Service Bulletin No. 1041

For ABC/ICP-staff only

MODEL	**:**	All
TYPE	**:**	Service information
MANUAL & SECTION	**:**	Spare Parts Manual no. 1224 "Fittings"
DATE	**:**	April 30th, 2000
SUBJECT	**:**	Introduction to fittings
CONDITIONS	**:**	Service information only.

DESCRIPTION:

This Bulletin has been compiled for service employees who are not familiar with the subject of fittings. It contains the information needed to identify, select, assemble and install the fittings and fitting accessories used on Van Hool coaches. To simplify matters, every effort has been made to provide clear, practical and easy to understand guidelines. It is recommended to file a copy of this Bulletin at the front of Manual no. 1224 for future reference.

PARTS:

Always use genuine maintenance products and parts. Do not accept imitations!

Part No.	Description	Qty.
VH 10702227	Spare Parts Manual no. 1224 "Fittings"	#

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Contents:

STATEMENT OF NONLIABILITY

This Bulletin contains the most complete and accurate information obtained from various authoritative sources at the time of publication. While every precaution has been taken in the preparation of this Bulletin, the publisher and author cannot assume responsibility for the accuracy of data, for errors or for omissions. Neither is any liability assumed for damages resulting from the use of the information contained herein. Persons using the information in this Bulletin should do so with regard to their own safety, the safety of others and the safety of property.

1. General: purpose of fittings

In automotive applications, fittings belong to the "plumbing" branch, a rather common term, which not only refers to the hoses, lines and tubes that transport fluids or gasses from one part of the vehicle to another, but also to the process of forming and installing them. Tubing, hoses and fittings are used in many parts of the vehicle. Brake systems, fuel delivery, compressed air applications, air conditioning, transmission fluid and engine cooling, heating, power steering, lubrication and instrumentation all utilize tubing and/or hose and fittings. The object is always the same: to transport the fluid or gas from where it is, to where it is needed with the minimum drop in pressure, while keeping all of it in the system. Plumbing connectors, or fittings, attach one piece of tubing to another or to the system units. Selecting, using and working with tubing and fittings is part of many repair jobs. It is imperative that the technician be thoroughly familiar with the different types, their application, and proper installation.

2. Summary of current standards, references, prefixes and abbreviations:

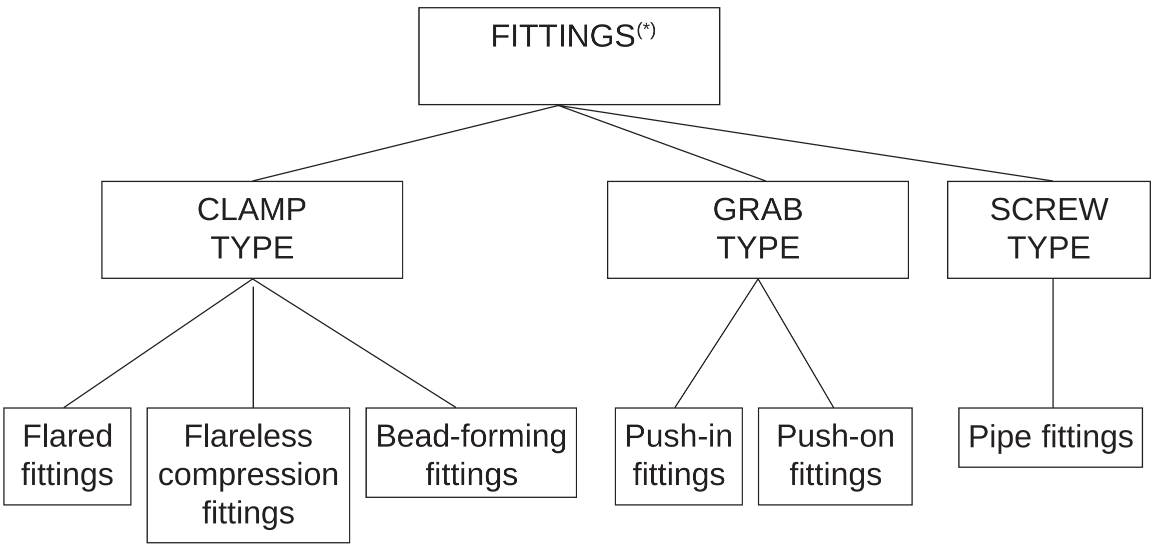
A standard can be defined as something that is set up and established by an authoritative source to serve as a reference for the measure of weight, length, quality etc. There are specific standards for the many branches of industry, e.g. shipbuilding, aeronautics, construction and so on. With respect to fittings and screw thread forms, quite a number of standards have been laid down, both by military and civil institutions from different countries. These standards contain recommendations which minutely detail the dimensions, tolerances, contours, materials and workmanship required to produce a particular type of fitting. Manufacturers who follow the standard guidelines during the design and production of their fittings may rest assured that their products meet nationally or internationally accepted specifications and can be widely used.
Some of the more common standards, references, abbreviations and prefixes that relate to screw thread forms, fitting configurations or both are listed below. Additional information may be obtained by purchasing the standard papers in volume form or single specifications sheets from the publishing authority.

Standard, reference, prefix or abbreviation	Description
AN	Air Force-Navy standard
BSF	British-Standard-Fine
BSP	British-Standard-Pipe
BSPP	British-Standard-Pipe; parallel thread
BSPT	British-Standard-Pipe; tapered thread
BSW	British-Standard-Whitworth
DIN	Deutsche Industrienorm ; German industrial standard
Dryseal	Dryseal thread form; see NPTF

Standard, reference, prefix or abbreviation	Description
ISO	International-Standard-Organization
JIC	Joint-Industry-Conference
M	Metric thread
MS	Military-Standard
NPSM	National-Pipe-Straight-Mechanical
NPT	National-Pipe-Taper
NPTF	National-Pipe-Taper-Fuel; Dryseal-American-Standard-Taper-Pipe-Thread
SAE	Society-of-Automotive-Engineers
UNC	Unified-National-Coarse
UNF	Unified-National-Fine
Whitworth (W)	Whitworth screw thread form

3. Common fitting designs:

Plumbing connectors, or fittings, attach one piece of tubing to another or to system units. There are basically three methods to accomplish this: by clamping, by grabbing and by screwing. The amount of pressure the system carries is usually the deciding factor in selecting a connector. The flow chart below shows what fitting designs suit a particular method.



(*) *NOTE: Crimp type and reusable hose fittings for flange or screw thread installation have not been included in this summary. The recently developed O-ring face seal tube fitting with flange or braze sleeve has also been omitted.*

- *Flared fittings:* In the flare connection, the end of the tubing is spread (flared) outwards at an angle. The tube fitting securely grasps both sides of the flare to produce a leak-proof joint (see Figure 1).

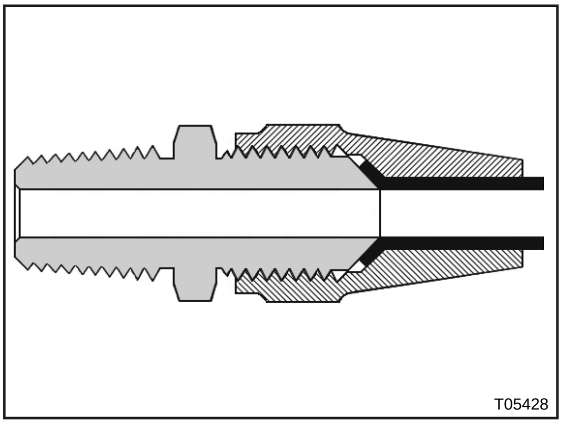


Figure 1: SAE 45 degree flare connection. Notice how flare is pinched between fitting body and nut.

- *Flareless compression fittings:* Compression type fittings consist of three parts: a body, a sleeve and a nut. The body has a counterbored shoulder, against which the end of the tube rests (see Figures 2 and 3). The angle of the counterbore causes the edge of the sleeve to take hold of the outside of the tube, when body and nut are joined.

  NOTE : DIN compression type fittings are also available with a special functional nut, containing a two-piece sealing and retaining ring, which provides a soft seal on the tube side. Since Van Hool do not use this type of fitting, its operation has not been discussed here.

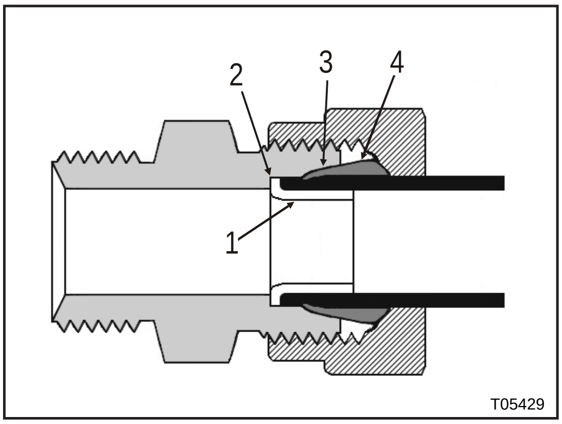


Figure 2: DIN compression type fitting with cutting ring and insert

1. **Insert**
2. **Butt end**
3. **Internal taper**
4. **Cutting ring**

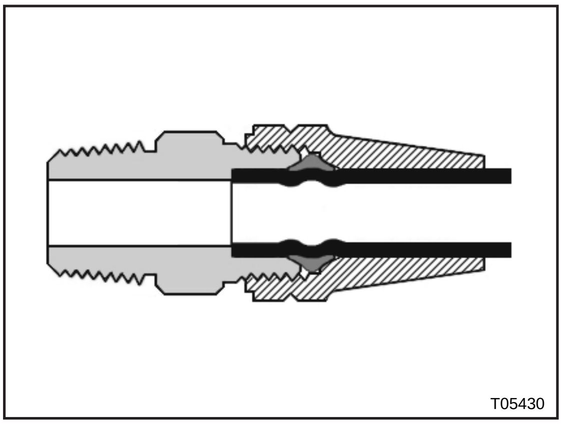


Figure 3: SAE compression type fitting with spherical sleeve and long nuts

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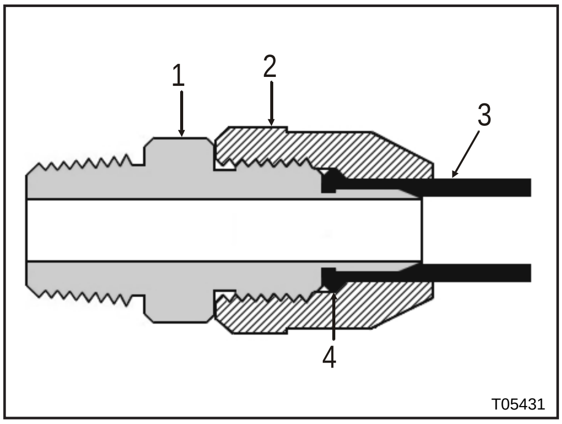

Figure 4: Bead-forming fitting

1. **Body**
2. **Nut**
3. **Soft plastic tubing**
4. **Bead**

- *Bead-forming fittings:* These fittings have been designed specifically for flexible tubing such as polyamide, Teflon, PVC etc. The seal is obtained by the bead formed at the tube end, when the nut is tightened to the fitting body (see figure 4).

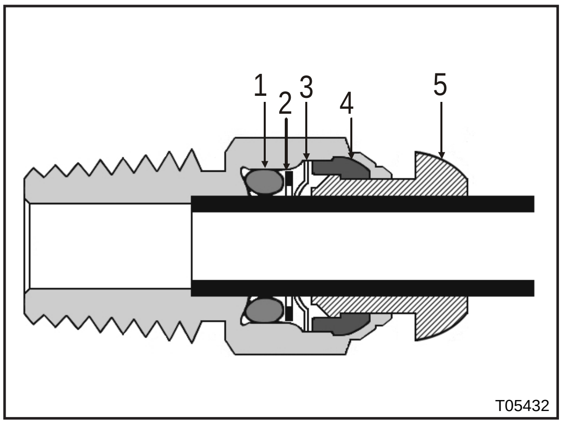

Figure 5: One type of push-in fitting

1. **O-ring**
2. **Backup washer**
3. **Grab ring**
4. **Sleeve**
5. **Push-button**

- *Push-in fittings:* Push-in fittings provide a positive hold on the tube by means of a flexible grabbing device (see Figure 5). Positive sealing of the tube is provided by an O-ring. A special backup washer protects the O-ring from the grabbing device, and prevents extrusion under pressure. In most cases a push-button allows instant disconnection of the tube.

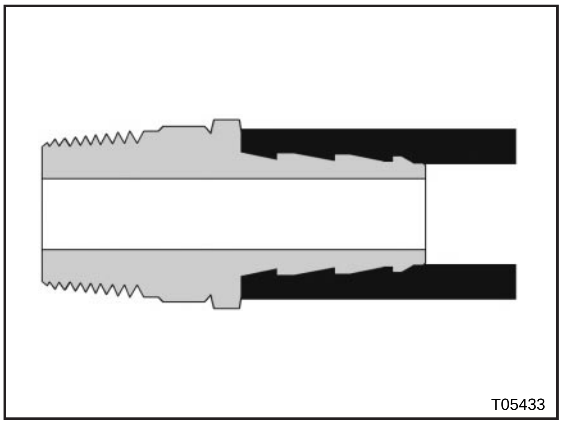

Figure 6: Push-on fitting

- *Push-on fittings:* Push-on fittings feature a notched male end, which fits inside the tube (see Figure 6). Grip and sealing are provided by the annular bulbs or barbs. Push-on fittings for tubes are intended for use with a hose clamp or a crimped ferrule.

- *Pipe fittings:* The pipe fitting uses a tapered thread that produces leak-proof joints. A development in pipe threads, called the DRYSEAL PIPE THREAD, produces leakproof joints without undue turning force. This is accomplished by a difference in truncation (cutoff point) of the thread root and crest. As the fitting is drawn together, the root (bottom) and crest (top) of the threads come in contact before the flanks (sides). Final tightening causes metal-to-metal contact between root, crest and flank. Figure 7 shows a section of steel pipe joined to a hex nipple by using a coupling. Note the tapered threads.

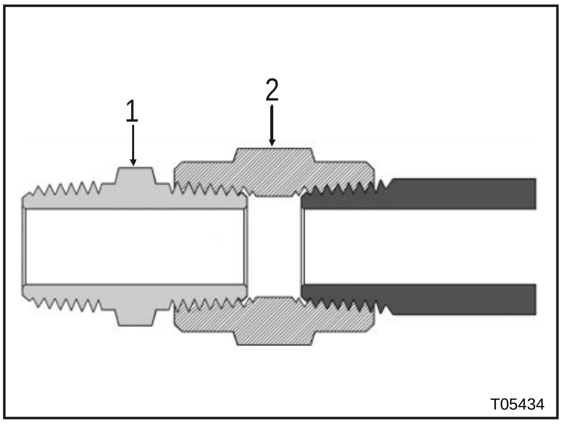

Figure 7: Pipe fittings

1. **Hex nipple**
2. **Coupling**

4. Fittings used on Van Hool coaches:

To connect the various tubes and lines of the coach plumbing system, the following types of fitting are used:

1. SAE flareless air brake compression fittings
2. DIN flareless compression fittings
3. Bead-forming fittings
4. Push-in fittings
5. Push-on fittings

With the exception of the SAE fittings, which are used exclusively for the braking system, the use of the other types is not restricted to a particular application, but depends on practical and design requirements.

5. Description of SAE flareless air brake compression fittings:

Flareless tube fittings are finding wide application in plumbing systems. Using this type of fitting eliminates all tube flaring, yet provides a safe, strong, dependable tube connection.
The SAE flareless air brake compression fitting consists of three parts: a body, a spherical sleeve and a nut.

Body: The body of a straight male stud connector (see Figure 8) is provided with a barrel to accept the tube. Inside the barrel is a counterbored

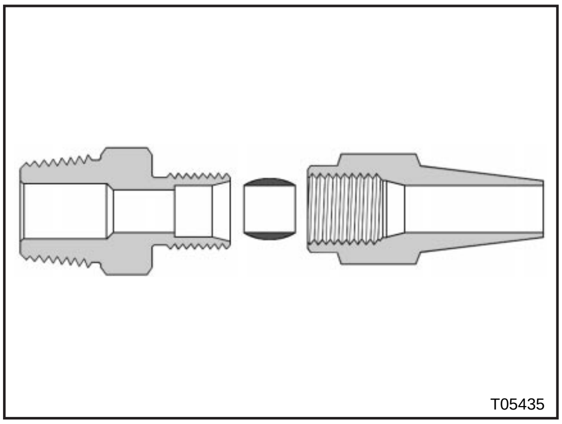

Figure 8: SAE Straight male stud connector assembly

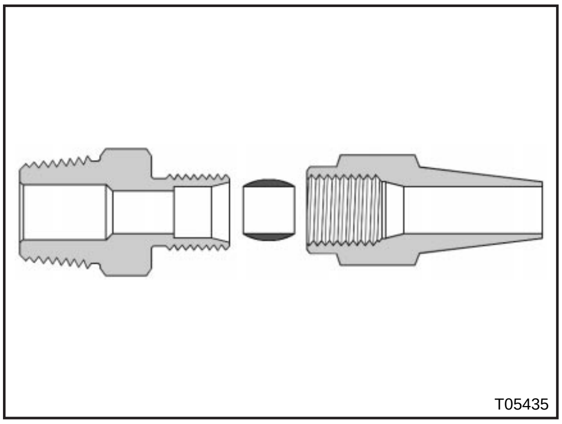

Figure 8: SAE Straight male stud connector assembly

shoulder, against which rests the tube end. The major diameter of the counterbore equals the tube outside diameter. The upper edge of the barrel has a 20° chamfer; the outside wall is straight inch threaded with an undercut at the bottom. The connector body also has a hex and a taper inch threaded stud coated with a band of sealant. Unions may have two or more barrels depending on their configuration.

Nut: The nut, which slides over the tube and sleeve, threads over the barrel of the connector body. Inside the nut, above the threaded part, are an undercut and a 20° conical seat, which blends into a cylindrical bore (see figure 8).
Nuts for SAE compression fittings are available in both standard and long versions. Where the installation is subjected to heavy vibration, long nuts are used. This will tend to support the tubing a greater distance from the actual connection. Van Hool use the long nuts for the braking systems of their coaches.
On the outside, the hex of the nut has several markings stamped on it, among others the letters "DOT" and "OD". "DOT" indicates that the fitting is approved for braking system applications by the Department of Transportation. "OD" refers to the Outside Diameter of the tube for which the fitting is intended. Tubes come in sizes 1/4, 3/8, 1/2, 5/8, 3/4 and 1 inch.
Only the first four sizes are used on Van Hool coaches.

Sleeve: To create a strong and leakproof joint, a spherical sleeve is used (see figure 8). When the fitting body and nut are drawn together, the sleeve is compressed between the two conical seats and forced against the tubing. The pinching action locks the tube securely in place. Annealed (soft copper), half-hard copper, steel, aluminum, plastic, and stainless steel are some of the materials used in the manufacturing of tubing. When rigid tubing material is used, a regular separate sleeve compression fitting will suffice. However, if the tubing is soft, a special insert is placed in the end (see figure 9) so the sleeve will not crush the tube.

NOTE: Although there is a resemblance between spherical sleeves, bicones and flanged sleeves (see Figure 25), only spherical sleeves may be used in this application, even when the other types fit the barrel and nut.

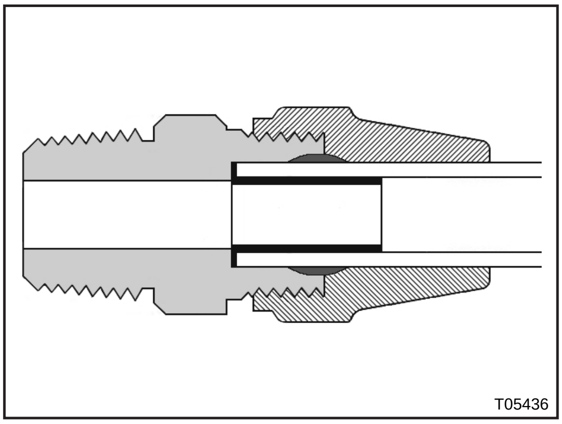

Figure 9: Use of special insert to prevent soft tubing from crushing

6. Description of DIN flareless compression fittings:

Unlike the previously discussed SAE air brake fitting, which is used for low pressure applications (27.5 bar/400 psi*), the DIN flareless compression fitting is designed to withstand high pressures (630 bar/9 130 psi*). This versatile fitting also consists of three parts : a body, a cutting (or clamping) ring and a (short) nut.

Body: The body of a straight male stud connector (see Figure 10) is provided with a short barrel to accept the tube and a cutting (or clamping) ring. The bore in the barrel is countersunk with a shoulder, against which rests the tube end. The major diameter of the counterbore equals the tube outside diameter. The barrel itself is cylindrical on the outside but tapered on the inside with a 24° included angle. The outside wall is straight metric threaded with an undercut at the bottom. The connector body also has a hex and usually a mounting flange. The stud is parallel or tapered, depending on the type of port it has to fit and the sealing method. Unions may have two or more barrels depending on their configurations.

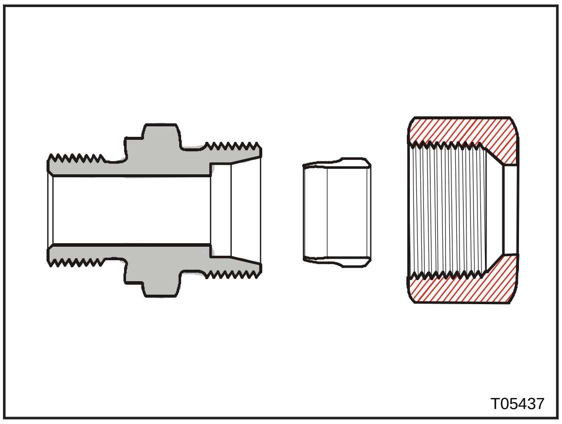

Figure 10: DIN compression type straight male stud connector

(*) Approximate values. Rated pressures have been given as indicators only. True ratings should be obtained from the supplier (manufacturer).

Nut: The nut, which slides over the tube and ring, threads over the barrel of the connector body. Inside the nut, above the threaded part, is a 45° conical seat. The nut has several markings stamped on it (see Figure 11), among which the letters LL, L or S and a number. The letters refer to the rated pressure of the fitting; the number denotes the diameter in mm of the tube the fitting is intended for. Refer to the summary below for pressure ratings and tube diameters.

