

SPECIFICATION

Fittings for fluid-tight connection to tubular members

5 Swaged fittings for joining tubular members together, or for connecting tubular members to other devices, as in a hydraulic system, have been used very successfully because
10 they are reliable, easy to service, as by making connections in the field, and are relatively low in cost. The integrity of the joint and life of the connection is very favourable compared with other types of fittings for connecting
15 tubular elements.

In one such device, the fitting includes exterior ridges which, upon swaging, are transferred to the inner surface of the fitting. This type of fitting relies upon the springback
20 of the tube in obtaining a strong connection between the fitting and the tube. This limits the utility of the fitting, because some tubes are made of low-yield-strength materials, such as copper, copper-nickel, some aluminiums,
25 some titaniums, and the like, and do not exhibit appreciable springback upon compression. Tubes of this type are used extensively in the hydraulic systems of ships. These tubes are of relatively great wall thickness which
30 renders it impractical to attempt to transmit the contour of the exterior of the fitting to the interior and so deform the tube upon a swaging operation.

Also, the creation of the ridges on the
35 inner surface of the fitting, and hence on the inner surface of the tube in the fitting, results in constrictions which may produce undesirable pressure drops. Also, such ridges on the interior of the tubes create noise as the hydraulic fluid is conducted through the system,
40 which may not be acceptable in the construction of submarines where silent operation is essential.

The present invention provides fittings
45 which are connected to tubular members by swaging, yet avoid the difficulties noted above. They can be used with thick-walled, low-yield-strength tubes, not relying upon the springback of the tube material. Also, they
50 create little distortion in the internal wall of the tubes so that pressure drop and noise difficulties are eliminated.

The present invention is a development of that described in our British Patent Application No. 7929706 (Specification No. 2 032
55 557 A).

A fitting according to the present invention comprises

60 a sleeve having
a first portion at one end thereof,
and a second portion inwardly of said end thereof, said first portion having ridge means on the inner periphery thereof adapted to
65 penetrate the periphery of a tubular member inserted therein for forming a retention ther-

eto,

the inner periphery of said second portion having a circumferential groove therein, said groove having a relatively deep portion
70 and a relatively shallow portion so that the wall of said groove defines a corner at the intersection of said relatively deep portion and said relatively shallow portion, whereby, upon application of an external radial force to said
75 fitting, said corner is forced against the periphery of a tubular member received in said sleeve for forming a seal therewith.

The accompanying drawings illustrate the invention. For convenience, Figs. 1 to 6 relate
80 to a construction which is the subject of Application No. 7929706, while Figs. 7 to 9 relate specifically to an embodiment of the present invention.

Figure 1 is a perspective view of one fitting;
85 *Figure 2* is a longitudinal sectional view of the fitting;

Figure 3 is an enlarged fragmentary longitudinal sectional view showing the details of the retention and sealing areas of the fitting prior
90 to swaging;

Figure 4 is an end elevational view, partially in section, illustrating the swaging of the fitting by a radial swaging tool;

Figure 5 is an enlarged fragmentary, longitudinal sectional view showing the fitting after
95 swaging onto a tube;

Figure 6 is an end elevational view of modified fitting provided with longitudinal internal slots for resisting rotational loads;

100 *Figure 7* is a fragmentary enlarged longitudinal sectional view of the centre portion of a form of fitting embodying the present invention;

Figure 8 is a fragmentary sectional view of
105 the fitting of Fig. 7 after swaging; and

Figure 9 is a further enlarged sectional view of the sealing area of the fitting of Fig. 7 after swaging.

The fluid fitting 10, as shown in Fig. 1, is a
110 metal sleeve which is adapted to couple pipes or tubes, typically in a hydraulic system. Each tube is connected to the fitting by swaging, using radial movement of swaging dies, which both retains the tube within the fitting and
115 provides a fluid-tight seal.

The end portions 11 and 12 of the fitting 10 act as the retention areas of the fitting, which mechanically interconnect the fitting to the tubes after the swaging operation. There
120 are in addition sealing areas 13 and 14 inwardly of the retention areas 11 and 12, which prevent leakage of the fluid being transmitted through the fitting from one tube to the other.

