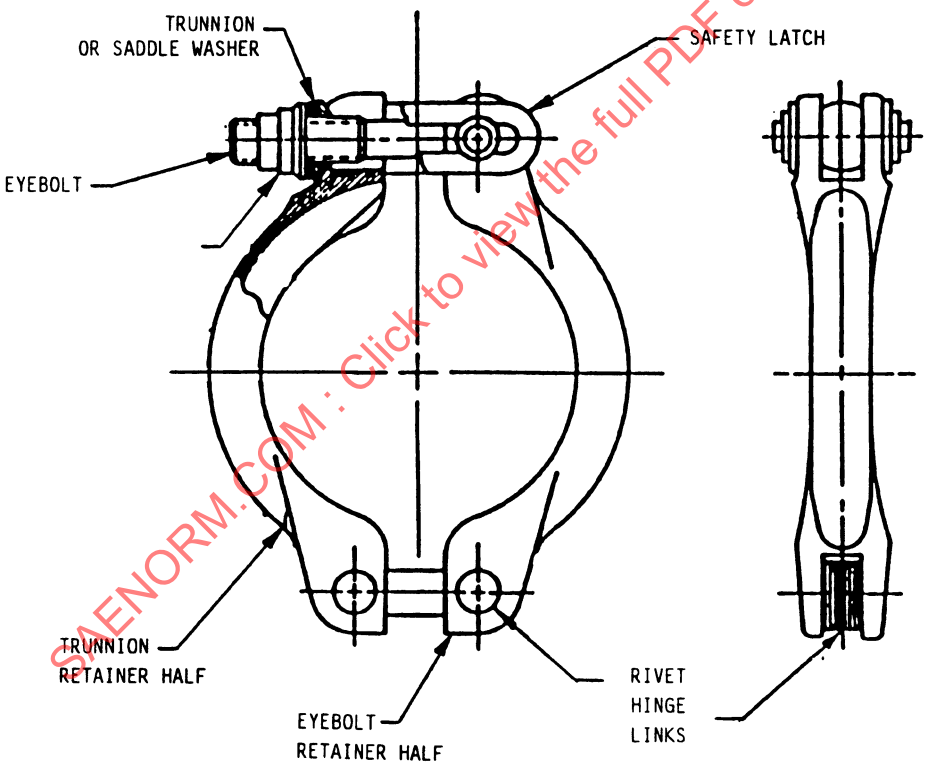


FIGURE 6 - V-Retainer Coupling

3.1.4 (Continued):

e. The majority of aerospace V-couplings are tightened with an all metal locknut. Such locknuts conform to either MIL-N-25027 or MIL-N-7873. These locknuts have a limited number of installations and removal cycles on a bolt before thread galling and seizure occurs. The following recommended guidelines will promote successful use of all-metal locknuts on V-coupling bolts.

(1) Both the locknut and bolt threads should be clean and free of dirt, burrs, and damaged threads. All stainless steel nuts should be silver plated or dry film lubricated, to prevent thread galling and seizure.

(2) Installation of the locknut should not exceed 2 rps or 120 rpm. Installation with a hand torque wrench is recommended. Excessive nut rotation speed causes frictional heat which promotes thread galling.

(3) Lubricants greatly reduce the free running frictional resistance between locknuts and bolts. Dry film lubricants per MIL-L-46010 when applied to bolt threads have significantly increased thread life and reduced galling. Wet antiseizing compounds and oils have also been used with success.

CAUTION: Use of lubricants on bolt threads can drastically affect torque/tension relationships. If lubricant is used, the installation torque must be reduced accordingly to prevent excessive rigging load.

f. Beware of excessive chlorine exposure to cres V-couplings. The 300 series cres materials are very prone to stress corrosion cracking when exposed to excess chlorides. The nickel alloys such as Inconel and Monel are recommended for excess chloride exposure.

3.1.5 Flange Configuration and Seal Selection: V-couplings are used on two different kinds of flanges, solid machined flanges and flexible sheet metal flanges. Solid machined flanges are usually used on high strength applications such as bleed air connections on engines and on mechanical accessory connections. Sheet metal flanges are lighter weight flanges and are usually used on pneumatic ducting. All solid machined flanges in pneumatic systems require a separate seal that is either elastomeric or metallic to effect a seal between the flanges. Flexible sheet metal flanges do not use a separate seal. These flanges are made so that they effectively seal themselves on finely machined face surfaces. A joint relationship exists between the seal, flange configuration, and the coupling. The choice of flange and coupling configuration is a result of joint analysis, testing, or both. Design and environmental conditions, as a rule, will dictate seal selection. The criteria for component selection are based upon specific system requirements. Design practices for some specific systems are referenced in Section 2.

3.1.5 (Continued):

The following items are very important considerations in any system:

a. Recommended machined flange profile configuration and tolerances should be per MS 24563, since most available V-couplings are designed to mate with these profiles.

b. Machined flanges should have their outside diameter flange corner machined to a radius no less than the maximum inside corner radius of the V-coupling retainer.

4. INSTALLATION PROCEDURE:

Prior to installation, all of the V-coupling components should be examined for defects. Prior to final assembly, a check of the installation should be conducted.

4.1 Coupling Examination:

Some V-couplings may appear to be of the same size but designed for different applications and could be physically interchanged. It is possible that a lighter duty V-coupling could be inadvertently installed in an application requiring a higher-strength coupling, or a coupling made from materials intended only for noncritical temperature applications may be improperly used in an elevated temperature installation. Beware of installation of the wrong coupling. Even though the fit may be good, the operating conditions require the correct V-coupling installations. Therefore, make sure the specified part number V-coupling is used.

(The Systems Engineer should design and select coupling joints so that the chances are reduced or eliminated for a physically interchangeable or incorrect couplings to be installed.)

The following examination should be made to assure:

a. The V-coupling has not been damaged.

b. The band is to be free from kinks or permanent twist due to overspreading and free from crowning or bending over the apex of the retainer due to overtightening.

c. Spotwelds are to be per MIL-W-6858 class B for the majority of aerospace sheet metal V-couplings and class A for critical applications.

d. Retainers should show no evidence of permanent deformation, such as overspreading of angle ϕ. (Overspreading is considered to be 4° greater than ϕ. (See Figures 2, 3, and 4.)

e. Retainer inside corner radii should be free from tool marks and cracks. A corner radius equal to the segment thickness is preferred.