

V-Retainer Couplings provide an economical and proven method for joining ducting, tubing, filters and other closures used in high-temperature and/or high-pressure pneumatic or mechanical applications. V-Retainer Couplings provide substantial savings in assembly and maintenance costs—especially when the connection requires frequent disassembly and re-assembly.

Compared to bolted flanges and welded joints, which are costly to manufacture and difficult to assemble, the V-Retainer Coupling, with only one or two bolts to fasten, can be easily assembled. This can be extremely important when limited access is an issue, or when a small envelope is specified. The coupling latch can be oriented at any convenient point for access around the flanges. Unlike bolted flanges, the coupling retainer applies a uniform closing force around the circumference of the flanges during and after installment. Also, a V-Retainer Coupling can be effective in reducing the overall weight of a design.

Benefits of Using V-Retainer Couplings:

- Lower assembly costs
- More efficient joint
- 360° positioning of latch
- Elimination of radial orientation of bolt holes
- Reduced weight
- Lower maintenance costs
- Aesthetically pleasing

Definition

Technically there are two V-Coupling forms. V-Band Couplings (*Figure 1*), and V-Retainer Couplings (*Figure 2*). V-Band Couplings are constructed with multiple retainer segments and a full sheet metal band either spot welded or riveted together. A V-Retainer Coupling is constructed using a single retainer segment with two sheet metal loops spot welded onto the retainer. In use, both terms have become interchangeable, with V-Retainer Coupling being the more common term.



Fig. 1 — V-Band Coupling



Fig. 2 — V-Retainer Coupling

Although the design considerations in this guide primarily concentrate on round applications (95% of usage), the V-Retainer Coupling principal can be successfully used to join a variety of square, oval, rectangular and other custom shapes. In addition to metal tubing and ducting, the V-Band principal can also be applied to composite constructions.

Typical Aerospace/Defense Applications Include:

- Engine bleed-air systems, auxiliary power units (APU's), and environmental control systems
- Missile pod sections and end caps on missile launch tubes
- Landing gear components
- Air intake systems
- Space vehicles and satellite launch applications
- Wing de-icing systems
- Exhaust systems
- Diesel engine turbochargers for military trucks and construction equipment
- Mounting pumps and filters
- Support equipment such as mounting power generators and air or water filtrations systems

How a V-Retainer Coupling Works

As torque is applied to the coupling nut, a radial (inward) force is created in the V-Retainer (*Figure 3*). The radial load created by band tension is then transmitted as an axial load on the mating flanges due to the wedging action of the V-Retainer. The retainer Apex Gap and Foot Clearances are typically .062" (*Figure 4*). This clearance must be maintained to prevent the V-Retainer from bottoming out on the flanges before the required loading has been achieved.