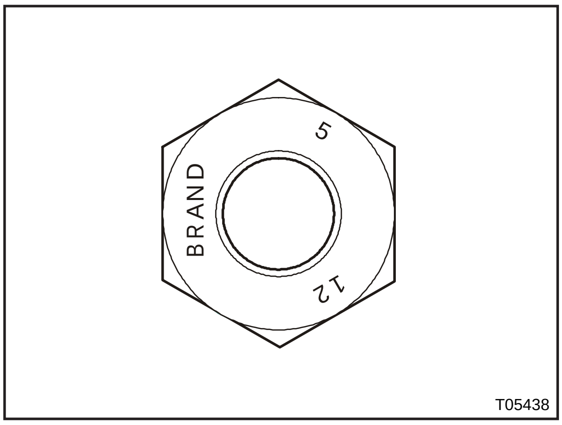

Figure 11: DIN compression type nut markings

Fitting series	Tube O.D. (mm)	Rated pressure (bar/psi)
LL light duty	4 6 8	100/1,450
L medium duty	6 8 10 12 15	250/5,800
	18 22	160/2,300
	28 35 42	100/1,450
S heavy duty	6 8 10 12 14	630/9,150 (*400/5,800)
	16 20 25	400/5,800
	30 38	250/3,600

(*) Concerning male stud connectors with tapered stud threads and parallel tapped ports as well as several pressure gauge connectors:
rated pressure= 100 bar/1,450 psi

NOTE: Rated pressures are given as an indication only. True ratings should be obtained from the supplier/manufacturer.

Cutting (or clamping) ring: To create a strong and leakproof joint, able to withstand the high pressures involved, a cutting ring is used. When tightening the nut, the cutting ring with its preformed and hardened cutting edge moves along the 24° inner cone of the connector body (see Figure 12A). When the ring meets the tube, it cuts into the tube with its cutting edge and produces a visible collar (see Figure 12B). The taper of the fitting mouth provides the seal between the fitting and the ring, and the seal between the ring and the tube is provided by the "bite" of the ring into the tube. Due to the internal form of the cutting ring, tube vibration is prevented.

NOTE: The tube, which is cut at right angles, must push against the shoulder in the body without fail, otherwise the ring will not cut in.

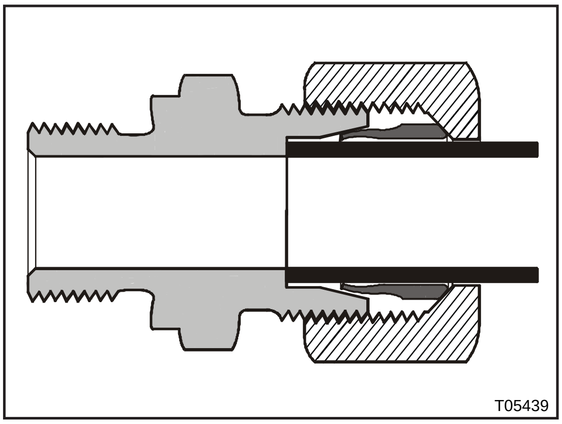

Figure 12A: DIN compression fitting, functioning of the cutting ring

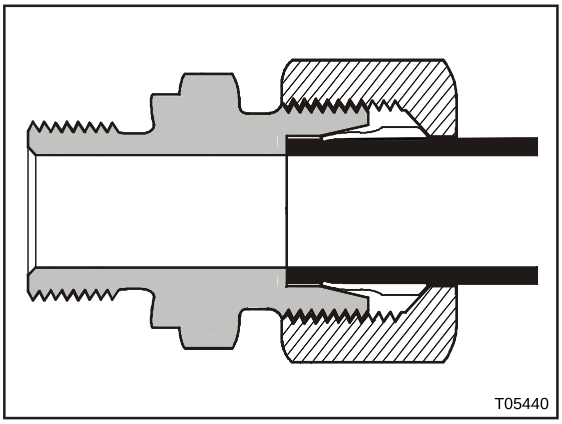

Figure 12B: DIN compression fitting, functioning of the cutting ring

Depending on the tubing material that is going to be used, three different types of ring may be selected. Two of them are "bite" or cutting rings, the third is actually a clamping ring. Seamless steel tubes should be fitted using the regular zinc plated cutting rings. For stainless steel tubes the greyish green bite rings are the proper choice. Plastic tubing should be fitted using the yellow copper clamping rings. These rings have a somewhat different shape; they are smooth on the inside and have a blunt edge to prevent damage to the tubing. A special insert (see Figure 13) should be placed in the end of the tubing to prevent crushing by the clamping ring.

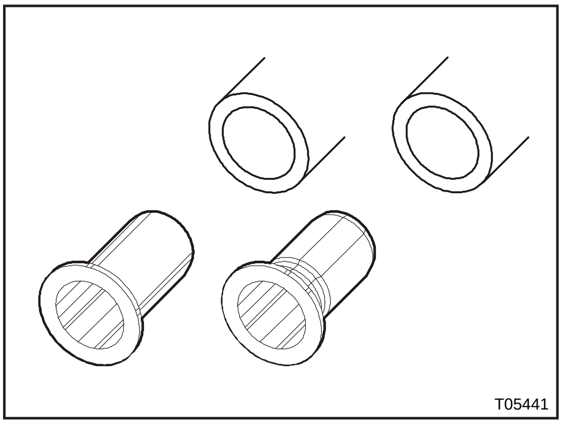

Figure 13: Inserts

Whenever thin walled or soft tubing is used, inserts should be used for all compression type assemblies to ensure a good seal and tight fit. Except in the case of copper tubing, inserts should not be forced or driven in as otherwise the tubes expand and the cutting rings can no longer be pushed on.

7. Description of bead-forming fittings:

These two-piece fittings have been designed specifically for soft and semirigid tubing such as polyamide, polyurethane, PEBA, polyethylene, Teflon, PVC etc.

The **body** of a straight male stud connector (see Figure 14) has an upset spigot that fits the inside diameter of the tube. At the base of the spigot, the connector widens into a shoulder against which rests the tube end. Below the shoulder is a parallel screw thread with an undercut ; a hex provides a positive stop for the nut. For most applications the hex doubles as a mounting flange. The stud is parallel or tapered, depending on the type of port it has to fit and the sealing method. Unions may have two or more spigots according to their configurations.

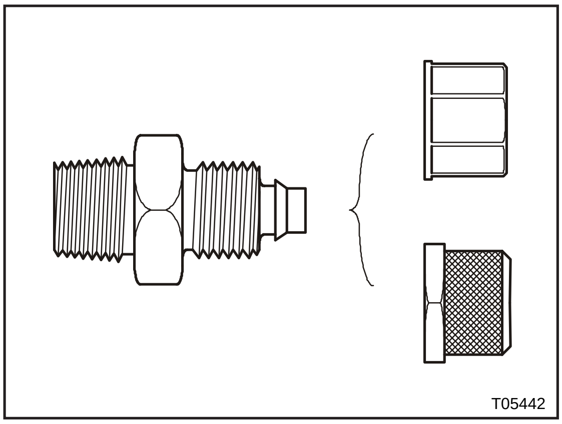

Figure 14: Bead-forming straight male stud connector

The **nut** slides over the tubing. By pushing the tubing over the spigot till it butts the shoulder and then tightening the nut to the fitting body, a bead is formed at the tube end (see figure 4).

The clamping of the tube between the spigot of the fitting body and the tube nut creates an effective seal with a high pull out performance. The connection is leakproof to the burst pressure of the tube.
The nut is mostly knurled but may have a hex as well. With soft tubing the nut should be finger-tightened to the end stop. When using semirigid tubing, tighten the nut to the end stop with a wrench.

Bead-forming fittings can be assembled and disassembled repeatedly. They should be used only in low pressure auxiliary air applications.

8. Description of push-in fittings:

Figure 5 shows one type of push-in straight male stud connector. This compact one-piece fitting is intended for use with most thermoplastic and soft metal tubing. It has been designed specially for low pressure circuits where fast assembly, disassembly and reassembly are important. No special tools are required for assembly; the tube is just inserted, until it bottoms the counterbore. Tube support is not necessary. Radial claws on the metal grab ring grip the tubing securely to provide retention (see Figure 15).

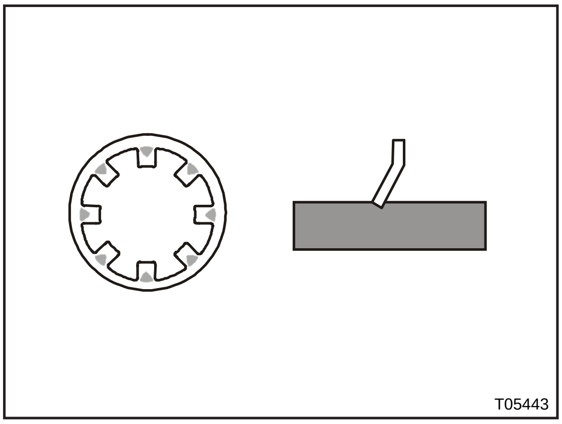

Figure 15: Grab ring operation

The special shape of the radial teeth prevents longitudinal scratch marks on the tube. The elasticity of the ring absorbs vibration and pulsating pressure. Once in the fitting, the tubing can rotate freely even under pressure. Sealing is obtained with an O-ring (see Figure 16).

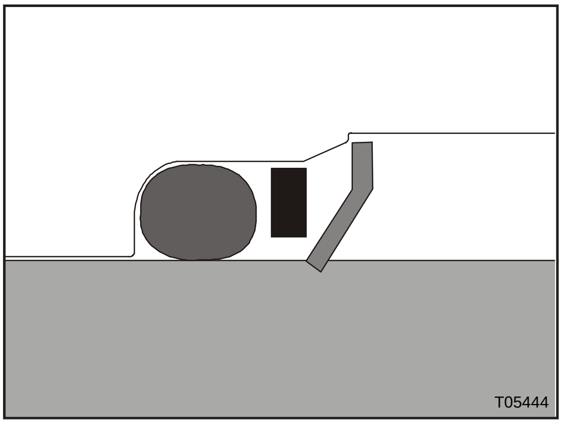

Figure 16: Tube seal, backup washer and grab ring (detail)

Different O-ring materials are available to provide media compatibility where a standard O-ring is insufficient. A push-in fitting can be assembled and disassembled without impairing its ability to seal. A special backup washer protects the O-ring from the elastic teeth of the grab ring, and prevents extrusion under pressure. The outside diameter of the tubing to be used with the fitting is marked on the release button (see Figure 17). Simple manual pressure on the button allows disconnection of the tube. The removable release button can be color coded for ease of identification.

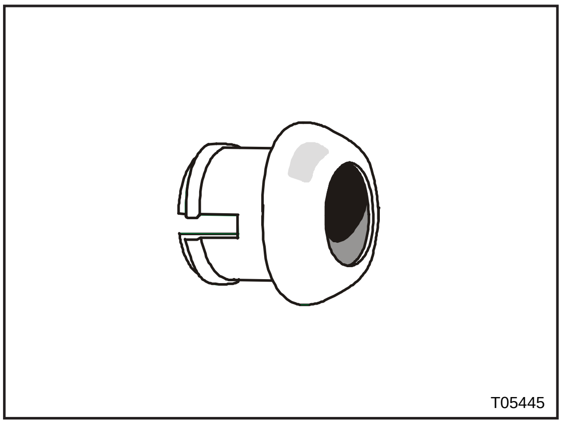

Figure 17: Release button with tube O.D. indication

Push-in fittings are available as stud connectors or unions. The stud is parallel or tapered, depending on the type of port it has to fit and the sealing method. Unions may have two or more push-in mechanisms depending on their configurations.

NOTE: This description refers to a particular design of push-in fittings. Other designs may have a different way of grabbing the tube or may not feature the release button. The principle of operation, however, remains the same.

Push-in fittings are great for road side repairs but should NOT be used on air brake systems.

9. Description of push-on fittings:

The push-on straight male stud connector shown in Figure 18 is a compact, one-piece fitting designed for low pressure applications. This fitting may be used to connect moving parts with stationary parts in locations subject to vibrations or where a great amount of flexibility is needed. The tubing is pushed over a barbed nipple or an annular bulb. Sealing and retention of the tube is carried out by either the wedge shaped barbs or the bulb. A conventional clamp or crimped ferrule secures the tubing to the fitting (not shown). A hex at the base of the nipple doubles as an end-stop for the tubing. A tapered or parallel stud is provided, depending on the type of port the connector has to fit and the sealing method. Unions may have two or more barbed barrels depending on their configurations.

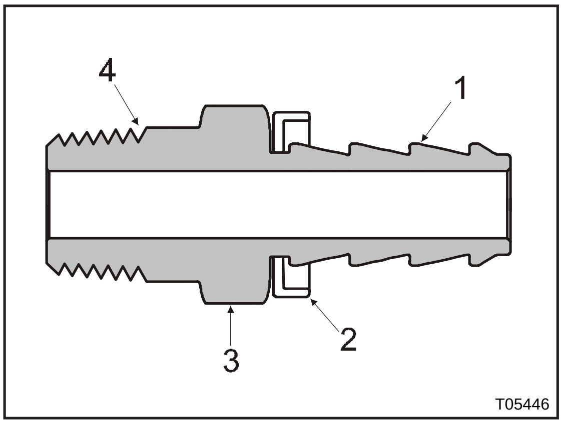

Figure 18: Push-on straight male stud connector

1. **Barbed nipple/annular bulb**
2. **End-stop (optional)**
3. **Hex**
4. **Stud**

10. Basic shapes:

Various shaped fittings have been designed to handle all types of installations. Moreover, since the form also provides an easy way of identifying a fitting, technicians should be familiar with the following basic configurations (see Figures 19 to 24).

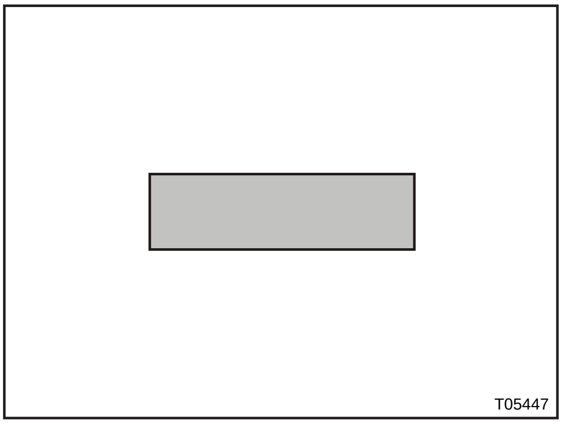

Figure 19: Straight fittings

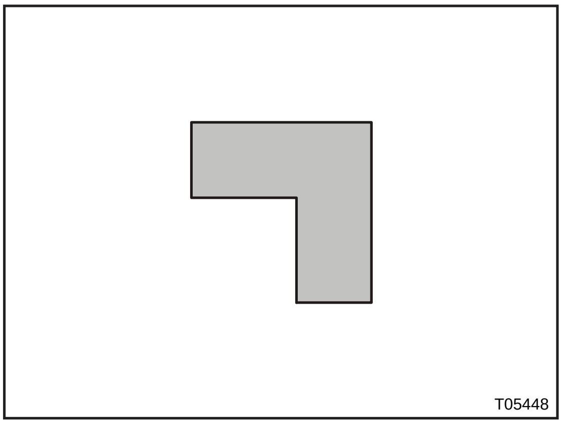

Figure 20: 90° Elbows

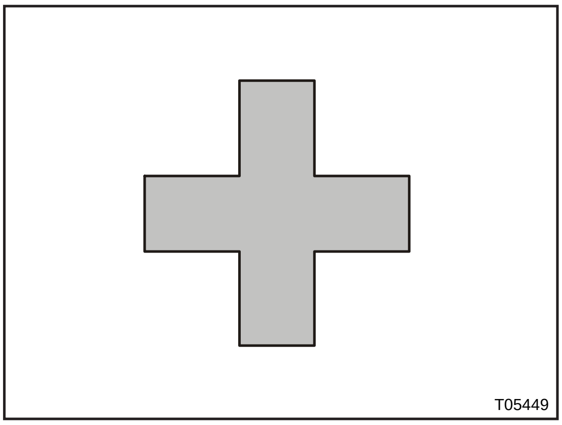

Figure 21: Crosses

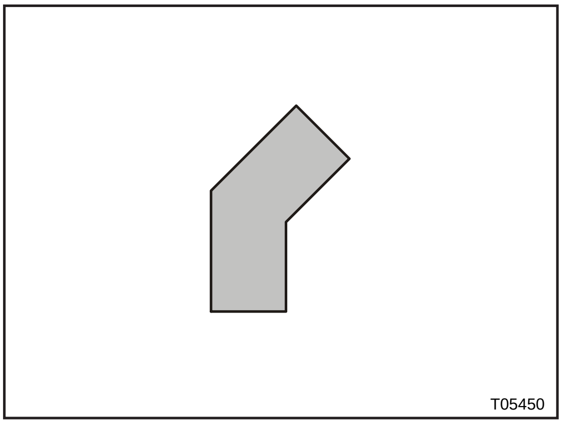

Figure 22: 45° Elbows

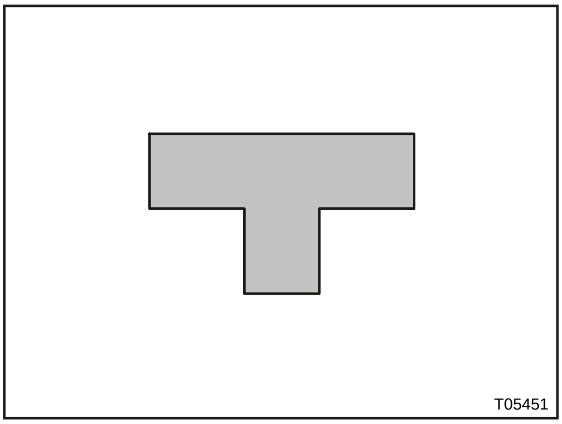

Figure 23: Tees

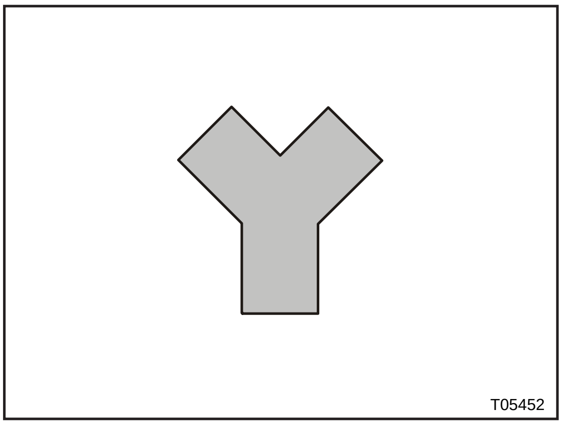

Figure 24: Ys

11. Special features/terminology:

True to common industrial practice, fitting manufacturers have developed their own technical language to describe and identify their products. The expressions below, listed in alphabetical order, refer to typical properties distinguishing one fitting from another.

Accessories:	refer to complimentary products such as plugs, ball valves, pressure gauge connectors, tools, sealants, etc.
Adapter:	connects two fittings or tubes with different properties (see also: **Reducer**)
Adjustable:	indicates that the installation of the fitting is not limited to one particular position
Banjo:	an elbow assembly, featuring a banjo-like fitting, two washers and a hollow bolt
Branch:	indicates that the leg of a T-fitting is a stud (see also: **Stud**) or a standpipe (see also: **Standpipe**)
Bulkhead:	indicates that a fitting is designed to pass through a partition between two spaces
Bushing:	(piping terminology): a female to male thread reducer (see also: **Reducer**)
Clamping ring:	a special ring, smooth on the inside with a blunt edge, to be used with DIN compression fittings in plastic tubing applications
Connector:	a fitting used to attach tubing to a system unit, or to connect the threaded end of a pipe to a compression fitting
Coupling:	(piping terminology): a female threaded connector, used to join the threaded ends of two pipes
Cutting ring:	a special shaped ring with a cutting edge, to be used with DIN compression fittings in steel tubing applications
Hose barb:	indicates that a fitting has a connection with wedge shaped notches
Insert:	a short reinforcement tube that is fitted inside semirigid and soft tubing to prevent the tubing from collapsing when compression type fittings are used
Nipple:	(piping terminology): a male threaded connector used to join couplings (see also: **Coupling**)

O-ring: a solid, round seal made of synthetic rubber

Reducer: connects tubes with different diameters

Run: indicates that one arm of a T-fitting is a stud (see also: **Stud**) or a standpipe (see also: **Standpipe**)

Sleeve: general denominator for the different types of rings used with compression fittings (see Figure 25)

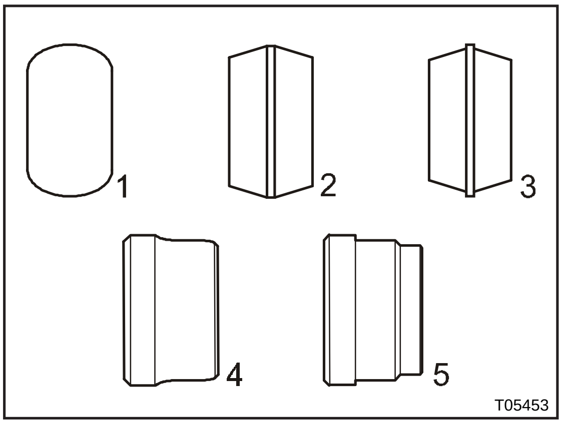

Figure 25: Some types of sleeves

1. **Spherical**
2. **Bicone**
3. **Flanged**
4. **Cutting ring**
5. **Clamping ring**

Standpipe: indicates that the body of a fitting has a thick walled tube, to which a nut and a cutting ring have been preset.

Street: (piping terminology): indicates that a fitting has male thread at one end and female thread at the other

Stud: male or female taper or parallel threaded part of a fitting used to connect the fitting to the port of a system unit or to another fitting

Swivel: refers to a rotatable fitting that allows the connected parts to move relative to each other

Throttle insert: insert with a small bore, which restricts the flow through a tube or a fitting (see also: **Insert**)

Union: joins two or more sections of tubing

12. Manufacturing techniques, materials, rated pressures and temperatures:

Extruded fittings: Hexagon, round and shaped bars are extruded in the configuration required, drawn to size, cut to length and straightened. First a solid round billet (200 to 300 mm/8 to 12 inches in diameter) is heated to the pliable state and forced by pressure of approximately 5,500 bar/80,000 pounds per square inch through a die. The resulting continuous length of bar is cooled and then drawn through dies to the desired external size (the drawing process also controls the temper.) After straightening, the bar is ready for machining (see figure 26). The process produces a dense, nonporous material somewhat stronger in the longitudinal direction due to an orientated flow of the grain.

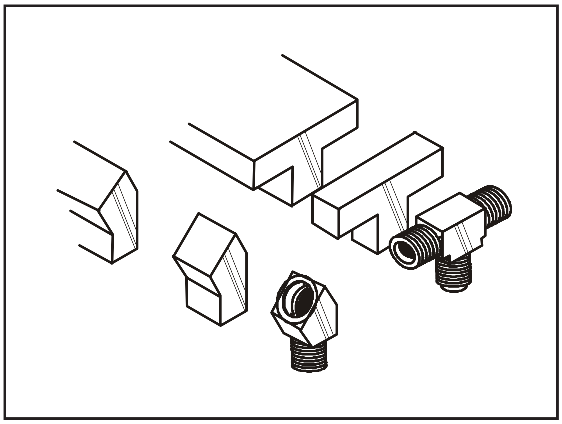

Figure 26: Machining fittings from billets

Forged fittings: Material for forgings is extruded in round bars, cut to length and straightened (at this point in the process, forging rod differs from round extruded machinable bars only in temper and chemical properties.). After straightening, the bars are cut again into slugs (short lengths), reheated to the pliable state and pressed under a pressure of approximately 1,720 bar/25,000 pounds per square inch between upper and lower die cavities. After cooling the flash is trimmed away and the forging blank is ready for machining (see figure 27). This process of forming under extreme pressure produces an uniformly dense material of exceptional strength. Because grain flow follows the contour, the fitting has high impact strength and is resistant to mechanical shock and vibration.