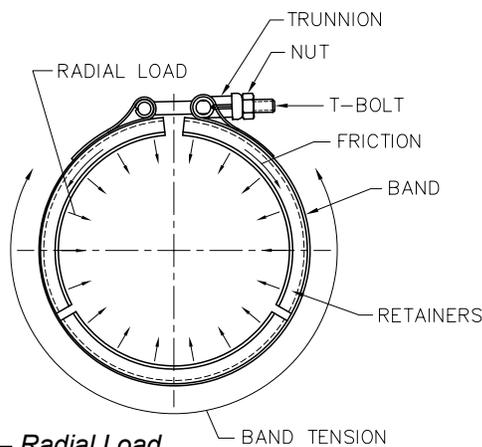


Fig. 3 — Radial Load

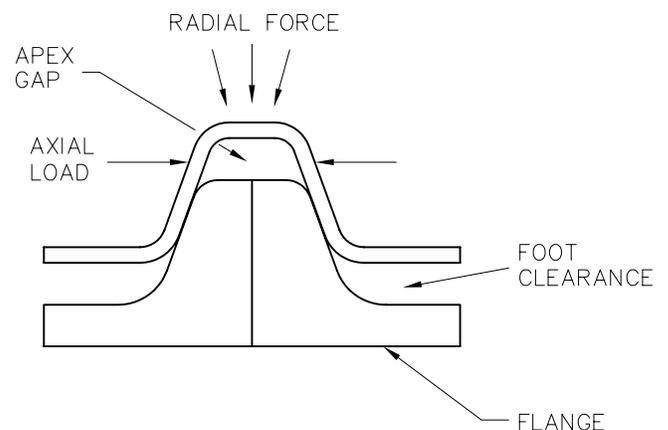


Fig. 4 — Apex Gap & Foot Gap Clearance

The included angle θ shown in *Figure 5a* can vary between 30 and 90 degrees. The accepted industry standard for an included angle is 40 degrees. This angle provides the optimum strength for drawing together a set of flanges and maintaining a tight seal. Using a 40 degree included angle the retainer exerts an axial load on the flanges with an 8.6 to 1 mechanical advantage as the outside band is tightened. While it is necessary to overcome friction during tightening of the V-Retainer, once tightened, friction actually helps reduce the bolt load required to keep the flanges from separating.

Figure 5b shows a cross-sectional view of a V-Retainer Coupling and Machined Flanges as well as the common nomenclature required when selecting a coupling for your particular requirement, while *Figure 5c* shows the cross-sectional view and nomenclature of a joint using a Rigid (Machined) Coupling and Machined Flanges.

Application Examples:

Connecting High-Temperature, High-Pressure Aircraft Bleed-Air Ducting

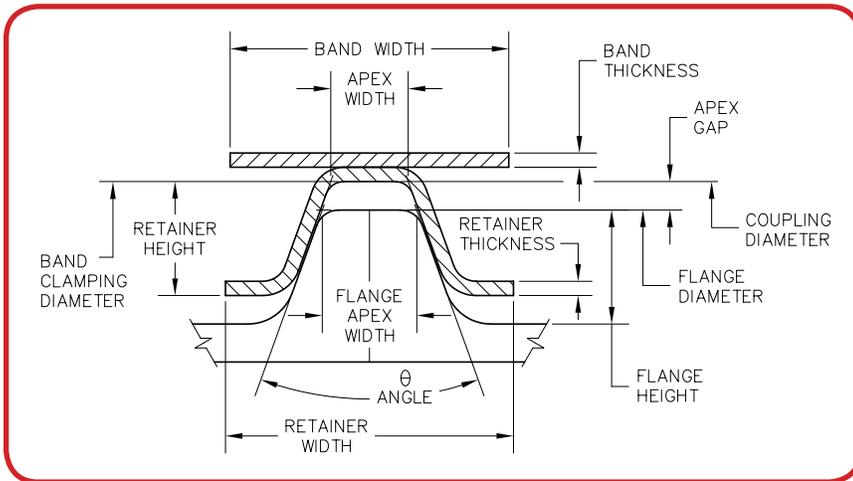


Fig. 5a — V-Retainer Coupling & Flange Nomenclature

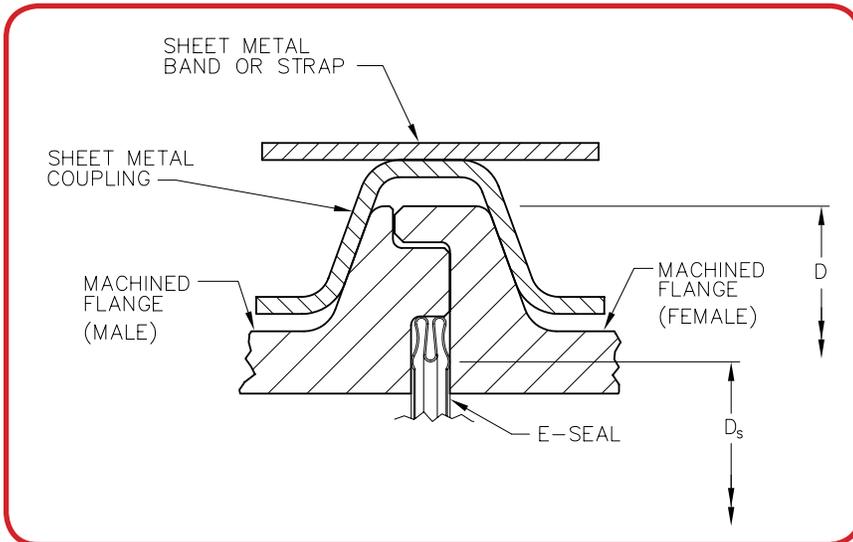


Fig. 5b — V-Retainer Coupling & Machined Flange Nomenclature

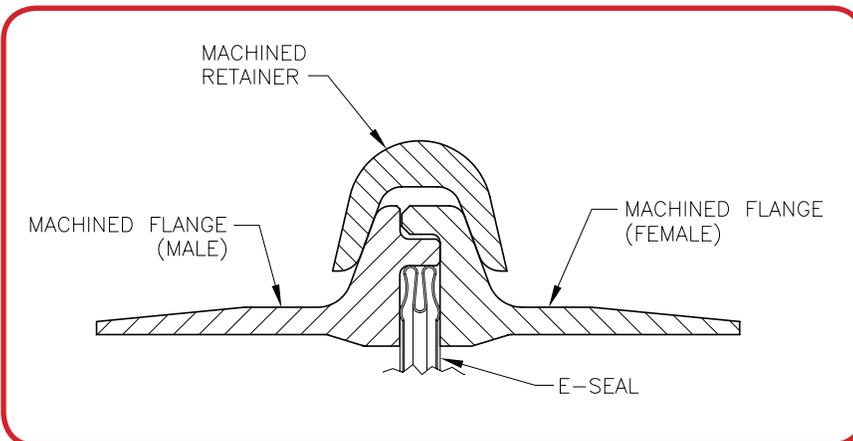


Fig. 5c — Rigid (Machined) Coupling & Machined Flange Nomenclature

Rigid Couplings and mating Machined Flanges are used with resilient all-metal seals on aircraft jet engine bleed-air ducting and other high-temperature, high-pressure aircraft ducting applications. Just as with V-Retainer Couplings, Rigid Couplings can also be used on auxiliary power units (APUs) and for mounting such accessories as pumps.

Figure 5c illustrates how Rigid Couplings and mating Machined Flanges are used with an all metal, "E" type, seal.

Figure 6 shows a pneumatic ducting connection, a typical application for a Rigid (machined) Joint.



Fig. 6 — Typical high-pressure pneumatic ducting connection

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Application Examples (cont.):

Three-Segment Rigid Coupling Prevents Valve Distortion

Two-segment Rigid Couplings, formerly used to mount start valve flow bodies, were distorting the round flanges which caused binding of the butterfly plate inside. The problem was magnified when the nut on the coupling was tightened beyond the recommended installation torque. Testing showed that a three-segment Rigid Coupling substantially reduced distortion of the round flange and prevented flange ovalization even if the nut was over-tightened.



Fig. 7 — Three-segment rigid coupling prevents valve distortion

Space Vehicle Satellite Spin Assembly: Payload Separation and Launch-lock Couplings

To ensure a clean and complete satellite release and launch, two different diameter V-Retainer Couplings were utilized (*Figure 8*). One for payload separation, and the second for launch release. This V-Retainer Coupling used a combination of titanium latches with explosive bolts as well as machined aluminum retainers with a PTFE Teflon coating to prevent the possibility of the satellite “hanging-up” during launch. At launch, the satellite was started spinning, then released by the explosive bolts. Titanium was specifically chosen for the latch mechanism because of the material’s ability to spring away as the bolts were exploded.