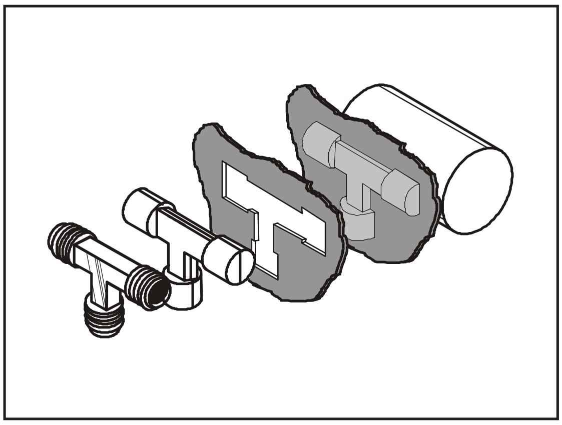

Figure 27: Machining fittings from forgings

SAE flareless air brake compression fittings: The air brake fittings used on Van Hool units are extruded from brass, a yellow alloy of copper with zinc and small amounts of other metals that is malleable and ductile and harder and stronger than copper.

Color: yellowish

Working pressure range: up to 27 bar/400 psi (*)

Temperature range: fittings will withstand variations
from -54 to +120°C /-65 to +250°F (*)

(*) Indicative value. Actual ratings should be obtained from the supplier/manufacturer

The **DIN flareless compression fittings** Van Hool use are manufactured from forged or drawn mild steel. The surface of the fittings is first galvanized and then yellow passivated.
The nylon tubing clamping rings that are used with the fittings are made of a yellow copper alloy; the regular cutting rings for mild steel tubes are made of steel, zinc plated and transparent passivated. The cutting rings for stainless steel tubing have a much harder cutting edge; they are zinc plated and greyish green passivated.

DIN compression fittings are also available in brass, high temperature steel, and stainless steel. Other surface finishes include: surface treated and phosphated, surface treated and galvanized, no surface finish and oiled.

For working pressure ranges in low (LL), medium (L) and high (S) pressure applications refer to *"6. Description of DIN flareless compression fittings"*.

Operating temperatures should not exceed 120°C/248°F for cutting ring fittings and fittings with O-ring sealing. In case of higher temperatures O-rings made of Viton instead of Perbunan should be used.

Bead-forming fittings are made of a variety of materials including brass, aluminum, zinc alloy, polyamide etc. Depending on the base material they may be surface finished by nickel plating, color anodizing or epoxy coating. The body and the nut of the same fitting may be manufactured from different stock: e.g. an aluminum body and a polyamide nut.

Color: depends on surface finish

Rated pressures and operating temperatures(*):

Material	Rated pressure	Operating temperature
Nickel plated brass	up to 40 bar/580 psi	-40 to +100 °C/-40 to 212 °F
Anodized aluminum	up to 10 bar/145 psi	-25 to +100 °C/-13 to 212 °F
Polyamide	up to 20 bar/290 psi	-25 to +70 °C/-13 to 158 °F

(*) Indicative values only. Actual ratings should be obtained from the supplier/manufacturer

Compared to the other types of fitting, **push-in connectors and unions** are fairly complex and contain quite a number of parts. Each part is made of a material that is best suited for the task the part is designed for. Materials include: polyamide, nickel plated brass, stainless steel, polyacetal, plain brass, nitrile etc.

Color: various

Rated pressures and operating temperatures depend on the design of the fitting and the materials used. The correct ratings for a specific application should be obtained from the supplier/manufacturer.

Push-on fittings are most of the time one-piece devices made of a variety of materials: brass, mild steel, polyamide, aluminum, polypropylene.... . Depending on the base material the fittings may be zinc plated, galvanized, color anodized, phosphated, yellow passivated and so on.

Colors are various but yellow, silver, black, white and transparent are most common.

Rated pressures and operating temperatures depend on the material the fitting is made of. The correct ratings for a specific application should be obtained from the supplier/manufacturer.

13. Threads and size designation:

a. Terminology:

Most connectors have a threaded stud to secure them either to a system component or to another fitting. Press-fitting or welding may also be used in some applications. The variety of available stud threads makes the identification and selection of fittings complicated. Therefore, some thread related terms need to be defined.

Helix : the spiral-like pattern of the thread, comparable to a coil formed by winding a wire around a tube.

Major diameter : the largest diameter of a screw thread (2, Figure 28).

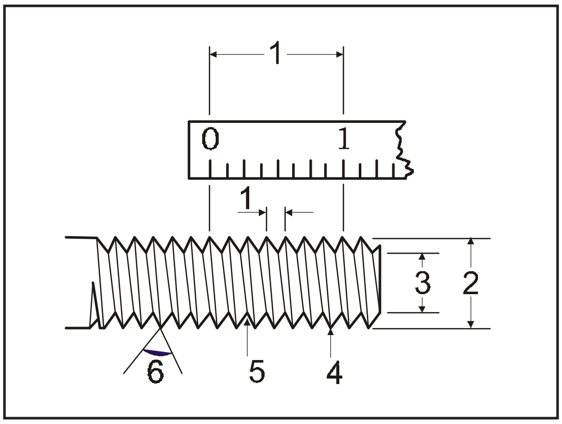

Figure 28: The parts of a thread

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Minor diameter : the smallest diameter of a screw thread (3, Figure 28).

Pitch: the distance between the crest of one thread to the same spot on the crest of the next thread (1, Figure 28) ; the smaller the pitch, the greater the number of threads per inch. The pitch, or number of threads per inch can best be determined by using a thread pitch gauge (see Figures 29 and 30).

Metric thread pitch is denoted as the distance in millimeters (mm) between two adjacent crests. Inch thread pitch is expressed as the number of threads per inch.

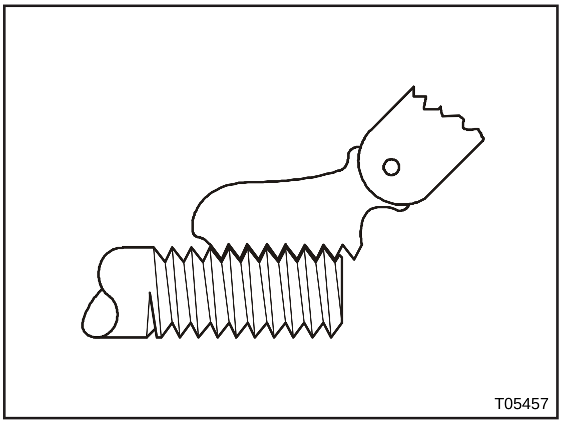

Figure 29: Using a thread-pitch gauge to determine the number of threads per inch of a stud

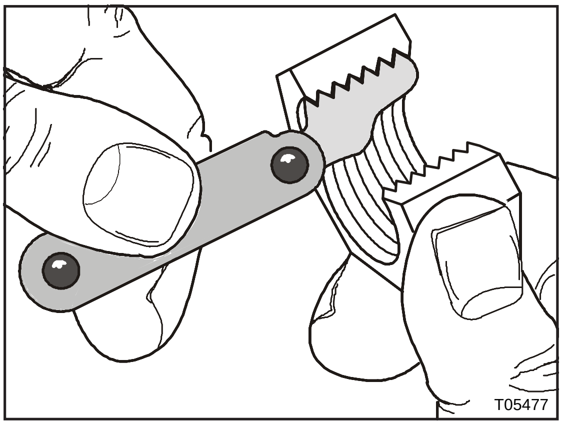

Figure 30: Checking a nut for number of threads per inch

Thread angle : the included angle between the adjacent flanks of a screw thread (6, Figure 28).

Thread, coarse : thread with the crests far apart; generally used for threading into cast iron or aluminum. Coarse thread has a larger and less critical shoulder bearing area, screws in and out more quickly, and is less subject to stripping and galling.

Thread crest : the top or peak of the thread (4, Figure 28).

Thread, fine : thread with the crests close together.

Thread height : the difference between the major diameter and the minor diameter.

Thread, left hand : studs with left-hand threads should be turned in a counterclockwise direction to tighten.

Thread, operation : the male part (stud) must advance as it turns through the female part (port), and when the hex flange bottoms, further tightening produces a tensile stress and a clamping force in the stud.

Thread, parallel : cylindrical thread; the major diameter is the same over the entire thread length.

Thread, right-hand : with common right-hand threads, the stud should be turned clockwise to tighten.

Thread root : the bottom or the valley of the thread (5, Figure 28).

Thread shape : the screw thread may be compared to a tapered wedge that has been wrapped around a cylinder; the wedge shape multiplies the force exerted in turning the stud and converts it to develop large clamping forces.

Thread, taper : conical thread; the major diameter changes from small at the point of the stud to large near the hex flange.

b. <u>Thread series:</u>

Because of the necessity for standardization, three main systems of screw threads have been developed gradually. They are the ISO Metric Form, the American Standard Form, and the British Whitworth Form. There are many variations of the basic types, as well as specialized forms. Some of these are listed on page 23.

The thread configurations commonly used for connector studs and casting ports are BSP threads, ISO metric pipe threads, UNF threads and NPT threads.

BSPP and BSPT pipe threads have a thread angle of 55° and are the most widely used fastening threads in pneumatic applications.
The spot face must be square to the pitch diameter and free from longitudinal and spiral tool marks.
BSPP-British Standard Pipe Parallel threads are used for tubes and fittings where pressure-tight joints are not made on the thread, i.e. when a peripheral seal is used.
BSPT-British Standard Pipe Taper threads are used for tubes and fittings where pressure-tight joints are made on the threads.
It is accepted common practice to fit a BSPT male thread into a BSPP female port tapping for pneumatic applications. In certain exceptional cases the port may also be tapered.

ISO metric pipe threads have a thread angle of 60°. They have mostly been used in miniature pneumatic applications because of the availability of small thread diameters, especially M5 and M3. They are also extensively used in the automotive industry.
There are two forms of sealing on metric threads: O-ring sealing into a profiled port, and peripheral sealing by a copper or bonded seal washer.

Parallel screw thread charts

ISO Metric screw thread (included angle 60°)

Major diameter (mm)	Coarse pitch (mm)	Fine pitch (mm)	Pipe thread pitch (mm)
M3	0.5	0.35	0.5
M5	0.8	0.5	0.8
M 6	1	-	-
M8	1.25	1	1
M10	1.5	1.25	1
M 12	1.75	1.25	1.5
M 14	2	1.5	1.5
M 16	2	1.5	1.5
M18	2.5	1.5	1.5
M 20	2.5	1.5	1.5
M 22	2.5	1.5	1.5
M 24	3	2	-

British Standard screw thread (included angle 55°)

Major diameter (fractional inch)	Pitch BSW (threads/inch)	Pitch BSF (threads/inch)
1/8	40	-
1/4	20	26
5/16	18	22
3/8	16	20
7/16	14	18
1/2	12	16
9/16	12	16
5/8	11	14
11/16	11	14
3/4	10	12
7/8	9	11
1	8	10

Size	Actual diameter (decimal inch)	Pitch BSPP (threads/inch)
G1/8	0.3829	28
G1/4	0.5179	19
G3/8	0.6559	19
G1/2	0.8265	14
G5/8	0.9020	14
G3/4	1.0409	14

American Standard screw thread (included angle 60°)

Major diameter (fractional inch)	Coarse pitch (UNC) (threads/inch)	Fine pitch (UNF) (threads/inch)
1/4	20	28
5/16	18	24
3/8	16	24
7/16	14	20
1/2	13	20
9/16	12	18
5/8	11	18
3/4	10	16
7/8	9	14
1	8	12

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Parallel screw thread sizes for barrels and nuts of compression type fittings

SAE flareless air brake compression fittings

Tube O.D. (fractional inch)	Thread size
1/4	7/16-24
3/8	17/32-24
1/2	11/16-20
5/8	13/16-18
3/4	1-18
1	11/4-16

DIN flareless compression fittings

Fitting series	Tube O.D. (mm)	Thread size (mm)
LL	4	M8x1
	6	M10x1
	8	M12x1
L	6	M12x1.5
	8	M14x1.5
	10	M16x1.5
	12	M18x1.5
	15	M22x1.5
	18	M26x1.5
	22	M30x2
	28	M36x2
	35	M45x2
	42	M52x2

Fitting series	Tube O.D. (mm)	Thread size (mm)
S	6	M14x1.5
	8	M16x1.5
	10	M18x1.5
	12	M20x1.5
	14	M22x1.5
	16	M24x1.5
	20	M30x2
	25	M36x2
	30	M42x2
	38	M52x2

Taper screw thread charts

British Standard screw thread (included angle 55°)

Size	Actual diameter (decimal inch)	Pitch BSPT (threads/inch)
R1/8(*)	0.3829	28
R1/4	0.5179	19
R3/8	0.6559	19
R1/2	0.8265	14
R5/8	0.9020	14
R3/4	1.0409	14

(*) Refer to pipe thread designation in text

American Standard screw thread (included angle 60°)

Size	Actual diameter (decimal inch)	Pitch NPTF (threads/inch)
1/8(*)	0.405	27
1/4	0.54	18
3/8	0.675	18
1/2	0.8399	14
3/4	1.05	14

(*) Refer to pipe thread designation in text

UNF threads have a thread angle of 60° and are normally used in hydraulic applications. Unified National Fine threads are used where pressure-tight joints are not made on the threads, i.e. when a peripheral seal is used.

NPT threads. The National Pipe Taper thread has a thread angle of 60°, and is used on SAE flareless air brake compression fittings.
NPT-National Pipe Taper threads are used for connections where pressure-tight joints are made on the threads utilizing a thread sealant.
NPTF-National Pipe Taper Fuel (Dryseal) threads are used for connections where pressure-tight joints are made on the threads, without a thread sealant, although this remains recommended.

American Standard pipe screw threads are tapered 1 inch in 16, or 1°47'. Their size designation is confusing because the numbers refer to the inside diameter of a piece of heavy wall plumbers pipe that was originally designed to receive the male thread. For example, a commonly used 1/8 inch pipe fitting to which a 1/4 inch tube attaches does not look like 1/8 inch anyway you measure it. Actually, a 1/8 inch NPT fitting screws into a hole about 3/8 inch in diameter. Figure 31 shows the different NPT thread designations and the actual stud sizes. Figures 32 and 33 and the accompanying charts indicate what measurements should be taken to determine taper pipe thread sizes.

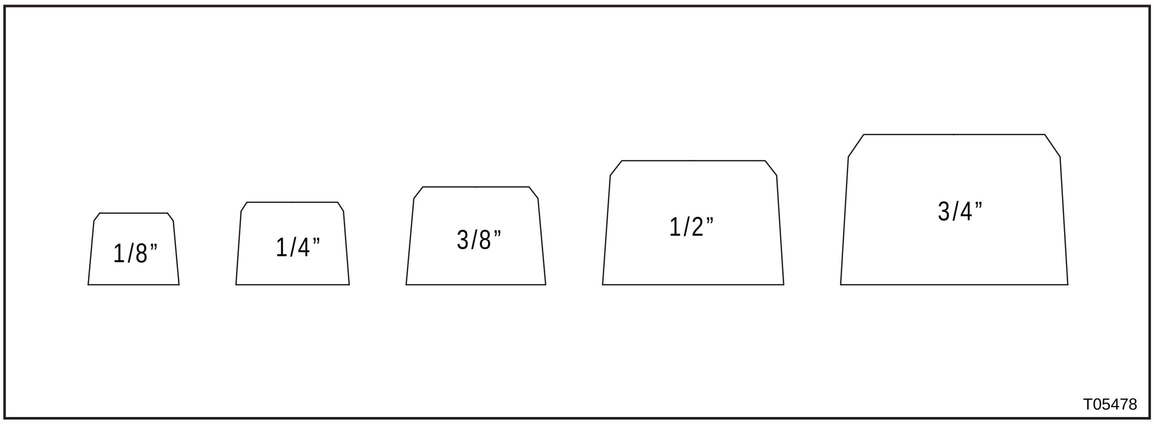


Figure 31: NPT thread silhouettes

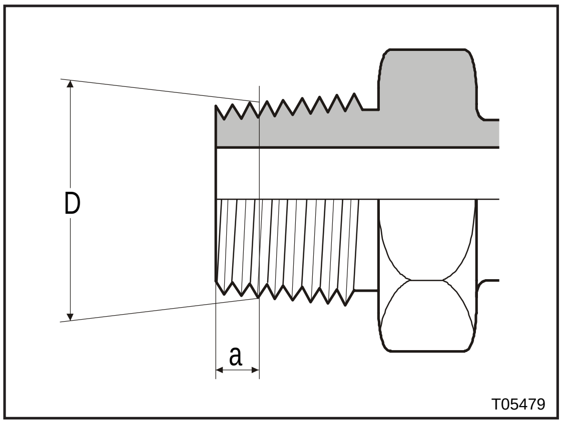
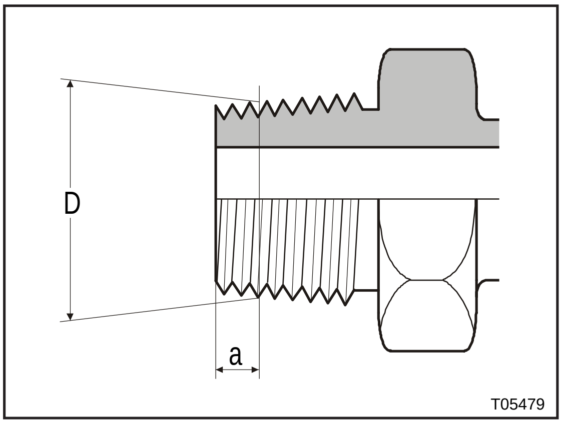


Figure 32: NPT dimensions

NPT size	D (decimal inch)	Threads/inch	a (decimal inch)
1/8	0.4015	27	0.1771
1/4	0.5314	18	0.1968
3/8	0.6692	18	0.2362
1/2	0.8346	14	0.3188
3/4	1.0433	14	0.3385
1	1.3070	11 1/2	0.3976



BSPT size	D (decimal inch)	Threads/inch	a (decimal inch)
1/8	0.3818	28	0.1574
1/4	0.5157	19	0.2362
3/8	0.6535	19	0.2519
1/2	0.8228	14	0.3228
3/4	1.0393	14	0.3740
1	1.3070	11	0.4094

Figure 33: BSPT dimensions

Port and stud compatibility. When fitting a stud to a port, the following combinations may be used provided the threads match as does the sealing method:

- internal thread parallel + external thread parallel
- internal thread parallel + external thread taper
- internal thread taper + external thread taper

How to measure parallel threads.
With a vernier type caliper, measure the major thread diameter. Measure the O.D. of male threads and the I.D. of the female threads as shown. Match the measurement to the charts. The O.D. is actually the I.D plus the thread depth.

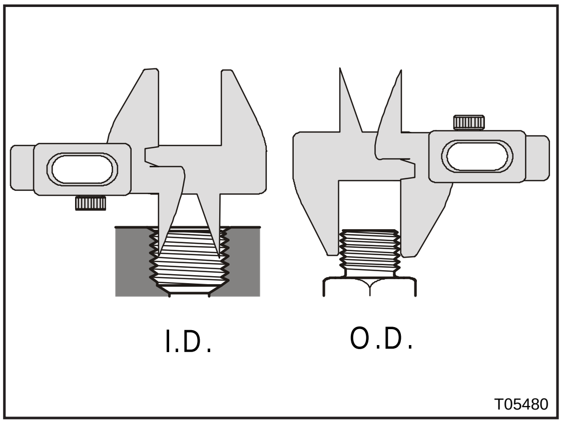


Figure 34: Measuring the inside diameter (I.D.) and outside diameter (O.D.)

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Use a thread pitch gauge with the correct thread angle (55° or 60°) to determine the distance between the threads. Select the gauge which fits the thread snugly and match the measurements to the charts.

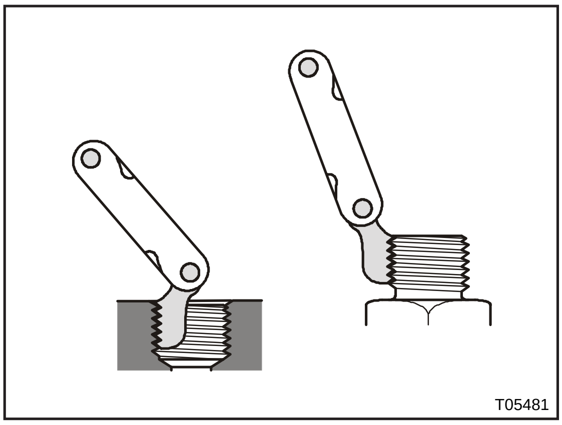


Figure 35: Measuring pitch

14. Common sealing designs:

When connecting a tube to a system unit, a leakproof joint must be provided between the connector stud and the threaded port in the casting. A number of accepted methods to achieve this are listed below. Special attention should be paid to the different shapes of the mounting flanges and the way the ports are spotfaced.

a. Peripheral sealing of parallel threads:

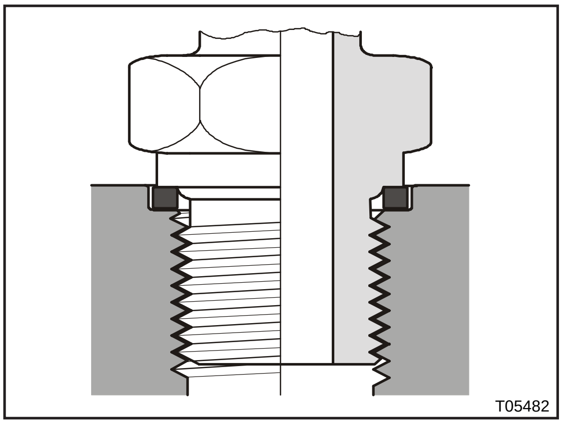


Figure 36A: Sealing by means of a washer

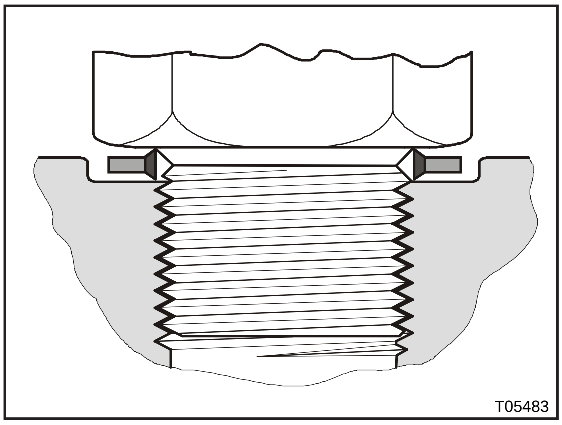


Figure 36B: Sealing by means of a bonded seal (stud not fully tightened)

Washers and *rings* are manufactured in many different materials including copper, aluminum, fibre, plastics, etc.
Bonded seals are elastomer sealing rings bonded into metal washers. They are reusable and cater for a variation in the dimensional tolerances of the machined surfaces.

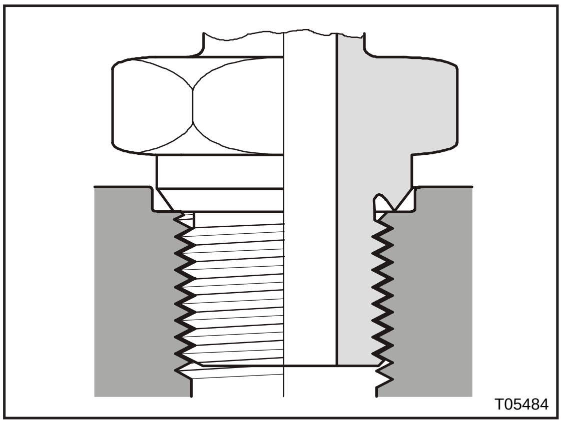


Figure 37A : Sealing by means of a cutting edge. A sealing washer is not necessary but may be fitted

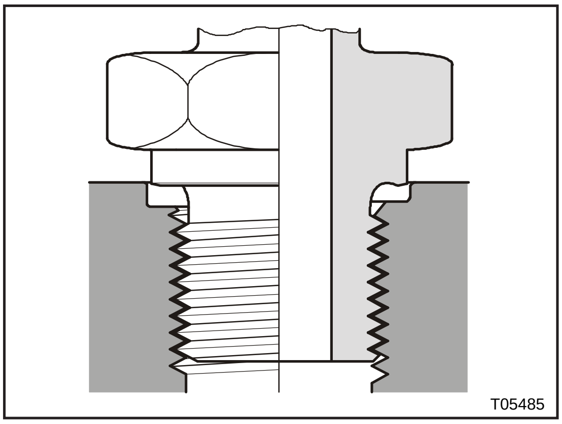
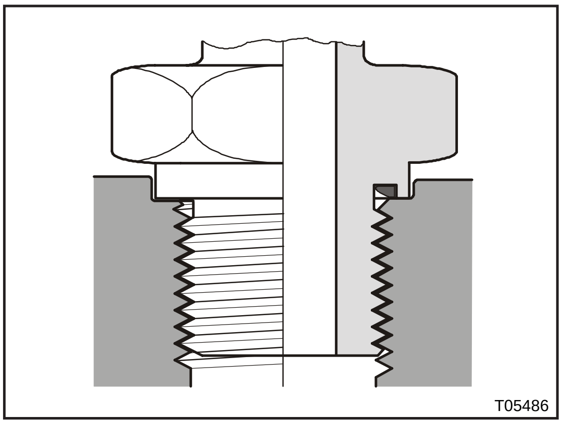
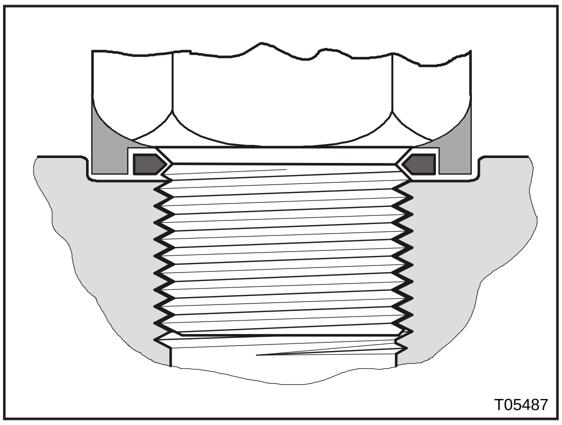


Figure 37B : Sealing by means of a sealing shoulder (stud not fully tightened)





Figures 38 A and B : Sealing by means of a profiled elastomer ring recessed into the fitting body. This ensures correct alignment.

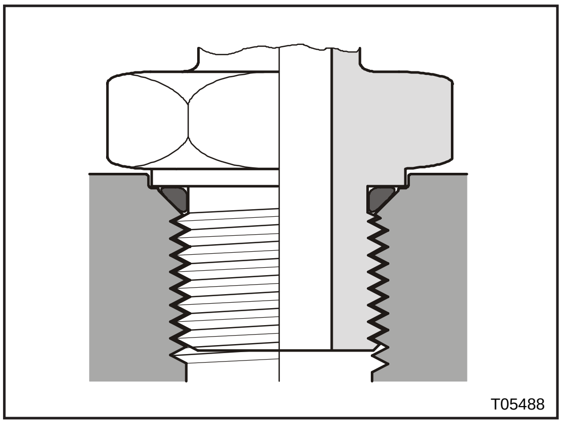


Figure 39: Sealing by means of an O-ring in the thread undercut

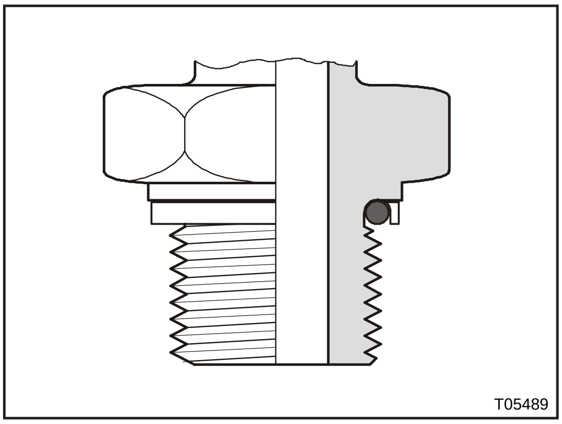


Figure 40: Sealing by means of an O-ring with a backup washer

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O-rings are solid one-piece synthetic rubber seals, moulded and vulcanized in a die, using heat and pressure. They are used to create a seal between two parts, close off passageways, prevent the loss or transfer of fluids and gasses, and help retard the entry of dust and water. Because the O-ring is composed of a somewhat soft, pliable material, it seals, when slightly squeezed between two surfaces. If the O-ring is also sealing under pressure, the pressure itself will aid in deformation of the ring, further making a final seal. O-rings can be used to seal both static (nonmoving) and dynamic (moving) parts, although the latter application is seldom used.

O-ring installation: Whenever an O-ring connection is undone, a new ring must be used before the fitting is reconnected. Following installation rules should be observed:

1. O-rings are made to close tolerances. Make sure the new O-ring is the correct size (designation: inside diameter x cross-section) and that it is compatible with the fluid or gas being sealed. Also check the temperature operating range:

   NBR-rings (e.g.Perbunan): -35 to +100°C/-31 to +212°F
   FPM-rings (e.g.Viton): -25 to +200°C/-13 to +392°F

   (Perbunan is a registered trademark of Bayer)
   (Viton is a registered trademark of DuPont)

2. Thoroughly clean the area where the O-ring is to be installed.

3. Inspect the O-ring grooves or notches for burrs or nicks which could damage the new ring. Dress any sharp areas with a fine abrasive stone. Again thoroughly clean the area to remove any metal and stone particles.

4. Before installation, lubricate the O-ring with the same type of fluid used in the part or system, if applicable.

5. Install the O-ring. Protect it from sharp edges and other parts. Do not stretch it.

6. Be sure the parts are correctly aligned before mating to avoid damage to the O-ring.

7. Make a final check after the O-ring is installed to be sure there are no leaks.

b. Interference sealing of taper threads:

Taper pipe threads made to the Dryseal American Standard (NPTF), unlike other types of threads, can seal joints pressure-tight. The dryseal pipe thread roots are wider than the crests. When the threads are wrenched together, the roots crush the sharper crests of the mating threads. This forms a metal to metal seal (see Figures 41 and 42). Dryseal threads improve sealing characteristics but a thread sealant is recommended. Some sealants used by Van Hool have been discussed below (see also item 24 "Fitting instructions for pipe-threaded fittings").

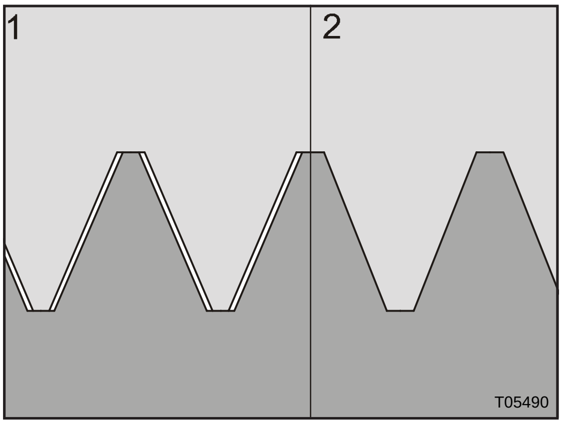


Figure 41: Dryseal thread operation

1. **Dryseal pipe threads hand-tight**
2. **Dryseal pipe threads wrench-tight. Seals tightly on all sides for positive sealing action.**

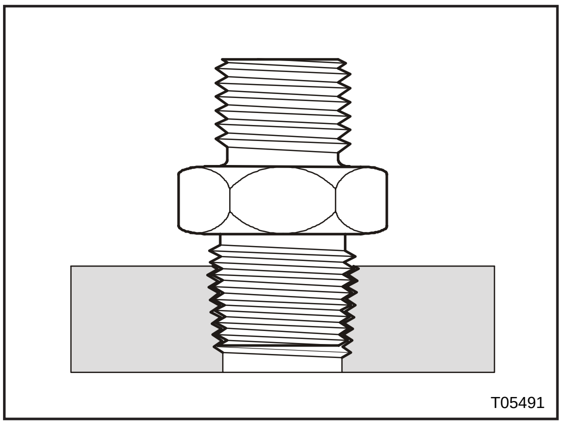


Figure 42: Sealing by means of tapered thread. Female thread may be parallel but must be tapered to achieve rated operating pressure.

PTFE (Teflon*) tape. One or two layers of PTFE tape are wound around the external taper thread, prior to assembly. It is recommended to leave the first two threads uncovered to avoid tape fragments entering the circuit during assembly, causing the possible malfunction of valves, filters, etc.

Sealing compounds and liquid sealants. Apart from polymer joint compounds and air-drying liquid sealants, the most common thread seal is an anaerobic synthetic resin, which cures in the absence of air. Following assembly and tightening, the curing process is induced by a catalytic reaction between the resin and the metal. Resins that contain PTFE ease disassembly. Connections are normally ready for operation after one hour's curing time. Complete curing may take up to 24 hours. Disassembly of the connection destroys the sealing surface.

(*) Teflon is a registered trade mark of DuPont.

For reassembly of hydraulic and pneumatic fittings (tube size up to 3/4 inch O.D.) Van Hool recommend Loctite 542 sealant (red-brown).
For larger sized fittings and fittings for water, antifreeze and sanitary applications Loctite 577 sealant (yellow) is preferred.

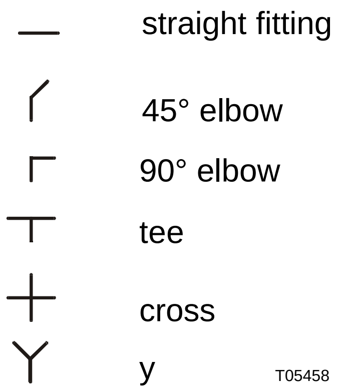
Pre-coated taper threads. SAE flareless air brake compression fittings have the taper threads pre-coated with a solution of PFTE powder carried in an acrylic base. No additional sealant is necessary for an effective seal during assembly. The male pipe thread can be reused up to five times without the use of additional sealing material.

15. Description examples:

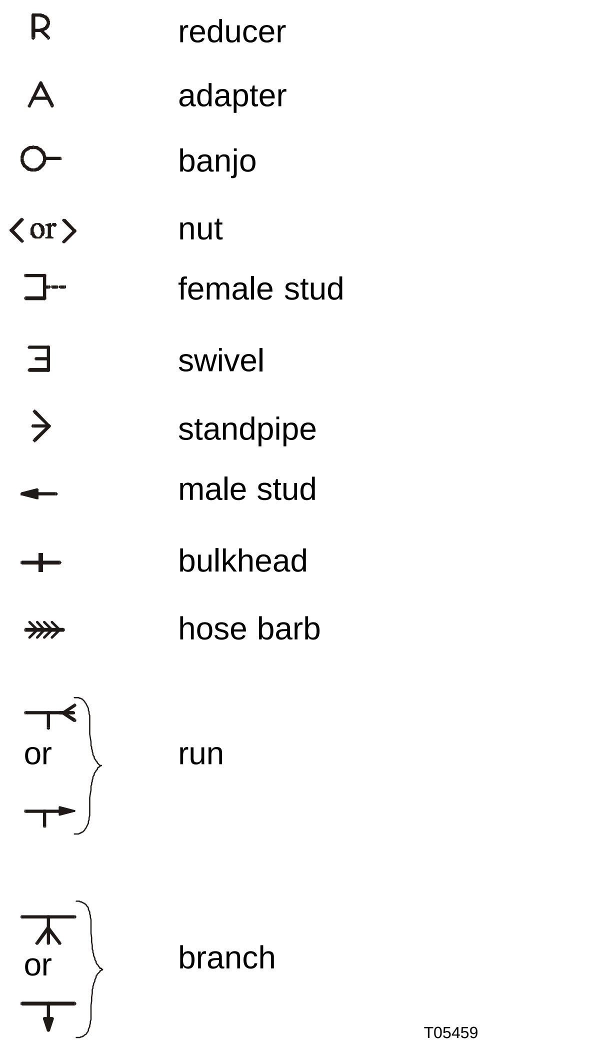
In the spare parts manual the description provides an important link between the actual hardware, the drawing and the part number. Definitions should therefore be accurate and consistent. Below are some example descriptions of the more common fittings used on Van Hool coaches. The symbol in front of the text represents the body shape and special features of the particular fitting.

a. Explanation of symbols used:

Body shapes:



Special features



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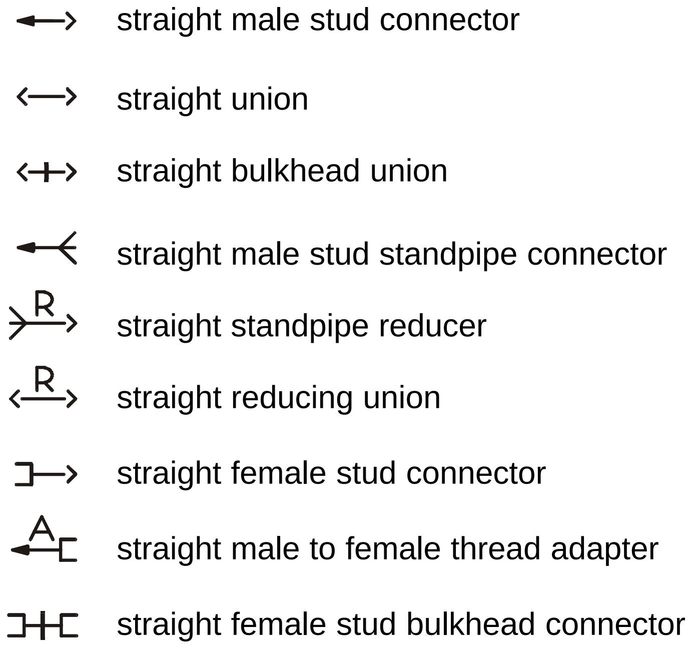
b. Straight fittings:



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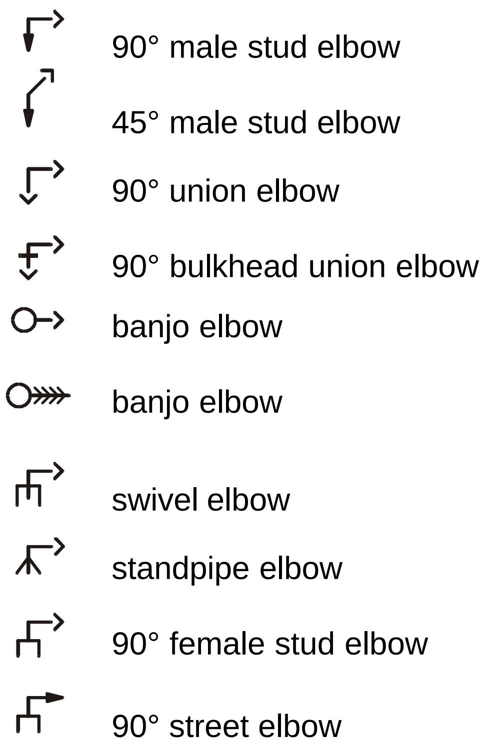
c. Elbows:



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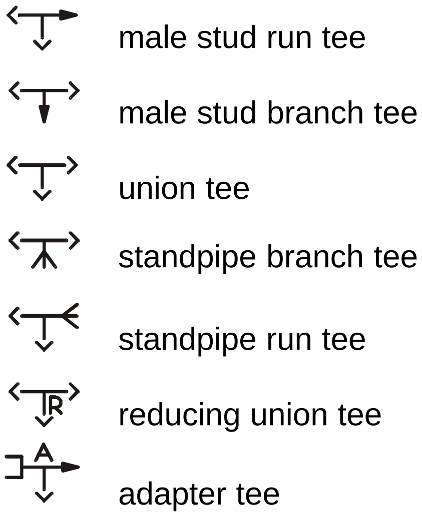
d. Tees:



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e. Crosses:

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16. Accessories:

The accessory section in the Van Hool fitting manual includes information on complimentary plumbing products such as:

- access valves
- ball valves
- blanking plugs
- breathers
- check valves
- drain cocks
- drain valves
- dust covers
- filters
- hose clamps
- plug valves
- pressure gauge connectors
- pressure gauges
- pressure regulators
- quick-release connectors
- sealants (liquid, semiliquid and tape)
- shut-off cocks
- silencers
- strainers
- throttle inserts
- throttle valves
- tools
- tubes
- tube clamps

These parts are available as complete units only. Components are not offered separately for service replacement. Relevant thread sizes have been provided in the "Fitting" manual under the "Specifications" heading.

17. Tubing: materials, handling and installation:

a. Materials:

Soft, half-hard and hard copper, brass, steel, aluminum, soft and semirigid plastic, and stainless steel are some of the materials used in the manufacturing of tubing. All of these are used on Van Hool coaches but the most common types are copper and nylon, supplemented by the odd steel or stainless steel tube. The choice of tube material depends on design requirements such as operating temperatures, flow rate, location on the coach, susceptibility to vibrations and heat, flexible or non-flexible installation and of course the rated pressure. Moreover a pressure safety factor between three and five to one needs to be respected (material three to five times stronger than the anticipated working pressure). It becomes therefore obvious that a technician must know what material is used in the tubing. He must also have accurate knowledge of the pressures and temperatures produced in the system the tubing is used on. Consequently it is also obvious that damaged tubes must always be replaced by tubing of the same material and with the same dimensions, provided the rated pressure remains the same.

Copper tubing is rust proof, easy to bend, and forms good joints. It is used in many low pressure applications such as the cooling system, the heating system, and sanitary installation, but also in the air-conditioning system, which has a higher rated pressure. Tube sizes are metric or inch, ranging from 3 mm/0.118 inch O.D. to 70 mm/2 3/4 inch O.D. with a choice of wall thicknesses. Sizes may be noted as O.D. x wall thickness (in mm or inch) or as O.D x I.D. (in mm or inch). Tubes come as coils or in 5m/16 ft standard lengths. Copper is subject to work hardening (material becoming hard and brittle from bending). Therefore it should be protected from excessive vibration. Never use copper tubing for brake or power steering work.

Plastic tubing. Polyethylene and nylon are two of the materials used in the construction of plastic tubing. Soft and semirigid plastic tubing has the advantage of flexibility, resistance to corrosion, and work hardening. It will not, however, stand high pressures and excess heat (operating temperatures from -40°C/-40°F to 60°C/140°F). It can be used for fuel, vacuum, compressed air and some lubrication lines. Special inserts are needed to attach it to conventional tube fittings. When replacing an air line, use nylon tubing only where it has been used previously. (Reinforced) soft plastic tubing is used in the rest room, in the cooling system (catch tank overflow line), at the evaporator drip pan etc.
Semirigid nylon tubing has been approved by the DOT for brake system applications. It is also used for the suspension system, the fuel system, and for peripheral equipment.
Nylon tubing comes as coils in metric and inch sizes. The chart below shows some typical (metric) examples.

Metric tube size (O.D. x wall thickness) in mm	Max operating pressure at 20°C/68°F in bar/psi	Burst pressure in bar/psi
6 x 1	27/392	81/1176
8 x 1	19/276	57/828
10 x 1	15/218	45/654
12 x 1,5	19/276	57/828
15 x 1,5	15/218	45/654
18 x 2	17/247	51/741

NOTE: Nylon air lines must never be routed in areas where temperature could exceed 93°C/200°F.

b. <u>Handling:</u>

When removing tubing from a roll, place the roll on a clean bench in an upright position. Hold the free end of the tube with one hand while rotating the roll over the bench with the other. Never lay the coil flat and pull the tubing upwards as it will be twisted. Avoid bending the tubing more than necessary. Store tubing where no heavy tools or parts are liable to cause damage. Keep the open end taped to prevent the entry of foreign material.

c. Cutting:

When cutting tubing, it is important to produce a square-end, free of any burrs, either on the outside or inside. Tubing may be cut with a tube cutter (see Figures 43 and 44) or with a hacksaw and a saw jig (see Figure 45).