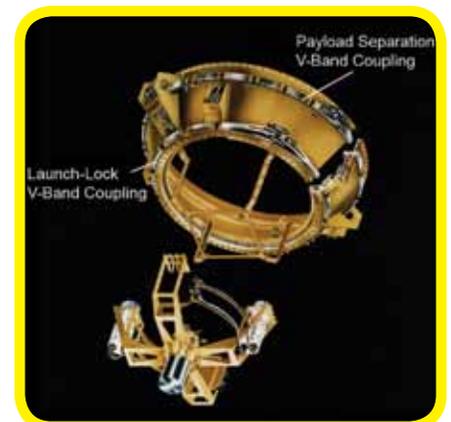


Fig. 8 — Satellite spin assembly, payload separation and launch

Quick Assembly and Component Replacement of Rocket Fuel Line Connections



Fig. 9 — Titan engine fuel connections

To prevent potential rocket engine loss due to extreme rotational vibration, eight different nickel alloy 718 V-Retainer Couplings (*Figure 9*) are used to hold the critical fuel management system on the Titan IV launch vehicle. The previous approach from a different supplier used a cantilevered T-bolt design, which failed. The improved Voss design incorporates a low-profile, socket screw latch and is assembled with solid rivets. Spot welds in the previous design were subject to failure.

Selecting the Proper Retainer Profile

The designer should first consider the maximum *proof pressure* the coupling will be subjected to, then from the Voss proof pressure curves, a retainer thickness can be established. If bending or axial loads are present, *SAE AIR869* should be used to combine or translate loads to pressure. (Note: standard retainer thicknesses are .032, .040, .050, .062, .070, .080 & .090.) Once retainer thickness is determined, the profile is the next decision. The overall height and width of the flange profile directly affects this decision.

1. Coupling Nominal Diameter:
= Flange diameter + .12" (or .095" for couplings with a retainer height less than .190")
2. Coupling Nominal Apex:
= Flange apex width - .046" (for 40 degree included angle)

It is important to understand what types of loads and temperatures the V-Retainer Coupling joint will be subjected to. To properly select a V-Retainer Coupling, the following load factors must be known to establish the total load the coupling must handle. The following five steps must be performed:

1. Pressure Load Factor $N_p = \frac{PD_s^2}{4D}$ (lbs. per inch of circumference)
2. Bending Moment Factor $N_B = \frac{4M}{\pi D^2}$ (lbs. per inch of circumference)
3. Axial Tension Factor $N_A = \frac{A}{\pi D}$ (lbs. per inch of circumference)

Where:

D_s = Seal Diameter (in.) M = Bending Moment (in-lbs) A = Axial Tension (lbs.)
 D = Flange O.D. (in.) SF = Safety Factor
 P = Pressure (psi) T_c = Temperature Correction Factor

4. The Total Load Intensity (N) = $[(N_p + N_B + N_A) \times T_c] \times SF$ (units = lb/in)
5. Convert Total Load Intensity (N) to an equivalent Pressure (P)

$$P = \frac{4ND}{D_s^2} \text{ (units = psi)}$$

TABLE 1: TEMPERATURE TABLE (T_c) FACTOR (YIELD STRENGTH)

°F	Aluminum	300 Stainless	Ti 15-3-3-3	A286	Ni718
200	1.06	1.15	1.02	1.04	1.03
400	2.00	1.52	1.15	1.09	1.06
600	---	1.67	1.35	1.14	1.09
800	---	1.70	---	1.16	1.09
1000	---	---	---	1.16	1.12
1200	---	---	---	---	1.23

Once the total load intensity (N) is known and converted to an equivalent operating pressure, the proper retainer cross-section can be selected from the manufacturer's published proof pressure chart.