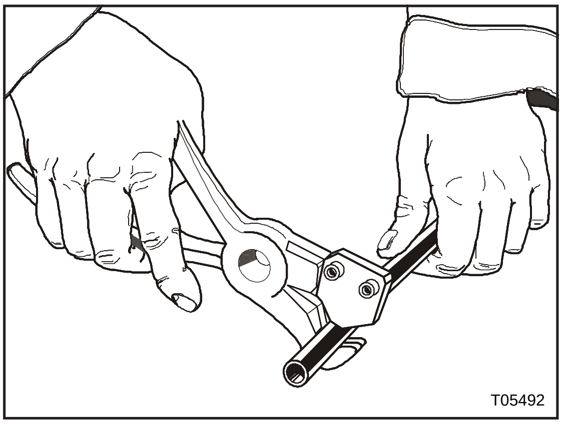

Figure 43: Cutting pliers for plastic tubing

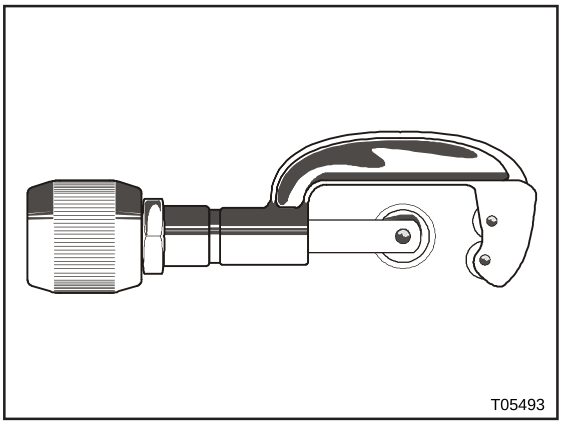

Figure 44: Tube cutter for soft metal tubing

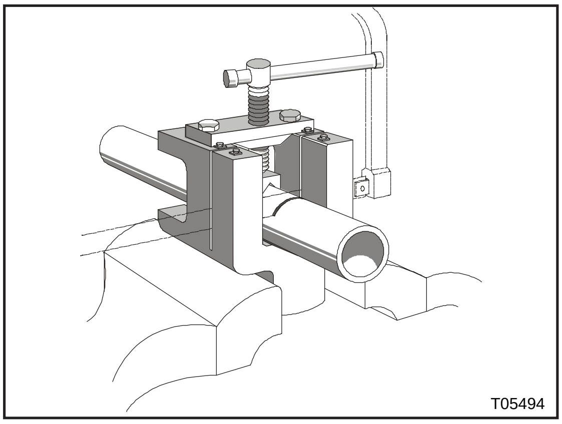

Figure 45: Hacksaw and saw jig for steel and stainless steel tubing

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Plastic tubing should be cut with purpose-made cutting pliers, never with ordinary cutting pliers or a hacksaw. The metal tube cutter may be used with any soft metal tubing, such as copper, aluminum, or aluminum alloy. The correct use of the tube cutter is shown in Figure 46.

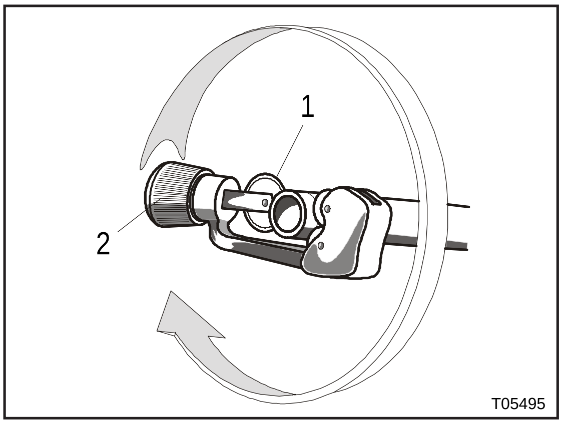

Figure 46: Tighten cutter wheel (1) by turning handle (2)

A new piece of tubing should be cut approximately 10 percent longer than the tube to be replaced, to provide for minor variations in bending. Place the tubing in the cutting tool, with the cutting wheel at the point where the cut is to be made. Rotate the cutter around the tubing, applying a light pressure to the cutting wheel by twisting the thumb screw after each complete revolution. Too much pressure on the cutting wheel at one time could deform the tubing or cause excessive burring. Repeat the process until the tubing is cut off. After cutting the tubing, carefully remove any burrs from inside and outside the tube. Do not chamfer ! Use a knife or the burring edge attached to the tube cutter. When reaming hold the end of the tubing downward so that the chips fall free. If tubing of hard material is to be cut, such as steel and stainless steel, use a fine tooth hacksaw, preferably one having 32 teeth per inch, and a saw-jig (see Figure 45). After sawing, file the end of the tube square and smooth, removing all burrs.

d. <u>Bending (nylon tubing):</u>

Nylon tubing can be bent cold, but attention should be paid to the bend radius indicated in Figure 47. Since the tubing has a tendency to straighten, it should be secured with supporting clamps before and after each bend.

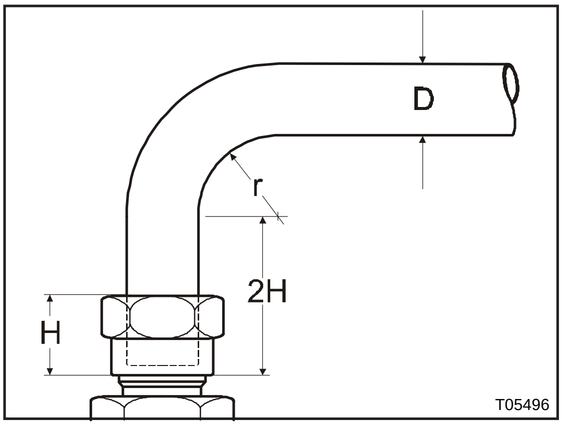

Figure 47: Nylon tubing bend radius

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To avoid kinking of the tubing, keep to the minimum bending radius shown in the chart below.

Tube size (O.D. x wall thickness) in mm	Minimum bending radius r (mm)
6 x 1	30
8 x 1	40
10 x 1	60
12 x 1,5	60
15 x 1,5	90
18 x 2	100

e. **Bending (metal tubing):**

The objective in tube bending is to obtain a smooth bend without flattening the tube. Soft copper and thin-wall steel tubing, in the smaller sizes, can be bent by hand. Slip a bending spring over the tubing, then form the bend with your hands (see Figure 48).

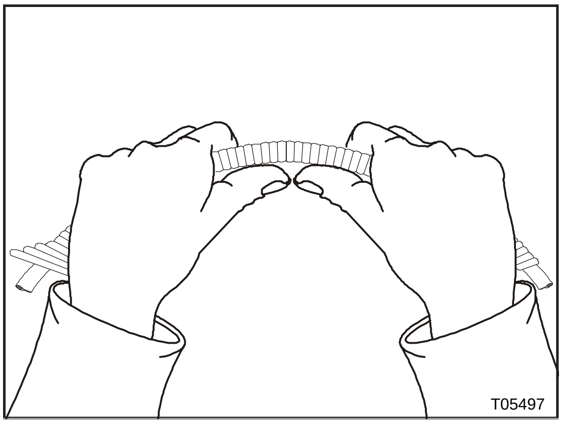

Figure 48: Using a spring tube bender

When using a bending spring, make sure it is the correct size. Bend the tubing slightly more than needed. When it is bent to the exact shape, the spring can be removed.

For tube sizes larger than 6 mm/¼ inch, a hand tube bender similar to that shown in Figure 49 is usually used.

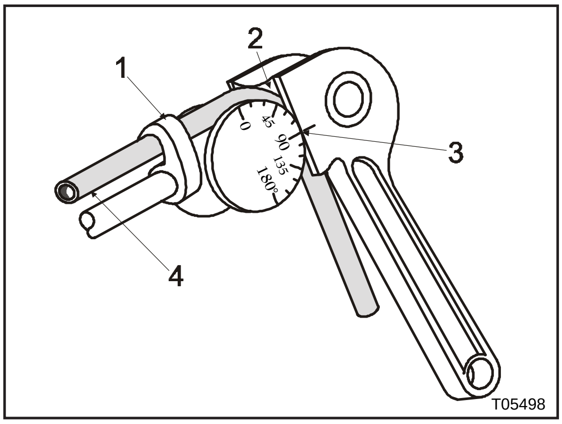

Figure 49: Tube bending with hand bender

1. Holding foot
2. Groove
3. Degree marks
4. Tubing

To bend tubing with the hand tube bender, insert the tubing by raising the slide bar handle as far as it will go. Adjust the handle so that the full length of the groove in the slide bar is in contact with the tubing. The zero mark on the radius block and the mark on the slide bar must align. Make the bend by rotating the handle until the desired angle of bend is obtained, as indicated on the radius block. Bend the tubing carefully to avoid flattening, kinking or wrinkling. Tubing with flattened, wrinkled or irregular bends should not be installed. Wrinkled bends usually result from trying to bend thin-wall tubing without using a tube bender. Examples of correct and incorrect tubing bends are shown in Figure 50.

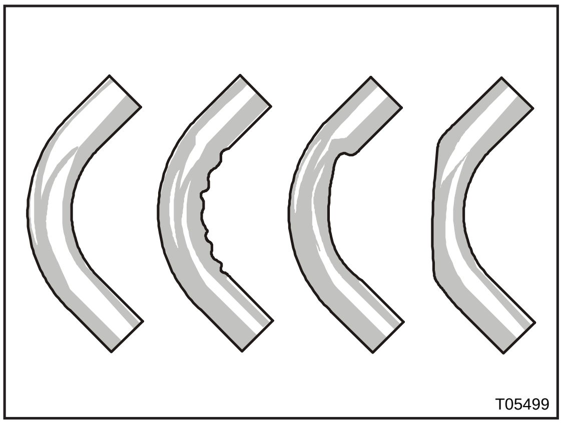

Figure 50: Correct and incorrect tubing bends. From left to right :

1. **Good bend**
2. **Wrinkled bend**
3. **Kinked bend**
4. **Flattened bend**

Tube bending machines for all types of tubing are generally used in repair stations and large maintenance shops. With such equipment, proper bends can be made on large diameter tubing and on tubing made of hard material. The principle of operation is similar to that of the hand tube bender.
When hand benders or tube bending machines are not suitable for a particular bending operation, a filler of metallic composition or of dry sand may be used to facilitate bending.

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f. Beading;

Tubing may be beaded with a hand-beading tool, with machine-beading rolls, or with grip dies. The method to be used depends on the diameter and wall thickness of the tube and the material it is made of. The hand-beading tool is used with tubing having 6 mm/¼ inch to 25 mm/1 inch outside diameter. The bead is formed by using the beader frame with the proper rollers attached. The inside and outside of the tube is lubricated with light oil to reduce the friction between the rollers during beading. The sizes, marked on the rollers, are for the outside diameter of the tubing that can be beaded with the rollers. Separate rollers are required for the inside of each tubing size, and care must be taken to use the correct parts when beading. The hand-beading tool works somewhat like the tube cutter in that the roller is screwed down intermittently while rotating the beading tool around the tubing.
Other methods and types of beading tools and machines are available, but the hand-beading tool is used most often. As a rule, beading machines are limited to use with large-diameter tubing.
The grip-die method of beading is confined to small tubing. Figure 51 gives the correct relationship between beaded tube, hose and hose clamps.

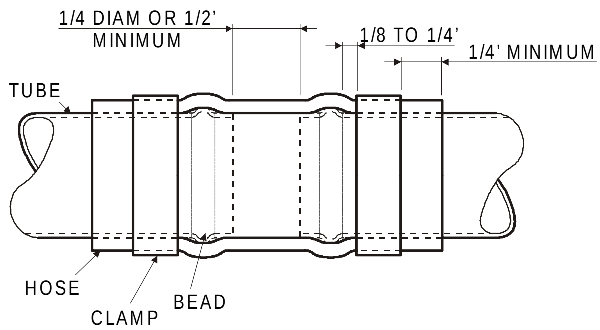

Figure 51: Correct relationships between beaded tube, hose and hose clamps.

g. Cleaning:

After finishing the tube forming processes, use compressed air to blow out the line and remove any chips or other foreign material. If during installation, there is any chance of dirt or grease being jammed into the ends, cover the ends with masking tape or plugs. Remember that tubing and hoses must be kept spotless to avoid future problems (see also note on pre-cleaning of air-conditioning lines below).

h. Installation:

Not only must the proper lines be installed in a coach, they must be installed properly. Below are some basic rules regarding the installation of soft, semirigid, and rigid tubing, and hoses. Some rules may be specific to either hose or tubing, some may apply to both.

- Before installing a line, be sure to blow it out with compressed air to remove any obstructions or particles that may have been left in the process of manufacture or which may have been allowed to enter while the hose or tube has been in storage. Before a line is stored, it should have both ends capped against any entry of contamination.

NOTE : Air-conditioning lines should under no circumstances be blown out with compressed air, because it contains moisture, which renders the lines useless. To remove any dirt, use dry nitrogen instead and seal off the line with plastic plugs.

- After a replacement tube has been formed into the proper shape and all the bends have been inspected to be sure they are not collapsed, kinked, or wrinkled, it is trial-fitted and checked to be sure that the tube aligns straight into the fittings at each end ; with a slight pressure on them.

- Figure 52 illustrates some typical line installations. Those in the left column are wrong. The correct methods are shown in the right column. Notice how single, smooth bends, without twisting are made.

INCORRECT CORRECT

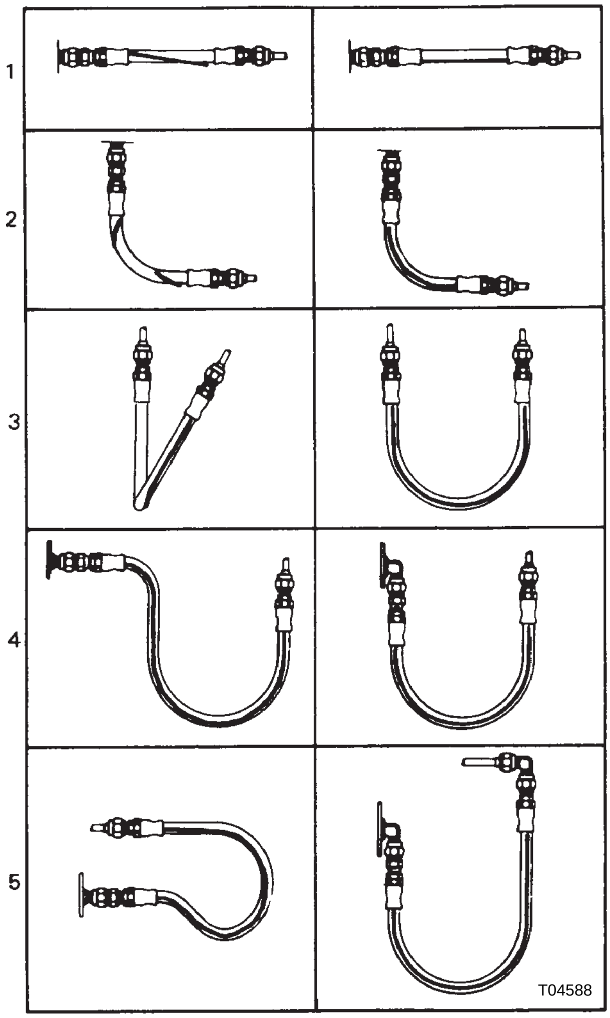

Figure 52 : Incorrect and correct line installations. Double bends and twisting are to be avoided

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- When making straight run connections, allow some slack to avoid stressing the hose from the pressure, vibration, or part shifting (see Figure 53). If the hose is run long, use clips or cushion clamps at regular intervals to secure it in place.

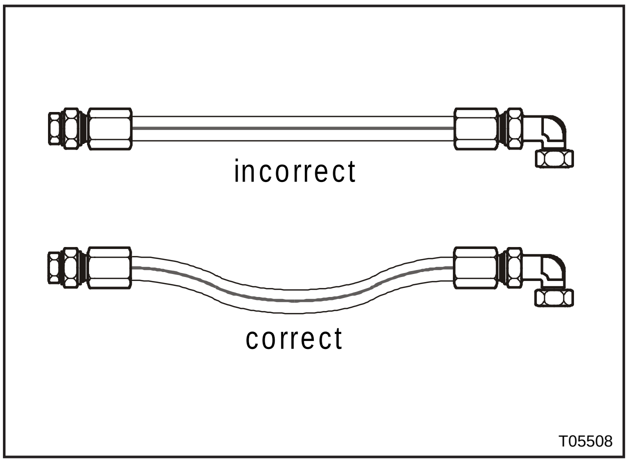

Figure 53 : Hose dip

- A line should NEVER be twisted, because this leads to a built-in strain. Pressure surges in a twisted line can cause failure. Markings on the line and the use of swivel head fittings facilitate a twist-free installation. When tightening the fittings, tighten the swivel end last. Always support one portion with one wrench, while tightening with another to prevent twisting the line. Use flare wrenches. Do not overtighten the line ends onto the adapter fittings or ports.

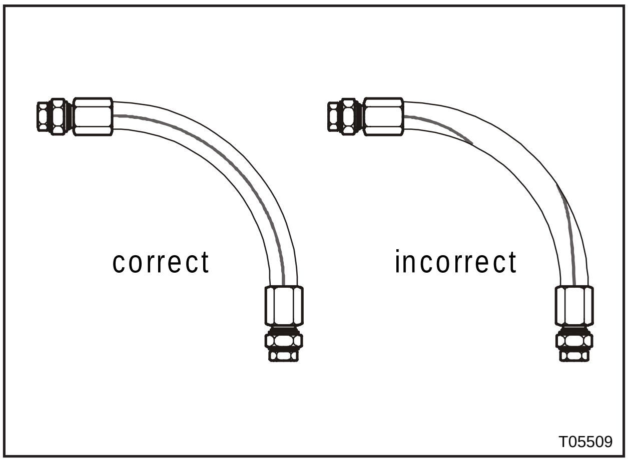

Figure 54 : Twisted and twist-free installation

- Avoid acute bending of the hose adjacent to the rear of the hose connection (see Figure 55). A minimum length of three times the outside diameter of the hose is recommended between the rear of the hose connection and the beginning of the bend radius.

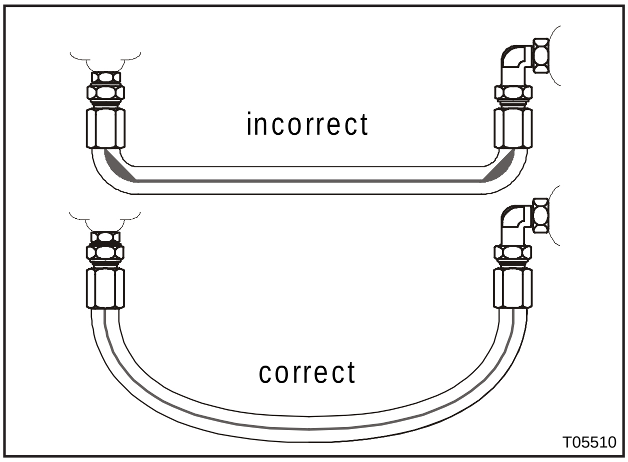

Figure 55 : Acute bending and installation with sufficient slack

- In the case of bends in rigid tubing, the straight tube end should have two times the height of the nut as a minimum length up to the beginning of the bend radius (see Figure 56).

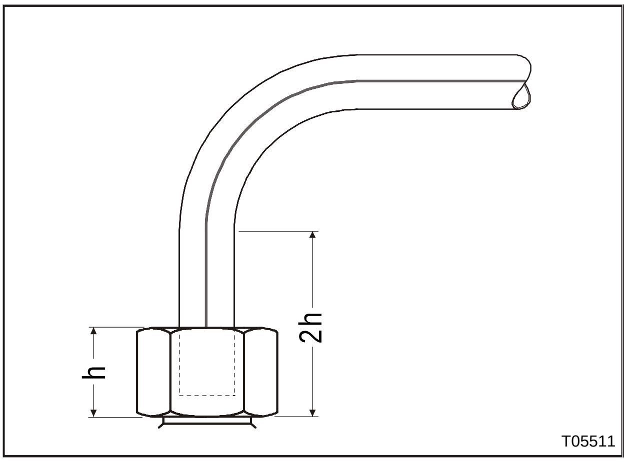

Figure 56 : Starting point of rigid tubing bend

- The minimum length for straight, short tubes should be approximately 2 ½ times the nut height.

- In determining how sharp a bend may be, figure that the bend radius should be at least five times the outside diameter of the line. For example : a line with an O/D of ½ inch should have a bend radius of 2 ½ inches. In other words, if the line were pulled around a circle, the circle diameter would be at least 5 inches.

- Avoid kinks caused by too tight a bend, by misalignment between the line and the port or connector on short assemblies or by getting the whole assembly into a helix on long assemblies. Align the line ends with the connectors so that the line is not placing any strain on the line ends or on the connectors. For right angle configurations of lines, use elbow fittings to prevent stress on the connection due to the line bend (see Figure 57).

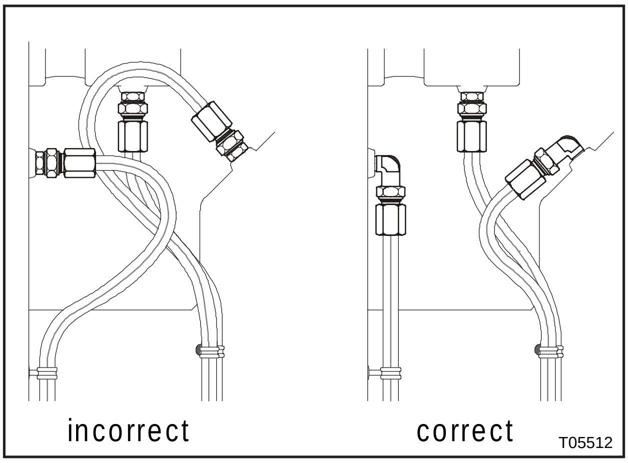

Figure 57 : Use of elbows to prevent stress

- Make sure there is adequate clearance between a line and anything it might be able to contact. Do not allow the line to rub against anything that may cause damage (sharp corners, nuts, bolts, rivet stems etc.), even when the surface it rubs on is flat. Spiral wrap is a convenient way to protect against chafe damage on flat panels.

- Never attempt to pull a hose up to its fitting by the nut. When pressure is applied to a hose, it will tend to expand its diameter and its length will shorten. Allow at least 2 to 4 % slack in the line.

- Keep lines away from extreme heat sources (like the combustion heater body and exhaust) as far as possible.

- When not using a bulkhead fitting to bring a line through a bulkhead, the line must be supported with the properly sized cushion clamps and centered in the hole in such a way that there is protection against chafing.

- Any time relative movement between two lines or between a line and a system unit is possible, a section of flexible line should be installed.

i. Support clamps

Support clamps are used to secure the various lines to the coach chassis and prevent damage by vibrations, shock loading and alternating bending loads.
Several types of support clamps are used for this purpose. The rubber-cushioned and plain are the most commonly used clamps. Rubber-cushioned clamps are used to secure lines subject to vibration ; the cushioning prevents chafing of the tubing or hose. Plain clamps are used to secure lines in areas not subject to vibration.
Bundles of nylon tubes may be held together with tie wraps and then be connected to the chassis with cushion clamps.
Make certain that clamps are of the correct size. Clamps or supporting clips smaller than the outside diameter of the line may restrict the flow by reducing the cross-section.
All plumbing lines must be secured at specified intervals. The maximum distance between supports for rigid tubing is shown below.

Tube O.D.		Maximum distance between supports	
mm	inch	mm	inch
3	1/8	250	10
6	1/4	350	14
10	3/8	450	18
12	1/2	550	22
15	5/8	600	24
18	3/4	650	26

Support clamps should be placed as near a bend as possible so there will be little overhang.

j. Repair tips:

- Damaged lines should be replaced with new parts whenever possible. Sometimes replacement is impractical and repair is necessary. Faulty lines can be repaired by cutting out the damaged section and inserting a tube section of the same size and material.

- If a tubing assembly is to be replaced, the fittings can often be salvaged, so the repair will involve only tube forming and replacement.

- When repairing a line, use the smallest number of fittings possible. Every additional fitting increases the chance of the system producing a leak.

- After repairing a system, always bring it up to its operating temperature and pressure, and check all connections for leaks.

- Never use racer's tape or tank tape to repair leaks. The tape will give way sooner or later and the line needs to be replaced anyway.

- If the damaged portion is short enough, omit the insert tube and repair by using a union.

- Remove the damaged or worn assembly, taking care not to further damage or distort it, and use it as a forming template for the new part. If the old length of tubing cannot be used as a pattern, make a wire template by bending the pattern as required for the new assembly. Then bend the tubing to match the wire pattern.

- In all cases and prior to installation the new tube assembly should be formed in such a way that it will not be necessary to pull or deflect the assembly into alignment by means of the coupling nuts.

- Avoid straight runs. Straight runs, especially if short, will not work well. The slightest shifting between the two units will impose a strain on the connections. They are also difficult to install or remove. Never select a path that does not require bends in the tubing. Bends allow the tubing to expand or contract under temperature changes and to absorb vibration.

k. <u>Precautions</u>:

Air system

To avoid personal injury when working on or around the air system and its components, the following precautions should be taken.

1. Always block the vehicle wheels and shut down the engine. Venting the coach air system pressure may cause the vehicle to roll. Keep hands away from chamber push-rods and slack adjusters ; they may apply as the system pressure drops. Stay away from deflating air bellows.

2. Vent all air pressure from the coach system.

3. Never connect or disconnect a line containing air pressure. It may whip, as air escapes. Never remove a component or open a line, unless you are certain that all system air pressure has been vented.

4. Never exceed the recommended air pressure and always wear safety glasses, when working on air systems.

5. When using an angle grinder or welding equipment on the coach, shield with a proper barrier any electric wires, air, hydraulic or fuel lines that could possibly be damaged.

Cooling, heating and air conditioning system

1. Before opening ANY system, make sure the pressure in the system is brought to and remains at the atmospheric pressure. Failure to comply may result in system damage and/or personal injury.

2. Before draining or working on the cooling/heating system, check that the coolant has cooled down to approximately 35 °C/95 °F. Shut off and disconnect the combustion heater.

3. When opening the cooling/heating system, use a suitable container to collect the coolant while draining the system.

4. The refrigerant circuit is pressurized. Opening and repairing that system should be left to a qualified technician.

5. Do not attempt any procedure that may result in the uncontrolled release into the environment of refrigerant or coolant (water with antifreeze and cooling additives).

18. Assembly and fitting recommendations:

Fittings are high quality products, made of the best materials to exacting standards. They are reliable and leakproof provided they are installed properly. Special attention should be paid to assembly and tightening. If overtightened, a fitting will stretch and possibly break. If undertightened, it will work loose and leak. The guidelines listed below will help to get the best performance from the coach's plumbing system.

- **Tightening.** To tighten a joint, one of the two methods described below should be used.

  These two methods are :

  1. the turns from finger-tight (T.F.F.T.) method, and

  2. the torque method.

  In the T.F.F.T. method the joint is tightened a given number of turns starting from a finger tight (snug) position. In the torque method, the nut is tightened (without lubrication) to a given torque.
  The T.F.F.T. method is the more forgiving of the two. It circumvents the effects of thread quality, plating differences, lubrication, surface finishes, etc., that greatly influence the torque required to achieve proper joint tightness and clamping load. Therefore the T.F.F.T. method is recommended especially during maintenance and repair where the components may be oily.

Turns From Finger-Tight Method

After hand-tightening the joint (approx. 3,5 Nm/30 in.lbf) make a longitudinal mark on one of the flats of the nut hex and continue it on the body hex with a permanent type ink marker as shown in Figure 58A.

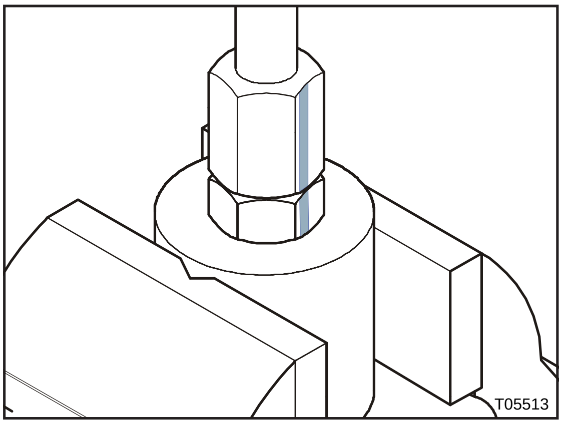

Figure 58A : Hand-tight with initial mark

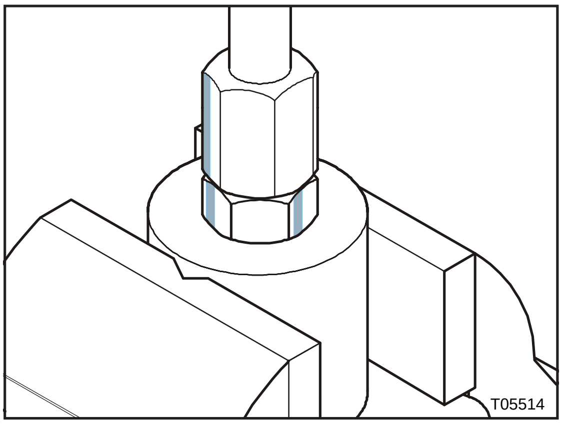

Figure 58B : Fully tightened with displaced mark

Then tighten the joint further by the number of turns required. Now mark the body hex opposite the displaced mark on the nut hex as shown in Figure 58B.

These marks have two important functions :

1. Displaced marks serve as a quick quality assurance check that the joint has been reference-tightened.

2. Second mark on the body serves as a proper tightening position after a joint has been loosened.

This method is slower than the torque method, but it has two distinct advantages :

1. It eliminates the problems associated with the force required to advance the screw thread.

2. It provides a quick visual check for proper joint tightening.

Torque method

Tighten the joint, until the appropriate torque value is reached. This method is fast and accurate, when preset torque wrenches are used. This makes it desirable for high production assembly lines where new fittings with clean, flawless threads are used. However, a joint made up this way can only be checked for proper tightening by re-torqueing.

NOTE : Because of variations in design, material, and structure, the torque and TFFT values given in this Bulletin are approximate. Good judgement must always be used, when assembling and installing fittings.

- **Presetting.** Flareless compression type fittings should ideally be preset or pre-assembled in a hardened pre-assembly body. If this tool is not available, an ordinary fitting body may be used. The presetting operation is performed as follows :

1. Cut and prepare the tubing as required (see assembly instructions for SAE air brake and DIN compression fittings).

2. Lubricate the threads and cone of the pre-assembly tool and the thread of the nut. Place the tool in a vise, and hold the tubing firmly and squarely on the seat in the tool (tube must bottom completely). Tighten the nut, until the cutting edge of the sleeve grips the tube. This point is determined by slowly turning the tube back and forth while tightening the nut. When the tube no longer turns, the nut is ready for final tightening.

3. Final tightening depends upon the tubing material. Refer to the instructions in items 19 and 20 of this Bulletin. After presetting the sleeve, disconnect the tubing and check for proper bite. A visible ridge must have been raised above the tube surface ahead of the sleeve's cutting edge, completely around the tube. It must be possible to turn the sleeve, but not to move it axially. A slight collapse of the tube at the sleeve cut is permissible.

NOTE : When presetting a ferrule with an actual fitting body, only this body should be used with the ferrule.

- **Reuse of fittings.** During service and repair, fittings can often be salvaged. These fittings should be thoroughly cleaned and inspected before they are reused. If the threads do not check out with a thread gauge, this is due to stretching and the fitting must be discarded. If the threads are badly nicked or galled, replace the fitting. Damaged or dirty threads can give a false sense of joint tightness because of their poor threading ability. An accurate torque reading with these threads is impossible.

NOTE : Galling occurs, when the threads rip particles of metal from each other, thereby damaging both threads. In severe cases it causes fittings to stick tightly.

Inspect the port spotface and make sure it suits the fitting. If the port threads are damaged, re-tap, if possible, or replace the component. If the port is cracked, replace the component.

Never interchange thread types or thread damage will result. Metric threads could be mistaken for inch size, if not inspected carefully. If a metric fitting is forced into a port with fine threads, either the fitting or port threads will be ruined.
Never attempt to reuse inserts or sleeves ; they must ALWAYS be replaced by new ones.

- **Lubricants.** The use of lubricant will prevent or reduce the possibility of galling, seizing or stripping. It will assure that the fastening torque has created the proper tension. It should be mentioned that the lubricant, while making the fitting easier to remove at some later date, will not (if torqued properly) cause it to loosen in service. To the contrary, the increased tensioning for the same torque reading will actually cause the fitting to remain more secure.

  NOTE : Most sealants are not compatible with lubricants.

- **Sealing washers.** Since all sealing washers settle under load, the fittings of new vehicles or installations must be retightened after a short time. The same also applies after replacement of devices since new sealing washers must always be used. Before retightening unions, first loosen the tube nut to avoid stressing the tube.

- **Cross-threading.** To prevent cross-threading and leaks and to facilitate installation, make sure the tubing ends are in line with the fitting. Fittings should start and run up several turns with finger pressure only. If they start hard, check for damaged threads, alignment and size.

- **Wrench rules.** Always use the right-size wrench. It must fit the hex securely. A loose fitting wrench will round off the corners.
  When possible, pull on the wrench. Then, if the wrench slips, you are less likely to hurt your hand.
  Never use a steel bar or pipe to increase the length of a wrench for leverage.
  When tightening fittings, always support one portion with one wrench, while tightening with another.

- **Installation.** Assemble both ends of the tubing before final tightening. Connect the tubing long leg end first. Leave the fitting loose so that the other end can be moved enough to make the connection. Use discretion when tightening. If torque figures or T.F.F.T. information are available, use them.

19. Assembly instructions for SAE air brake fittings:

1. Cut off tubing to length squarely with a tube cutter. Any burrs, either on the outside or inside must be removed.

2. Slide the nut, followed by the sleeve, on the tubing. Place the special insert in the end so the sleeve will not crush the tube. When the tube is aligned with the fitting, insert the tubing, until it bottoms on the seat.

3. While holding the tubing in, run up the nut finger-tight. Using a tubing wrench, bring the nut up, until the sleeve just grabs the tubing.

4. To tighten, give the nut the additional turns indicated in the tables below, while holding the tubing in the fitting.

Copper tubing:

Tube O.D. (fractional inch)	T.F.F.T.(*)
1/4, 3/8, 1/2	2
5/8, 3/4	3

Nylon tubing:

Tube O.D. (fractional inch)	T.F.F.T.(*)
1/4	3
3/8 and 1/2	4
5/8 and 3/4	3 1/2

(*) Additional number of turns from finger-tight.

NOTE : The foregoing tightening procedure applies to new compression fittings only. When assembling used (preset) fittings, bring up the nut firmly without additional turns.

20. Assembly instructions for DIN compression fittings:

DIN flareless compression fittings have been designed to be used with steel and stainless steel tubes in high pressure fluid applications. They may, however, also be used in low-pressure systems using copper, thin walled or nylon tubing.

The following assembly procedures apply to steel and copper tubes.

Assembly in a fitting body

1. Saw off the tube square, with 1/2° angle tolerance to the tube axis (see Figure 59).

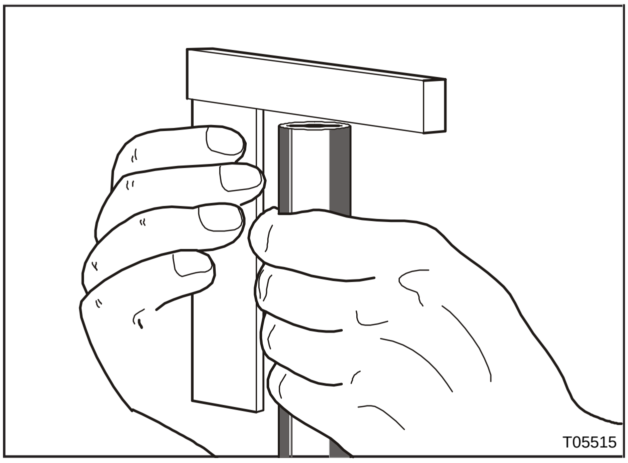

Figure 59 : Checking tube cut for squareness

Cutting the tube square is easily made with a tube cutting guide (see Figure 60).

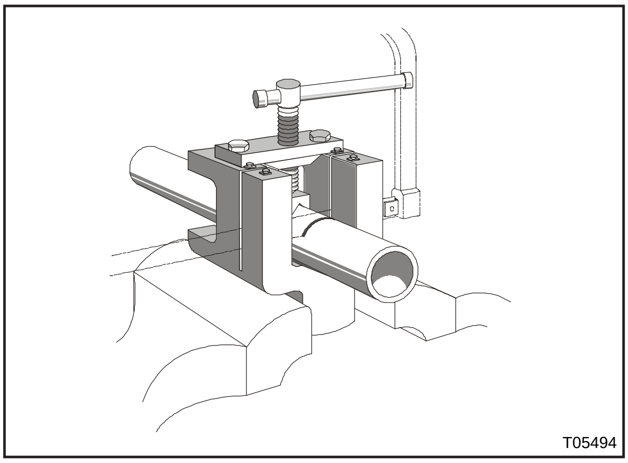

Figure 60 : Tube cutting guide (hacksaw jig)

Do not use a tube cutter with steel and stainless steel tubing. Heavy burr/ bevel will result (see Figure 61).

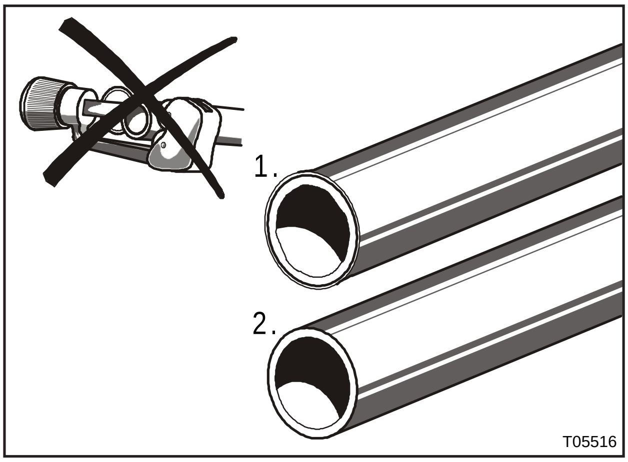

Figure 61 : Do not use a tube cutter with steel tubing

1. **Tube cut with tube cutter**
2. **Tube cut with fine tooth hack-saw**

2. Lightly de-burr the tube inside and outside edge. Do not chamfer (see Figure 62).

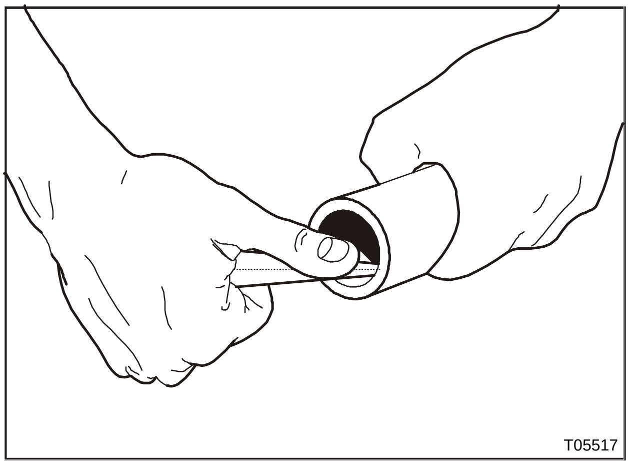

Figure 62 De-burring tube edge

3. Lubricate the threads and cone of the fitting body, also the sleeve and the thread of the nut. Do not grease (see Figure 63).

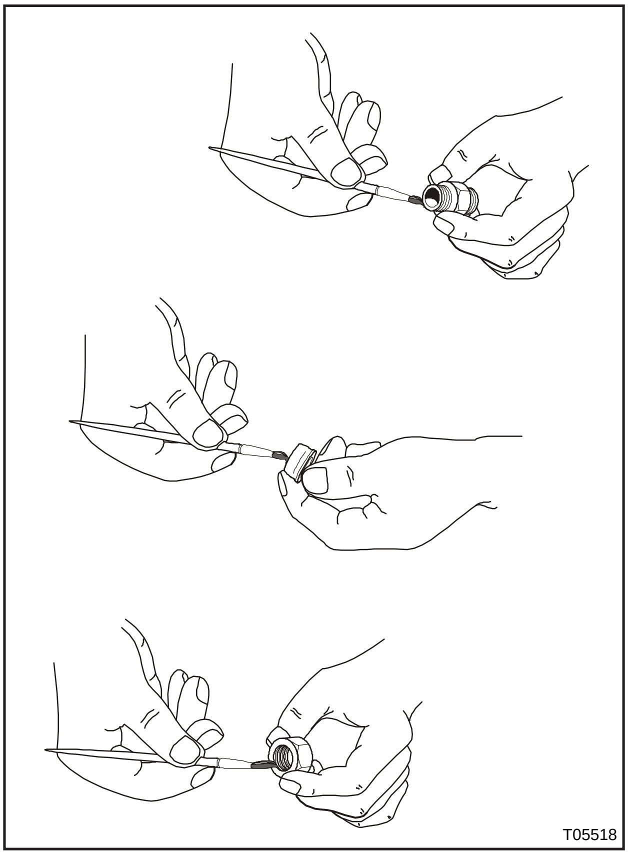

Figure 63 : Lubricating the fitting components

4. To ensure a safe assembly, a reinforcing insert should be used for tubes made of copper or aluminum respectively, and for thin walled steel tubing. For plastic tubes, inserts are always necessary (see Figure 64). Inserts for metal tubing need to be driven in ; inserts for plastic tubing are merely pushed in by finger pressure.

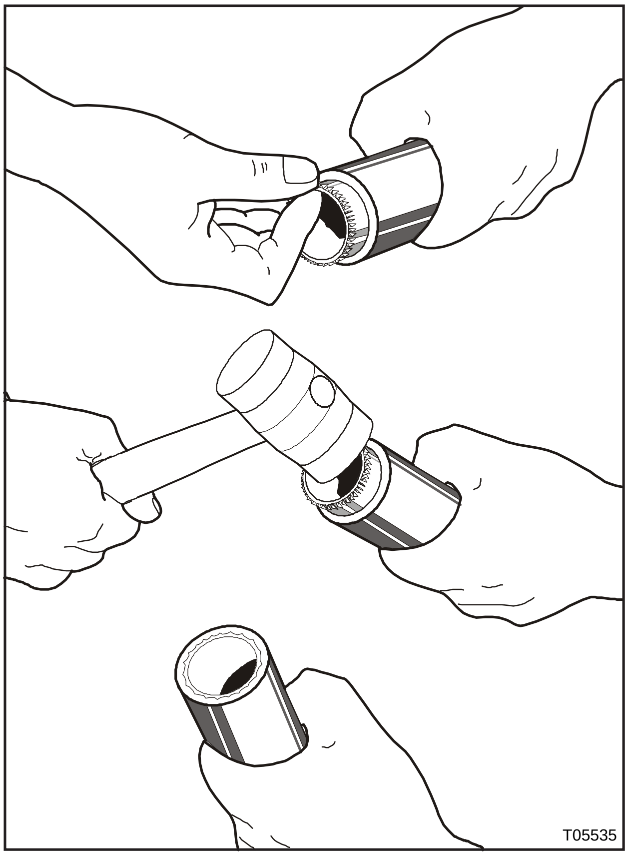

Figure 64 : Fitting metal tubing insert

Top : **Push supporting insert up to knurled edge**

Center : **Drive knurled edge into tube**

Bottom : **Check insert is flush with tube end**

5. Slip the nut and cutting ring over the tube end as shown in Figure 65.

   Ensure that the nut and cutting ring are fitted the right way. The threaded end of the nut must face the tube end. The leading edge of the cutting ring must face the tube end while the thrust collar must face the nut (see Figure 66).

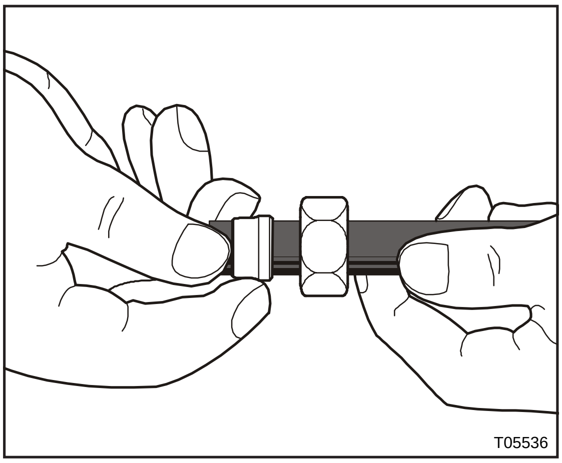

Figure 65 : Fitting nut and cutting ring

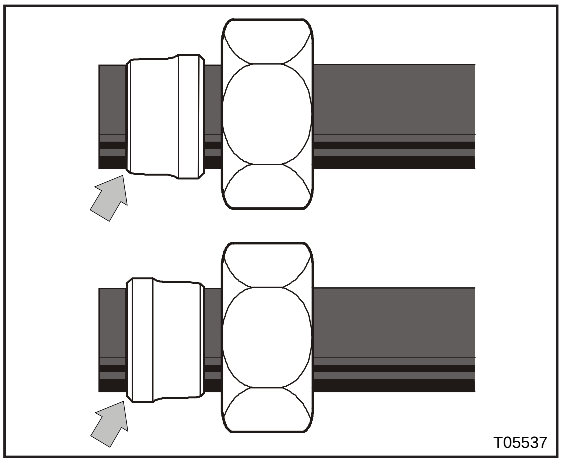

Figure 66 : Positioning of nut and cutting ring

Top : **Correct**

Bottom : **Incorrect**

6. Screw the nut manually onto the fitting body until finger-tight. Hold the tube against the shoulder in the cone of the fitting body (see Figure 67).