Example:

Flange Apex Width [in.]	=	.252
Flange O.D. [in.] (D)	=	5.00
Tube Diameter [in.]	=	4.00
Seal Diameter [in.] (D_s)	=	4.75
Internal Pressure [psi] (P)	=	200
Bending Moment [in-lbs] (M)	=	1000
Axial Tension [lbs.] (A)	=	1000
Operating Temperature [°F]	=	200
Safety Factor (SF)	=	1.1

***ALL CALCULATIONS BASED ON STAINLESS STEEL CONSTRUCTION**

Coupling Nominal Apex
.252" - .046" = .206"

Coupling Nominal Diameter
5.00" + .12" = 5.12"

$$N_P = \frac{200 \times 4.75^2}{4 \times 5.00} = 225.6 \text{ lb/in}$$

$$N_B = \frac{4 \times 1000}{\pi 5.00^2} = 51 \text{ lb/in}$$

$$N_A = \frac{1000}{\pi 5.00} = 64 \text{ lb/in}$$

$$T_C = 1.15 \text{ (From Table 1 @ 200°F)}$$

$$N = [(225.6 + 51 + 64) \times 1.15] \times 1.1 = 431 \text{ lb/in}$$

To convert total load intensity to an equivalent operating pressure:

$$P = \frac{4ND}{D_s^2} = \frac{4 \times 431 \times 5.00}{4.75^2} = 382 \text{ psi}$$

- Proof pressure is defined as 2 times operating pressure (*burst pressure equals 3 times operating pressure*).
- Therefore: 382 psi x 2 = 764 psi (proof pressure).

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Looking at the proof pressure chart in *Figure 11*, the 6100 Series Retainer can handle a proof pressure of approximately 800 psi. *This is a proper selection.*

Types of Flanges Used with V-Retainer Couplings

Flanges can be either sheet metal, machined or a combination of both (see *Figures 10a, b, c*)

- Sheet Metal Flanges (No Seal Required)



Fig. 10a

- Machined Flanges (Requires Seal)

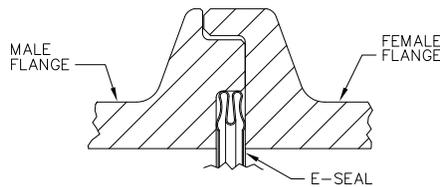


Fig. 10b

- Machined Flange with Sheet Metal Flange (No Seal Required)



Fig. 10c

Sheet Metal Flanges are self-energizing and do not require a seal. Sheet Metal Flanges are based on two main profiles, narrow radius and wide radius (see *Figures 12a, b*), the difference being the size radius at the top of the flange apex.

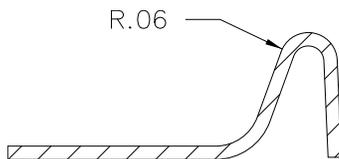


Fig. 12a — Narrow Profile Sheet Metal Flange

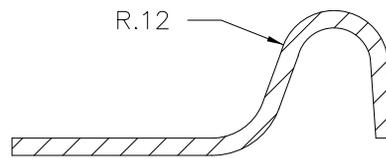


Fig. 12b — Wide Profile Sheet Metal Flange

Sheet metal flanges that are bulge-formed are available in a range of sizes from $\varnothing 1''$ to $\varnothing 10''$. They are roll-formed and welded when a larger diameter is required. Sheet metal flanges are generally used in lower bending moment applications and are available in aluminum, stainless, titanium, and nickel 625 & 718 for high temperature applications.

When high-pressure applications are presented, machined flanges are used. Available in the same basic materials as sheet metal flanges, machined flanges are more robust and use a seal. (An O-Ring for low temperature applications, and Ni718 E-Seals in high-temperature conditions.) Machined flange profiles are defined by standards AS24563 and AS1895.