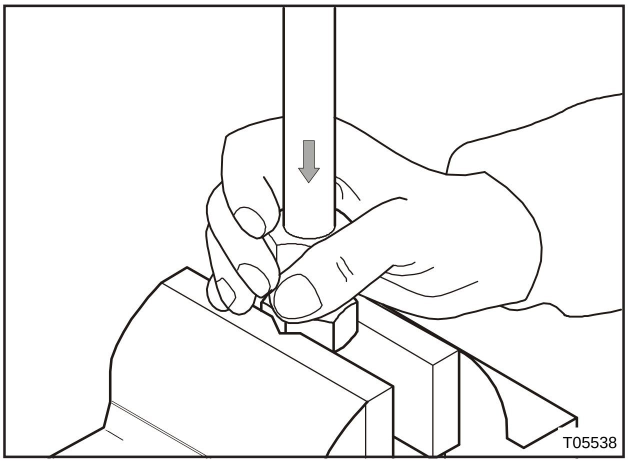

Figure 67 : Manual tightening

7. To measure the prescribed turns of the nut, mark nut and tube (see Figure 68).

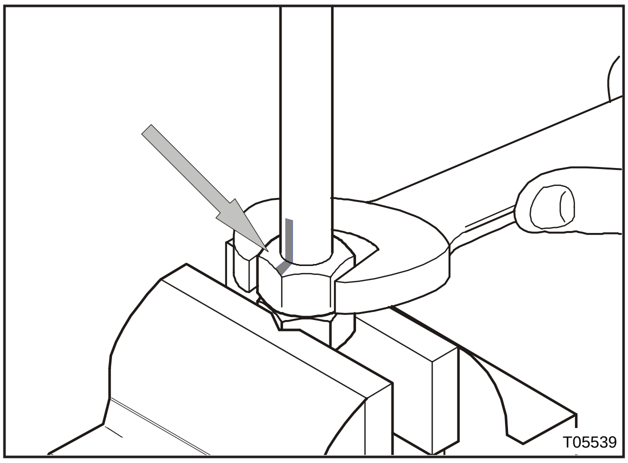

Figure 68 : Tube and nut markings

8. Tighten the nut 1 1/2 turns (tube must not turn with nut), as shown in Figure 69. The stop edge of the cutting ring causes a sharp increase in tightening forces which is clearly perceptible.

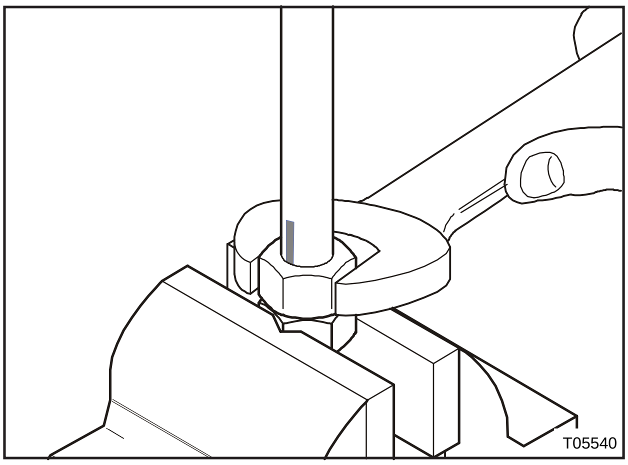

Figure 69 : Wrenching down the nut and cutting ring

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9. Loosen the nut. Remove the tube from the fitting body and check if a visible collar completely fills the space in front of the cutting ring leading edge (see Figure 70). If not, tighten slightly more. It does not matter, if the ring can be rotated on the tube end. A troubleshooting guide at the end of this item deals with bite type hydraulic fitting problems, which are most often traced to faulty preset/assembly procedures.

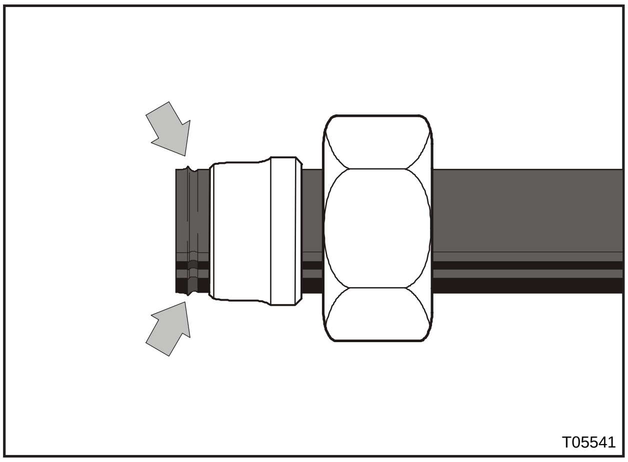

Figure 70 : Ring bite check

10. For final assembly, tighten the nut at least 1/4 turn beyond the point of a clearly perceptible resistance. Support the fitting body with one wrench while tightening the nut with another (see Figure 71).

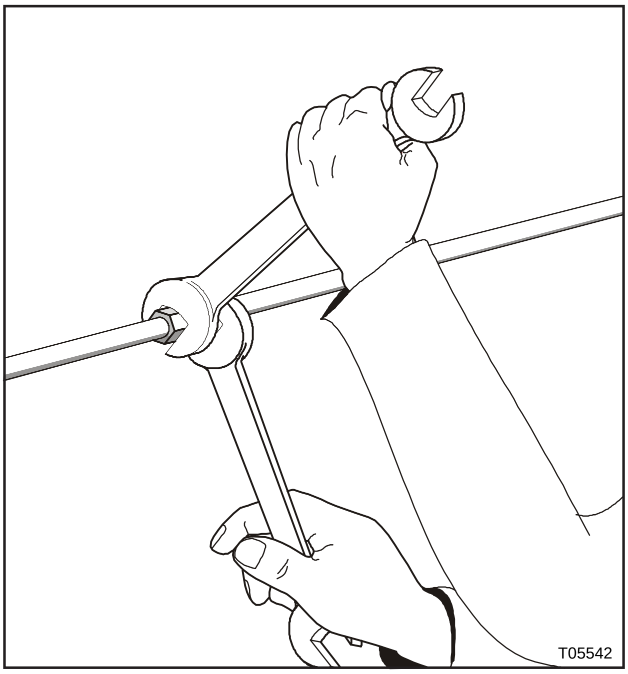

Figure 71 : Final assembly

NOTE : After dismantling the tube ends for inspection, they should be refitted into the same inner cone of the fitting body the assembly was carried out in.

NOTE : It is recommended to preset stainless steel tubing into a hardened pre-assembly body.

Troubleshooting

1. *Condition* : Tube not bottomed (see Figure 72).

   Cause : Check for the indentation on the tube end or compare the length from the end of the tube to the leading edge of the cutting ring of a known good assembly to that of the assembly in question. This assembly should be scrapped.

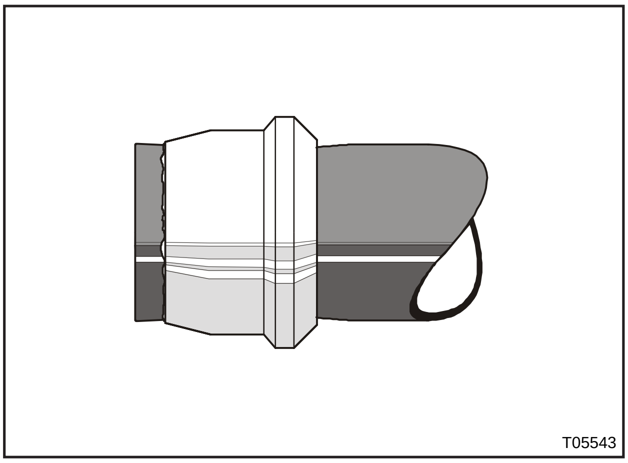

Figure 72 : Tube not bottomed

2. *Condition* : Shallow bite (see Figure 73).

   Cause : Inspect for turned up ridge of material. Failure to achieve this ridge can be traced either to the nut not being tightened enough or the tube not being bottomed against the stop, allowing the tube to travel forward with the cutting ring. In some instances this assembly may be reworked.

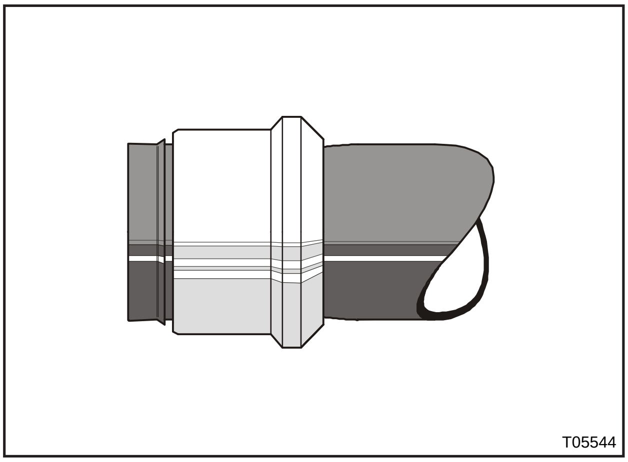

Figure 73 : Shallow bite

3. *Condition* : Over-set cutting ring (see Figure 74).

   Cause : Too much pressure or more than recommended turns from finger-tight were used to preset the ring, or the nut was severely over-tightened in final assembly. This assembly should be scrapped.

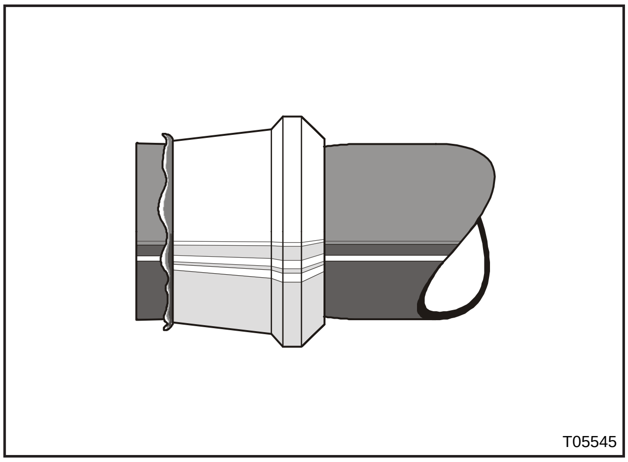

Figure 74 : Over-set cutting ring

4. *Condition* : Cutting ring cocked on tubing (see Figure 75).

   Cause : The cutting ring may become cocked on the tube, when the tube end is not properly lined up with the body. Generally, this condition is caused by faulty tube bending. All bent tube assemblies should drop into the fitting body prior to make up. This assembly should be scrapped.

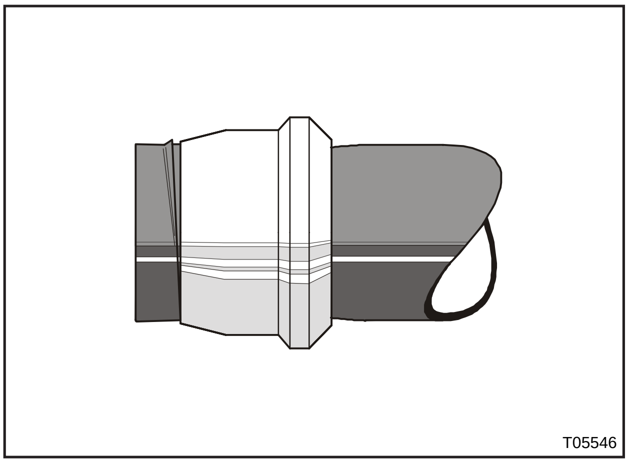

Figure 75 : Cocked cutting ring

5. *Condition* : No bite (see Figure 76).

   Cause : If all of the prior checks have been made and the cutting ring still shows no sign of biting the tube, it may be that the tube is too hard. This assembly should be scrapped.

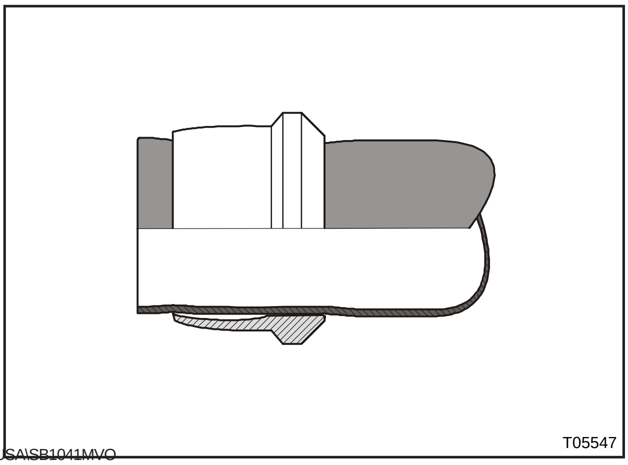

Figure 76 : No bite

21. Assembly instructions for bead forming fittings:

Bead-forming fittings can be assembled finger-tight, when used with soft tubing, e.g. polyurethane, polyethylene etc. This facilitates rapid assembly and disassembly.

1. Cut the tubing squarely, using the tube cutter shown in Figure 77.

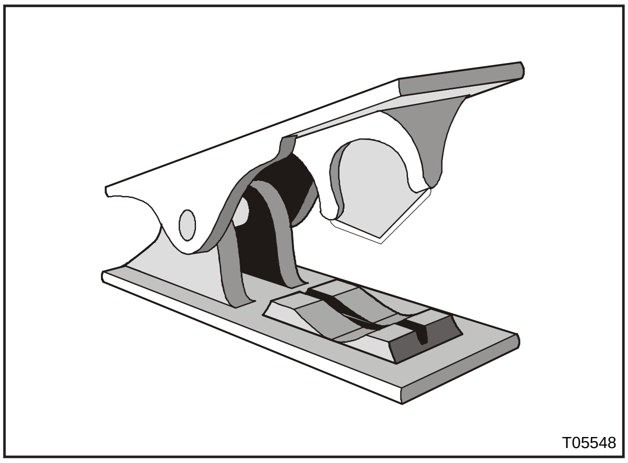

Figure 77 : Cutter for thermo-plastic tubing

2. Begin assembly by inserting the tube through the nut (see Figure 78).

3. Push the tube over the spigot of the fitting, until it comes into contact with the stop.

4. Finger-tighten the nut to the end stop, when using soft tubing.

5. Tighten the nut with a wrench to the end stop, when using semirigid tubing.

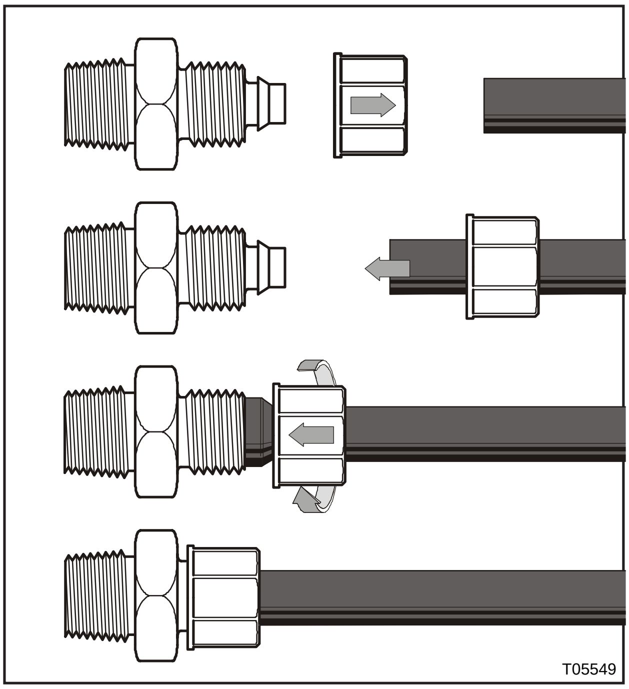

Figure 78 : Assembling bead-forming fittings

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22. Assembly instructions for push-in fittings:

1. Cut thermoplastic tubing squarely, using the tube cutter shown in Figure 77.
   Metal tubing should be cut squarely with a tube cutter or a fine toothed hacksaw and be free of burrs.

2. Insert the end of the tubing, until it bottoms in the fitting (see Figure 79).

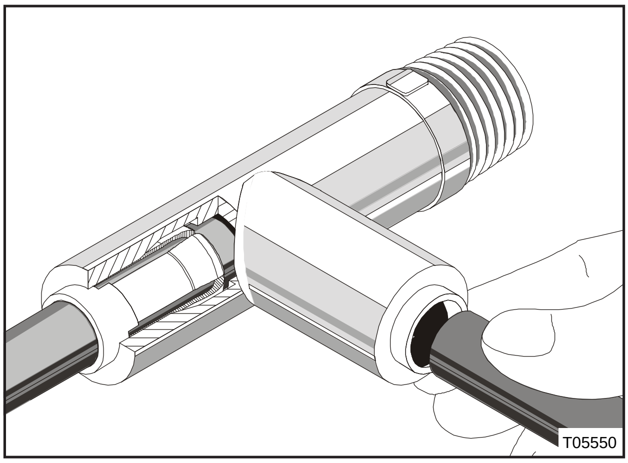

Figure 79 : Assembling push-in fittings

3. Depressing the release button allows the tubing to be removed.

23. Assembly instructions for push-on fittings:

Assemblies with hose clamps

1. Cut the hose cleanly and squarely to length.

2. Slide a suitable clamp on the hose.

3. Lubricate the hose. Push the hose over the barbed nipple or annular bulb of the fitting, until the hose bottoms against the stop ring or hex.

4. Position the hose clamp as shown below in Figure 80, and secure it with a screwdriver or wrench. Maintain dimension "A" noted below for proper clamp positioning.

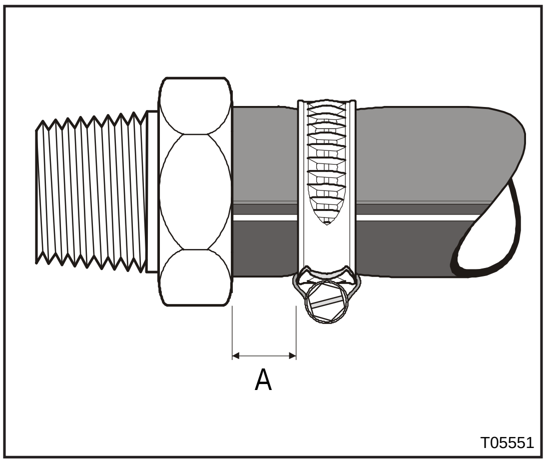

Figure 80 : Proper positioning of hose clamp

Hose size fractional inch	Dimension A fractional inch
3/16	1/4
1/4	1/4
5/16	1/4
3/8	1/8
1/2	1/8
5/8	1/8
3/4	1/8

Assemblies with crimped-on ferrules

1. Cut the hose to length cleanly and squarely.
2. Slide the proper size ferrule over the hose end, until it bottoms.
3. Lubricate the barbed nipple and push the hose over it, until the ferrule butts against the stop ring or hex.
4. Crimp the ferrule onto the hose with the proper crimping tool and check the assembly for tightness.

Assemblies with collar and self-grip hose (Parker)

Parker self-grip hoses assemble in seconds without the need for clamps, bands, clips or wires. They can be used for shop air, pneumatically operated systems, and general industrial maintenance ; also automotive applications for air, water, lubricating oils, and antifreeze.

1. To assemble, cut the hose right-angled with a sharp knife. If necessary, it is possible to use a lubricant (water/soap solution with 5 % soap fluid and 95 % water) for easy assembly.
2. Insert the fitting into the hose, until the first barb is in the hose. Place the end of the fitting against a flat object (bench, door, wall). Grip the hose approximately 1 inch from the end and push with a steady force, until the hose end is covered with the yellow plastic collar.

To disassemble proceed as follows :

1. Below the collar, cut the hose lengthwise with a sharp knife. The cut should be approximately 1 inch long. Be careful not to nick the barbs, when cutting the hose.

2. Grip the hose with one hand and the fitting with the other and give a sharp downward tug to separate them.

NOTE : Before reuse of the fitting, check it for damage. Damaged fittings can cause leakage.

Hose clamps

In low-pressure application, such as the cooling system, and the air and water supply, the hose is merely slid over the fitting. A clamp (see Figure 81) is then installed to prevent the hose from working loose.

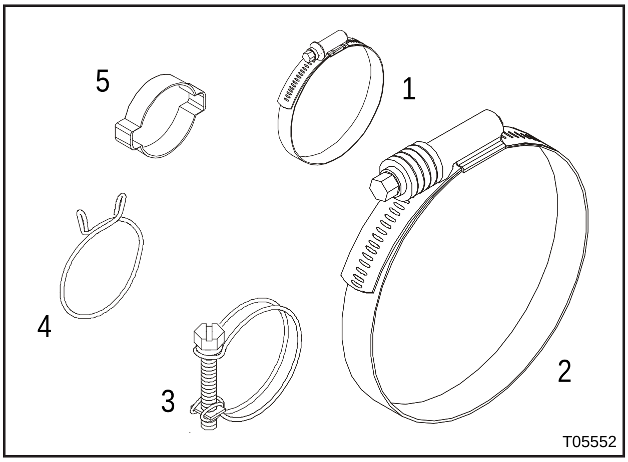

Figure 81 : Some types of hose clamps

1. **Worm-drive clamp**
2. **Constant torque clamp**
3. **Twin wire clamp**
4. **Spring clamps**
5. **Pinch clamp**

Worm-drive hose clamps

Hose clamps for silicone hoses must be of the proper type and must be tightened to the correct torque.

<u>Hose O.D. 3/4 to 1 3/8 inch</u>: tightening torque 2.6 to 3.3 ft.lbf.

<u>Hose O.D. 1 1/2 to 3 inches</u>: tightening torque 2.95 to 3.7 ft.lbf.

Constant torque hose clamps

Many hose clamps, used on the heating and cooling systems are of the constant torque type. They are worm-driven, and provided with a series of spring washers. They feature an extended integral liner that covers the band slots, protecting the silicone hoses from damage. The liner also helps maintaining a consistent sealing pressure. The constant torque hose clamp is designed to automatically adjust its diameter to compensate for the normal expansion and contraction of hose and tubing during vehicle operation and shutdown. Coolant losses are virtually eliminated and clamp maintenance is greatly minimized.

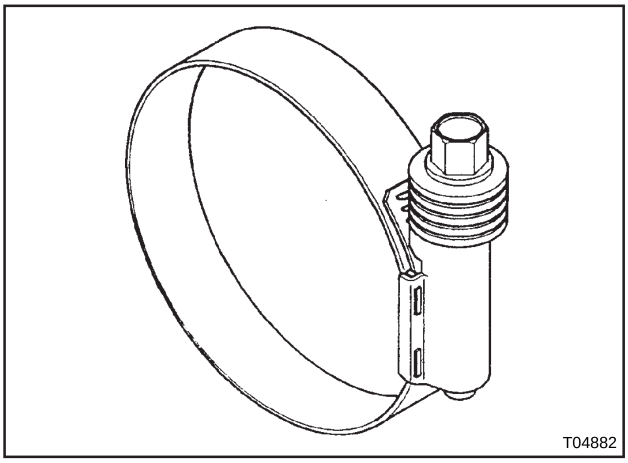

Figure 82 : Constant torque hose clamp

Use a torque wrench for proper installation. The recommended torque for hose clamps type A (9/16 inch wide and four spring washers) is 40 to 70 in.lbf. Hose clamps type B (5/8 inch wide and five spring washers) should be torqued with 90 to 125 in.lbf. The spring washer stack should be nearly collapsed flat. The screw tip of the hose clamps type A should extend 7/32 inch beyond the housing when properly torqued. The screw tip of hose clamps type B should extend 1/4 inch beyond the housing.