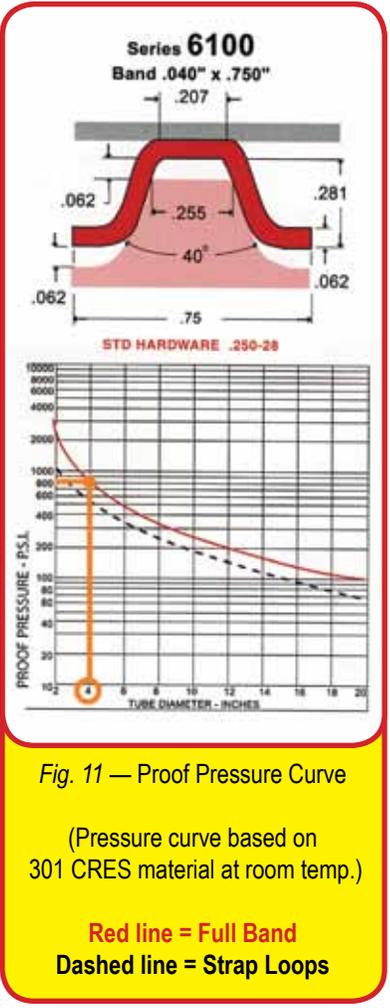


Fig. 11 — Proof Pressure Curve

(Pressure curve based on 301 CRES material at room temp.)

Red line = Full Band
Dashed line = Strap Loops

Other Design Considerations:

Number of Retainer Segments

V-Retainer Couplings can be made using a single retainer segment (generally the most economical design, *Figure 13a*), or multiple retainer segments. Adding retainer segments adds flexibility to aid in installation of the coupling over the flanges. A single segment retainer is the least flexible and is not recommended for small diameters. The most popular design uses three retainer segments (*Figure 13c*). In addition to providing needed flexibility, this design also provides more uniform clamp loading. For larger diameter couplings ($\varnothing 8''$ and larger), a two-latch design (*Figure 13d*) is recommended. Two latches provide for more uniform torquing and seating of the V-Retainer onto the flanges.

V-Retainer Coupling Sizes

- In general, sizes range from $\varnothing 1\text{-}\frac{1}{2}''$ to $\varnothing 12''$
- Have been made as large as $\varnothing 12$ feet
- When less than $\varnothing 3''$, a bent T-Bolt is used to ease installation and to avoid the bolt interfering with the outside diameter of the flanges
- When coupling diameter is greater than $\varnothing 8''$, it is recommended to use a two latch design
- Single-segment couplings should generally not be used when the coupling diameter is less than $\varnothing 5''$

• Single Segment:

Single-segment couplings are lightweight and relatively economical. Due to the stiffness of a continuous ring, single-segment couplings are typically available only in larger diameters, and for infrequent removal. Single-segment couplings are usually provided with strap loops rather than a full band.



Fig. 13a

• Two Segment:

Two-segment couplings provide greater flexibility for ease of installation and removal. They are used on larger diameters. Two-segment couplings can be provided with two latches or with strap loops.



Fig. 13b

• Three Segment:

Three-segment couplings provide more flexibility for removal and installation and can be used for large and small diameters; it is the most useful and economical segment design configuration.



Fig. 13c

• Four Segment:

Four-segment couplings are used in large diameter applications where two- or three-segment couplings are not adequate. Four-segment couplings can be used with multiple latches and must be used with a full band.



Fig. 13d

Other Design Considerations (cont.)

Band Loop Options

There are two different band loop styles available. A “standard” backbend and a “tangential” backbend (*Figures 14a, b*). For aerospace and other critical applications, a tangential backbend loop should be used. The reason is that a standard backbend band loop, while torqued, will stretch and relax as temperatures rise, eventually causing some loss of bolt torque.

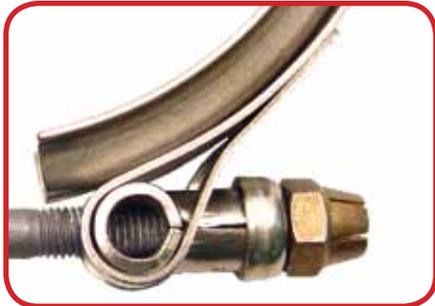


Fig. 14a — Standard Backbend



Fig. 14b — Tangential Backbend

Construction Method

Construction of the V-Retainer coupling can be done by spot welding in accordance with AWS D17.2, or by riveting the hardware into the loops and the retainer segments onto the band. Spot welding is more economical and does an excellent job. However, riveting is the preferred choice for highly critical applications (*see Figure 15*).

Material Considerations

For saltwater or other corrosive environments it is recommended to use 316 CRES; which is passivated to remove any free iron.

- Do not use *Aluminum* in applications over 400 °F
- Do not use *Titanium* in applications over 600 °F
- Do not use *Stainless Steel* in applications over 800 °F
- Do not use *A286* in applications over 1000 °F
- Do not use *Nickel 718* in applications over 1200 °F



Fig. 15 — Construction Methods

T-Bolt and Nut Recommendations

There are many combinations of T-Bolt and Lock Nut materials offered. For aerospace and high-temperature applications, it is recommended to use A286 CRES for T-Bolts and Lock Nuts with UNJF threads. This alloy is widely accepted as the material of choice throughout the industry. The nut should be silver plated in order to reduce friction.

To help reduce friction between the coupling and flanges, Dry Film Lubricants (D.F.L.) have been highly successful when coated on the inside of the retainers. Dry film lubricants are also highly recommended on T-Bolt threads to help reduce galling and extend thread life. It also helps in achieving the true torque applied to the coupling. This is very important to assure proper joint performance—especially in high-vibration applications.

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Installation of the V-Retainer Coupling

Proper installation of V-Retainer Couplings is as critical to their performance as is their selection. Tubes or components to be joined must be properly aligned with each other before installing the coupling. Correct alignment of the flanges prior to coupling installation is critical in achieving good joint performance.

- **Never use the V-Retainer Coupling to pull Flanges into alignment**
- **Never use a nut runner over 120 RPM**

The following instruction guide should be used in accordance with SAE AIR869

Assembly

After the flanges have been carefully examined and proper alignment achieved, the joint may be assembled.

- a. On single-latch V-Retainer Couplings, slip the Coupling over the flanged tube end. Avoid overspreading the band on sheet metal couplings.
- b. Install the seal (if needed) and mate the flanges.
- c. Install the V-Retainer Coupling onto the mated flanges and tighten the nut.
- d. On Quick Release Latch type V-Retainer Couplings (style 2), the bolt must be fully seated in the latch so that the bolt head resists rotation in the latch. Improper orientation can cause latch failure.
- e. Tighten the nut to approximately 70% of the required torque (on double-latch assemblies, torque both latches equally). Check to assure the coupling has seated over flanges equally around the periphery. Also, check for correct flange alignment; radial flange alignment can be checked visually in the gap between adjacent retainer segments.
- f. Lightly tap the coupling around its circumference with a plastic or non-metallic mallet to distribute band tension. Lubricant on the inside of V-Retainer Coupling retainers can reduce friction between flanges and the V-Retainer Coupling as well as minimize the requirement for tapping (use only the lubricant specified for the application).
- g. Dry Film Lubricant, when applied to the inside retainer surfaces, reduces friction. Couplings which cannot be tapped should have Dry Film Lubricant applied to the inside of retainers.
- h. As torque is increased toward 100% of the specified value, lightly tap around the outer periphery as necessary to prevent unequal loading.
- i. When 100% of specified torque is reached, again tap around the band and re-torque once more to the specified value. A torque wrench should be used to prevent excessive tightening and damage to the V-Retainer Coupling. No additional tightening should be required.
- j. After torquing, examine the V-Retainer Coupling for contact between the strap (or band) loops as well as between the retainer segments in the latch area. Contact in either location indicates an improper installation and can seriously impair joint performance.

All recommended torques are normally based on *unlubricated* threads and include the torque required to overcome the friction of the nut. Dry Film Lubricant on bolt threads reduces friction and promotes more accurate and uniform tightening of nuts.

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Latch Styles

Before selecting a latch style, consideration should be taken as to how frequently the coupling must be removed or reassembled, and the pressure the application is under (see Figures 16a–16e for popular latch styles).