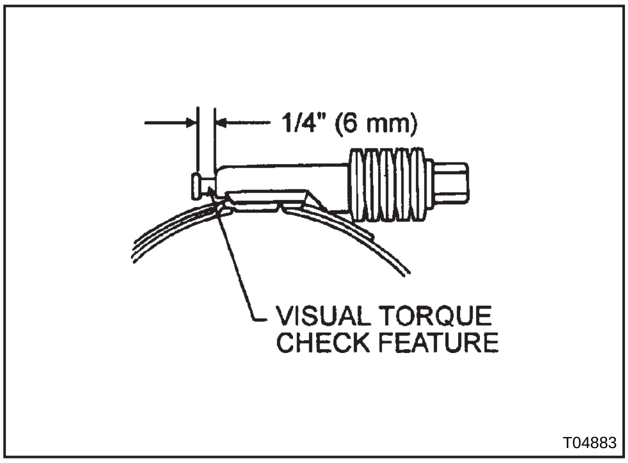

Figure 83 Visual torque check feature on constant torque hose clamps (B type clamp)

Since the constant torque clamp is self-adjusting to keep a consistent sealing pressure, there is no need to retorque the hose clamp on a regular basis. When the tip of the screw is extending out of the housing, by the correct amount, the clamp is properly installed and maintains a leak proof connection. Proper torque installation should be checked at room temperature.

24. Fitting instructions for pipe threaded fittings:

The majority of pipe thread fittings used on Van Hool coaches are machined with the NPTF thread form. NPTF is also referred to as Dryseal Pipe Thread.

The proper method of assembling pipe threaded connectors is to assemble them finger-tight and then wrench-tighten further to the specified number of turns from finger-tight (T.F.F.T.) given in the chart further in this item. The assembly procedure given here is recommended to minimize the risk of leakage and/or damage to components.

1. Inspect port and connector to ensure that the threads on both are free of dirt, burrs and nicks.

2. Apply sealant/lubricant to the male pipe thread (pre-applied dry sealants are preferred over other sealants). With any sealant, the first one to two threads should be left uncovered to avoid system contamination. If Teflon tape is used it should be wrapped 1 1/2 to two turns in clockwise direction.

NOTE : More than two turns of tape may cause distortion or cracking of the port. In addition, due to Teflon's high lubricity, fittings are likelier to be over-tightened. Moreover, when Teflon is used, there is little resistance to loosening due to vibration. The use of Teflon is not recommended by Van Hool.

3. Screw the connector into the port to the finger-fight position.

4. Wrench-tighten the connector to the appropriate T.F.F.T. values shown in the chart below, making sure that the tube end of a shaped connector is aligned to receive the incoming tube or hose assembly (see Figure 84).

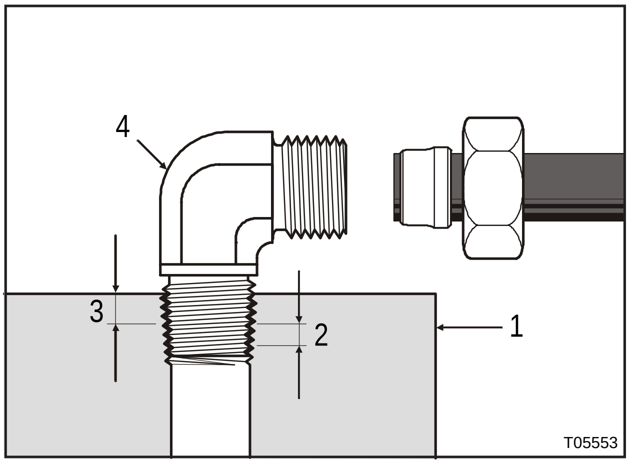

Figure 84 : Elbow fitting assembled to pipe port, aligned to receive incoming tube

1. **Component with female pipe thread (NPTF) port**
2. **Sealant free area**
3. **Thread sealant area**
4. **Elbow connector with male pipe thread assembled into port**

NOTE : Never back off pipe-threaded connectors to achieve alignment.

5. If leakage persists after following the above steps, check for damaged threads and total number of threads engaged.

Pipe thread size NPTF	T.F.F.T.
1/8 - 27	2 - 3
1/4 - 18	2 - 3
3/8 - 18	2 - 3
1/2 - 14	2 - 3
3/4 - 14	2 - 3
1 - 11 ½	1.5 - 2.5

If threads on the fitting are badly nicked or galled, replace the fitting. If the port threads are damaged, re-tap, if possible, or replace the component. If the port is cracked, replace the component.

Normally, the total number of threads engaged should be between 3 1/2 and 6. Any number outside of this range indicates either under- or overtightening of the joint or out of tolerance threads. If the joint is undertightened, tighten it further, but no more than one full turn. If it is overtightened, check both threads and replace the part having out-of-tolerance threads.

As a general rule, pipe-threaded fittings should not be assembled to a specific torque, since the torque required for a reliable joint varies according to the thread quality, port and fitting materials, and sealants used. In spaces where many of these factors are well controlled, such as on an assembly floor, a torque range producing the desired results may be determined by test and used instead of turns count for proper joint assembly.

25. Fitting instructions for O-ring fittings:

Metric straight port and stud ends (see Figure 85) are similar in design to SAE straight thread port and stud ends, respectively. Therefore, the fitting procedure is the same for both.

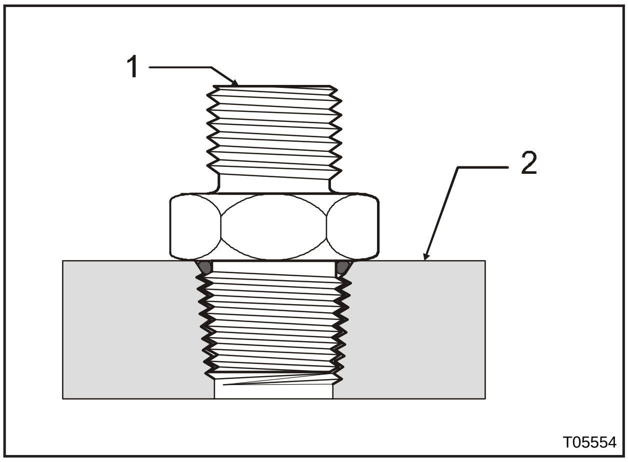

Figure 85 : Straight male stud connector fitted to parallel SAE or Metric port

1. **Straight (non-adjustable) connector with male O-ring straight end fits into port**
2. **Component with straight thread port**

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1. Inspect components to ensure that male and female port threads and sealing surfaces are free of burrs, nicks, and scratches, or any foreign material.

2. If an O-ring is not pre-installed to the fitting port end, install a proper size O-ring.

3. Lubricate the O-ring with a light coating of system fluid or compatible oil.

4. Screw the fitting into the port, until the hex flat contacts the port face. Light wrenching may be necessary.

5. Tighten to the given torque for the size appropriate tables below :

Thread size UN/UNF	Fitting torque (+10 % - 0 %)	
	ft. lbf	Nm
5/16 - 24	7	9.5
3/8 - 24	13	17.5
7/16 - 20	17	23
1/2 - 20	21	28
9/16 - 18	25	34
3/4 - 16	45	60
7/8 - 14	85	115

Thread size Metric	Fitting torque (+10 % - 0 %)	
	ft. lbf	Nm
M12 x 1.5	26	35
M14 x 1.5	33	45
M16 x 1.5	41	55
M18 x 1.5	52	70
M22 x 1.5	74	100

NOTE : Always lubricate the threads and mating surfaces. The values in the charts are for steel fittings in steel ports. For stainless steel fittings, use the upper limit of the torque range. For brass fittings, decrease the torque figures by multiplying the value given in the table by 0.65.

26. Fitting instructions for fittings with flat-faced and metal-to-metal sealing flanges

1. Inspect the components to ensure that the male stud and female port threads and sealing surfaces are free of burrs, nicks and scratches, or any foreign material.

2. If a sealing device (plain washer, elastomer ring, backup washer and O-ring...) must be fitted and it is not pre-installed to the fitting port end, install the proper sized device.

NOTE : Fittings with metal-to-metal sealing flanges don't need a sealing device. However, a plain washer may be fitted.

3. Lubricate threads and sealing device with system fluid or compatible oil.

4. Screw the fitting into the port, until the sealing device contacts the port face. Light wrenching may be necessary.

5. Tighten to the given torque for the size from the appropriate charts below :

BSP Thread "G"

			Assembly torque Nm + 10 % - 0 %(*) Straight male stud connectors		
Series	Tube O.D. mm	BSPP thread G Size	for sealing washer	with cutting face	with elastomer ring
L	6	G 1/8A	9	18	18
	8	G 1/4A	35	35	35
	10	G 1/4A	35	35	35
	12	G 3/8A	45	70	70
	15	G1/2A	65	140	90
	18	G 1/2A	65	100	90
	22	G 3/4A	90	180	180

(*) Tightening torques are for steel fittings assembled in steel components

Metric Thread "M"

			Assembly torque Nm + 10 % - 0 %(*) Straight male stud connectors		
Series	Tube O.D. mm	Metric thread M Size	for sealing washer	with cutting face	with elastomer ring
L	6	M 10 x 1	9	18	18
	8	M 12 X 1.5	20	30	25
	10	M 14 x 1.5	35	45	45
	12	M 16 x 1.5	45	65	55
	15	M 18 x 1.5	55	80	70
	18	M 22 x 1.5	65	140	125
	22	M 27 x 2	90	190	180

(*) Tightening torques are for steel fittings assembled in steel components

27. Fitting instructions for banjo elbows and adjustable fittings:

Banjo fittings (see Figure 87)

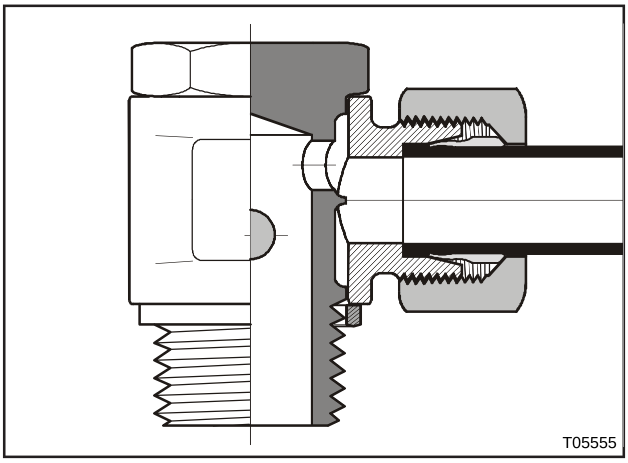

Figure 87 : Banjo union with hardened sealing ring

1. Inspect components to ensure that male and female port threads and sealing surfaces are free of burrs, nicks and scratches, or any foreign material.

2. Lubricate the thread of the hollow banjo bolt lightly with system fluid or compatible oil.

3. Screw the fitting into the port, until the sealing ring contacts the port face. Light wrenching may be possible. Make sure that the tube end of the banjo is aligned to receive the incoming tube or hose assembly.

4. Using two wrenches, hold the fitting in the desired position and tighten the hollow bolt to the appropriate torque value shown in the charts below.

			Assembly torque(*) Nm + 10 % - 0 % Banjo fittings	
Series	Tube O.D. mm	BSPP thread G Size	with soft sealing ring	with hardened sealing ring
L	6	G 1/8A	18	18
	8	G 1/4A	45	40
	10	G 1/4A	45	40
	12	G 3/8A	70	65
	15	G1/2A	120	90
	18	G 1/2A	120	90
	22	G 3/4A	230	125

(*) Tightening torques are for steel fittings assembled in steel components

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			Assembly torque(*) Nm + 10 % - 0 % Banjo fittings	
Series	Tube O.D. mm	Metric thread M Size	with soft sealing ring	with hardened sealing ring
L	6 8 10 12 15 18 22	M 10 x 1 M 12 x 1.5 M 14 x 1.5 M 16 x 1.5 M 18 x 1.5 M 22 x 1.5 M 27 x 2	18 45 55 80 100 140 320	18 35 50 60 80 120 130

(*) Tightening torques are for steel fittings assembled in steel components

Fittings with O-ring, backup washer and jam nut (see Figure 88)

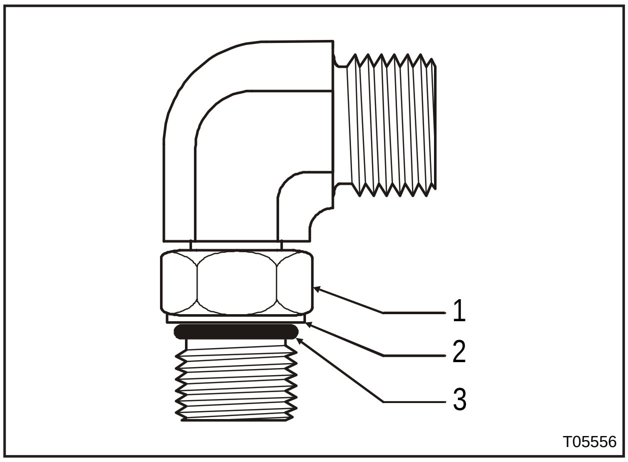

Figure 88 : Elbow fitting with adjustable straight thread O-ring end

1. **Locknut**
2. **Backup washer**
3. **O-ring**

1. Inspect components to ensure that male fitting and female port threads and sealing surfaces are free of burrs, nicks and scratches, or any foreign material.

2. Install an O-ring on the port end of the fitting, if it is not pre-installed, taking care not to nick the O-ring.

3. Lubricate the O-ring with a light coat of system fluid or compatible oil.

4. Back off the lock nut as far as possible (1, Figure 89). Make sure the backup washer is not loose and is pushed up as far as possible.

5. Screw the fitting into the port, until the backup washer contacts the face of the port (2, Figure 89). Light wrenching may be necessary.

6. To align the tube end of the fitting to accept the incoming tube or hose assembly, unscrew it by the required amount, but not more than one full turn (3, Figure 89).

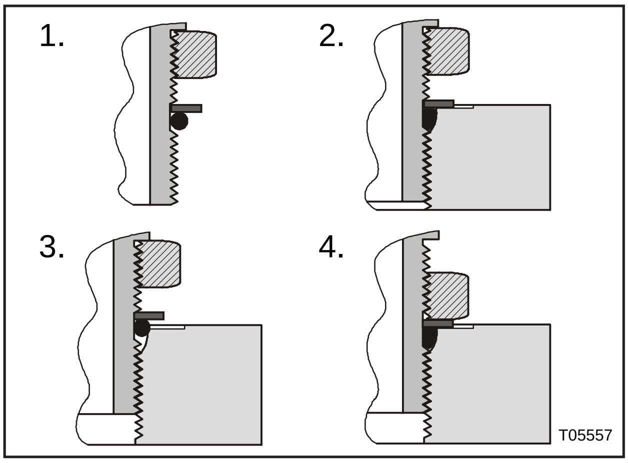

Figure 89: Adjustable fitting assembly

7. Using two wrenches, hold the fitting in the desired position and tighten the locknut to the appropriate torque value shown in the table below (4, Figure 89).

Thread size (UN/UNF)	Assembly torque (+ 10 % - 0)(*)	
	ft. lbs.	N-m
5/16 - 24	5	7
3/8 - 24	10	13.5
7/16 - 20	13	17.5
1/2 - 20	21	28
9/16 - 18	25	34
3/4 - 16	40	55
7/8 - 14	60	80

(*) *NOTE : Always lubricate the threads and mating surfaces. The torque values are for steel fittings in steel ports. For stainless steel fittings, use the upper limit of the torque range. For brass fittings, decrease the torque by multiplying the value given in the table by 0.65.*

8. Check to make sure that the O-ring is not pinched and that the washer seats flat on the face of the port.

Standpipes (see Figure 90)

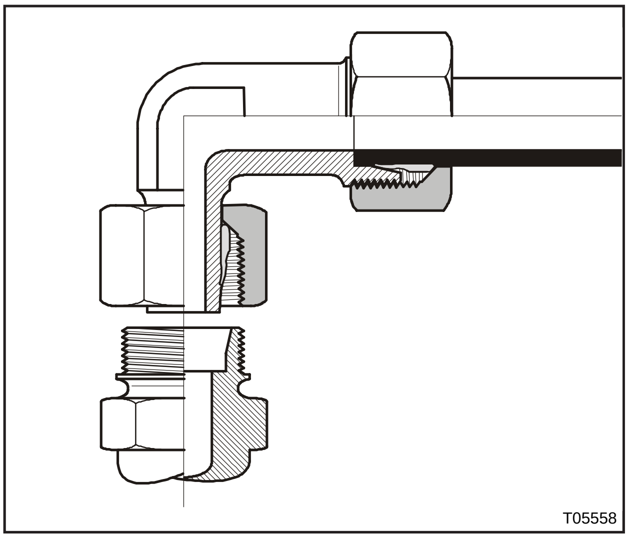

Figure 90 : Standpipe elbow

1. Inspect the components to ensure that the male and female threads, cone, and cutting ring are free of burrs, nicks, and scratches, or any foreign material.

2. Lubricate the threads, cone and cutting ring with a light coating of system fluid or compatible oil.

3. Screw the nut manually onto the fitting body already assembled to the port, until finger-tight. Make sure that the tube end is aligned to receive the incoming tube or hose assembly.

4. Using two wrenches, hold the fitting in the desired position and tighten the nut ¼ to ½ turn beyond the point of a clearly perceptible resistance.

Flared swivel connectors (see Figure 91)

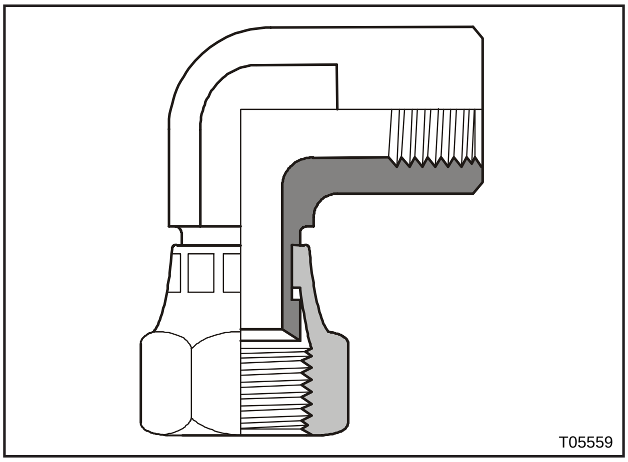

Figure 91 : Swivel elbow

The most important preparation prior to assembly is to make certain that the seats of the swivel and the mating connector have the same angle. A chamfer or break will not suffice as a sealing surface ; a full seat is required.

1. Inspect both the swivel connector and mating male seat for any visible burrs, nicks, or thread damage. These faults may inhibit a tight connection and sealing.

2. Lubricate the threads, cone and flare with a light coating of system fluid or compatible oil.

3. Thread the swivel end onto the male end until finger-tight. The swivel should thread completely onto the male thread, until the male and female seats mate. The threads should not become tight, before the seats mate. To assure seat-to-seat contact, check for relative movement between the two fittings by rocking or rotating the fittings. There should be no end play. Make sure that the tube end is aligned to receive the incoming tube or hose assembly.

4. Using two wrenches, hold the fittings in the desired position and tighten the swivel nut 1/4 to 1/2 turn from fully seated.

28. Service information:

- Fittings have been designed and selected for specific applications and should be used for those applications only.

- Replacement fittings should be identical to OE fittings.

- The following Van Hool fittings are available as complete assemblies or separate components:

  1. SAE flareless air brake compression fittings
  2. DIN flareless compression fittings
  3. Bead-forming fittings

- Accessories are available as complete units only. Components are not offered for service replacement.

- Apart from catalogues, many fitting manufacturers and distributors offer tools, training aids and training programs to support their products. Some examples have been listed below.

  From Parker Fluid Connectors :

  Thread Identification Kit (Part # MIK-1) ; *Portboard for NPT and SAE St. Threads* (Part # Portboard A) ; *Portboard for BSPP, BSPT and metric* (Part # Portboard B).

  From Maryland Metrics : Measuring tools, thread identification charts and conversion tables.

  From VOSS Inc :

  Male Thread Identification Kit (Part # TGK 98) and *Female Thread Identification Kit* (Part # FTGK 98).

29. How to identify a fitting ?

The elements defining a fitting can be summarized as follows :

FITTING

↓

SHAPE

↓

TYPE

↓

SPECIAL FEATURES

↓

TUBE DIAMETER & THREAD

Tube connection end — Port connection end

metric tube diameter — inch tube diameter — metric stud thread — inch stud thread

MATERIAL

CU (copper) ; BR (brass) ; ST (steel) ; SS (stainless steel) ; P (plastic) ; AL (aluminum)

↓

SEALING METHOD

Tube connection end

- flare
- sleeve
- upset spigot
- grabbing & sealing device
- hose barb
- pipe thread
- flange & O-ring
- globe seal

Port connection end

- plain washer
- bonded seal
- metal to metal
- elastomer ring
- O-ring
- O-ring & backup washer
- pipe thread
- dry seal

Using this summary as a reference, an unknown tube fitting can be identified in 6 easy steps. The chart below shows what needs to be checked to establish the identity of a fitting assembly, body, nut, sleeve, or insert.

STEP	CHECK	REFER TO ITEM # (*)	ASSY	BODY	NUT	SLEEVE	INSERT
1	SHAPE	10	•	•			
2	TYPE	3,5,6, 7, 8,9	•	•	•	•	•
3	SPECIAL FEATURES	11 &15	•	•			
4	THREAD/TUBE SIZE	5, 6, 13	•	•	•	•	•
5	MATERIAL & SURFACE FINISH	12	•	•	•	•	•
6	SEALING METHOD	14	•	•			

(*) See table of contents.

With the checks completed, the part illustration, description and matching part number can now be retrieved from the fitting manual.

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30. Bibliography/references:

The following books, manuals and catalogues have been used as a reference while writing this Bulletin :

"4300 Catalog" (Parker Fluid Connectors)

"Aircraft hardware standards manual & engineering reference" by Stanley J. Dzik (Aviation Publications)

"Aircraft hydraulic systems" by Dale Crane (Aviation Maintenance Foundation, Inc.)

"Aircraft & powerplant mechanics - General handbook" (Department of Transportation, Federal Aeration Administration)

"Auto service and repair" by M.T. Stockel (The Goodheart-Willcox Company, Inc.)

"Brass fittings and valves" (Parker Fluid Connectors)

"Hose, fittings, accessories and equipment" (Parker Fluid Connectors)

"Hydraulic fittings" (Bell - Hermetic)

"Hydrauliek" (Central Auto)

"Hydrauliek & pneumatiek voor mobiele werktuigen" by M.J. van de Velde and F. van den Heuvel (Delta Press b.v.)

"Legris product catalogue" (Legris S.A., France)

"Modern automotive mechanics" by James E. Duffy (The Goodheart-Willcox Company, Inc.)

"Modern metalworking" by John R. Walker (The Goodheart-Willcox Company, Inc.)

"Nuts, bolts, fasteners and plumbing handbook" by Caroll Smith (Motorbooks International)

"Pipe coupling list" (WABCO Automotive Products Group)

"Pneumatic connectors handbook" (Parker Fluid Connectors)

"Production guidelines" (Van Hool)

"SAE handbook 1982, Part I" (Society of Automotive Engineers, Inc.)

"Standard aircraft handbook" by Stuart Leavell and Stanley Bungay (Aero Publishers, Inc.)

"Tube couplings" (Armaturenfabrik Hermann Voss G.m.b.H. & Co.)

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