Fig. 16a

Style 1:

Standard T-Bolt and Trunnion Latch

For applications where infrequent clamp removal is anticipated. May be used with any size coupling and is one of the strongest standard latch styles available. Nut must be removed to open the coupling.

Style 2:

Standard T-Bolt Quick Release Latch

Useful where frequent coupling removal is necessary. Can be quickly and easily opened by loosening the nut and raising the hinged latch. This design permits T-bolt replacement. Applicable for couplings of any diameter.



Fig. 16b

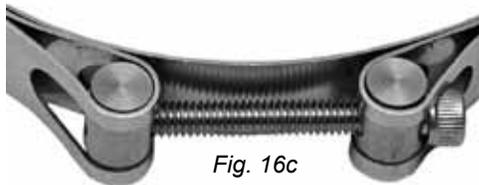


Fig. 16c

Style 3:

Socket Head Capscrew Latch

Uses Barrel Trunnion and Barrel Nut hardware. This latch style has the most compact profile. Capscrew must be removed to open the coupling. Used for permanent and high-strength applications.

Style 7:

T-Bolt Over-Center Handle Latch

Used where frequent removal of the coupling is required. Features over-center handle; requiring no tools to open or close once initial adjustment is made. Nut provides adjustable tension. Self-energizing latch clip helps prevent accidental opening. Not recommended for pressurized applications.

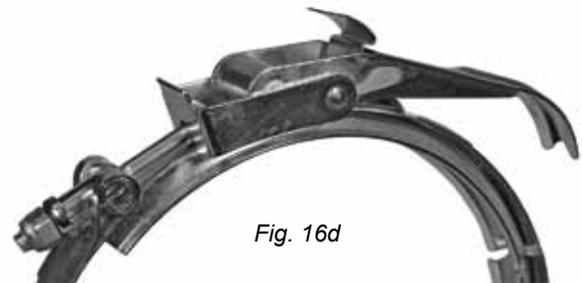


Fig. 16d



Fig. 16e

Style 9:

Saddle Latch with T-Bolt

This quick-release latch style is for light- to medium-duty applications, permitting quick access where coupling must be periodically removed.



Founded in 1957, **Voss Industries, Inc.** has been a major supplier of high quality V-Retainer couplings and mating flanges, T-bolt clamps, strap assemblies, precision stampings, specialty fasteners and other specialty products, such as bulge-formed components, to aerospace, military and industrial markets.

To ensure that Voss Industries has the experience and capabilities to best serve customers now and into the future, there are three distinct divisions:

Voss Aerospace specializes in the design and manufacture of high-performance clamping and coupling components and fabricated sub-assemblies for the aviation and aerospace markets. Principal product lines include: V-Retainer couplings, rigid couplings, sheet metal and machined flanges, clamps and attachments for commercial and military aircraft pneumatic ducting systems, jet engine bleed air connections, accessory attachments and missile components—as well as retention bands for satellite and space shuttle booster rocket assemblies.



Voss Technologies designs and manufacturers specialized, high-quality clamp and coupling devices and custom fabrications for many “hi-tech” industries. Voss Technologies uses innovative design capabilities and special processes developed for aerospace applications and applies them to product development and production for applications in such industries as: telecommunications (navigation and positioning receivers), medical (imaging equipment), instrumentation (optical measuring multi-positioning supports) and defense (tanks, power units, missiles and torpedoes).

Clamp Technology division of Voss Industries, Inc. produces high-quality competitively priced clamping and coupling devices for a broad spectrum of industrial OEM applications. These products include a wide variety of light- to heavy-duty hose clamps, V-Retainer couplings, brackets, metal hold-down straps, and a variety of weldments and fabrications. Voss Clamp Technology products are used on diesel engines, heavy-duty trucks, off-road equipment, turbochargers, air conditioners, filtering devices, tanks and pressurized vessels, diaphragm and centrifugal pumps—to name just a few applications.



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