125 In exterior configuration prior to swaging, the two retention areas 11 and 12 are of constant cylindrical shape, as defined by surfaces 15 and 16 (see also Figs. 2 and 3). Inwardly of the surfaces 15 and 16, the
130 fitting has a larger external diameter as de-

finned by a cylindrical surface 17. Annular ridges 19 and 20, which have cylindrical surfaces of still greater diameter, are spaced inwardly from shoulders 21 and 22 at the ends of the surface 17. The ridges 19 and 20 are positioned at the sealing areas 13 and 14. An additional cylindrical annular ridge 24, which has a diameter comparable to or greater than that of the ridges 19 and 20, is positioned between and spaced from the ridges 19 and 20.

The interior surface 26 of the fitting (Fig. 2) prior to swaging is cylindrical in shape with counterbored ends 28 which form the entrances to the fitting. Relatively thin layers 30 of Teflon (RTM) or of an elastomer such as silicone rubber line the entrances 28 of the fitting.

In the retention areas 11 and 12, grooves 33 are cut so as to produce helical ridges 35 throughout the lengths of these sections of the fitting (see also Fig. 3). Alternatively, a series of annular ridges of similar cross section may be formed, although helical ridges are preferred because of ease of manufacture. The ridges 35 have radial walls 36 facing toward the centre of the fitting and inclined walls 37 facing toward the outer end of the fitting. The ridges have flat crests 38 and flat roots 39.

Between the retention areas 11 and 12 and the sealing areas 13 and 14 are relatively wide and deep cylindrical relief grooves 42 (Figs. 2 and 3). These grooves, which have cylindrical inner surfaces, are positioned inwardly of the end shoulders 21 and 22 of the external surface 17, where the fitting has less wall thickness than at the retention area.

Inwardly of the grooves 42, at the sealing areas 11 and 12, and radially aligned with the external ridges 19 and 20, are sealing grooves 46, which are generally similar in shape to the relief groove 42, but more narrow and shallow than the relief groove. Seals 48 of elastomeric material such as silicone rubber fill the grooves 46. Alternatively O-rings or metallic seals may be employed. These sealing grooves 46 are in accordance with Application No. 7929706, whereas sealing grooves embodying the present invention will be described below.

In joining the tubes 52 and 53, which in the example illustrated are relatively thick-walled and are of a low-yield-strength material, the ends of the tubes first are inserted into the opposite ends of the fitting and are positioned adjacent to each other at the central portions of the fitting. Next, the fitting is swaged and for this it is preferred to use a radial swaging tool. This tool, as shown in Fig. 4, includes opposed segmented die halves 55 and 56, which extend around the fitting when the swaging operation is to take place. The upper die half 55 is supported by a removable restraining head 57 which remains

fixed as the tool is actuated. The lower die half 56 is carried by a die block 58 which is at the outer end of a piston rod 59 that extends into a power cylinder 60. Consequently, upon actuation of the tool, the rod 59 is moved outwardly by the power of cylinder 60, thereby pressing the die block 58 towards the restraining head 57. This in turn causes the sets of segmented die halves 55 and 56 to be compressed around the fitting.

It is preferred to swage the sealing areas 13 and 14 separately from the swaging of the retention areas 11 and 12. Consequently, the swaging tool first will be positioned around one of the sealing areas, for example, circumscribing the annular ridge 20 of the sealing area 14. Upon compression by the swaging tool, the exterior ridge 20 becomes flattened so that the outer surface at that area assumes approximately the same diameter as that of the surface 17. This in turn causes the seals 48 to be pressed tightly against the periphery of a portion of the tube 53 that is within the end of the fitting. The existence of the annular ridge 20 concentrates the swaging force at the zone of the seals 48. The seals 48, being of resilient material, become compressed and are in fluid-tight engagement with the surface of the tube 53 after the swaging. During this swaging operation, the centre ridge 24 of the fitting, by strengthening the centre area of the fitting, prevents the centre portion of the fitting from collapsing around the tube as the sealing area 14 is compressed. The centre ridge 24, with the resulting increased wall thickness at the centre of the fitting, also imparts a high resistance to bursting forces to the fitting.

The relief groove 42 helps limit the swaging action to the area of the seals 48, separating the sealing area 14 from the retention area 12. In other words, the retention area is unaffected by the swaging of the sealing area, as the wall of the fitting experiences some deflection at the zone of the relief groove.

After swaging of the sealing areas 13 and 14, the retention areas 11 and 12 of the fitting are swaged. Upon the compression of the fitting at the retention areas, the ridges 35 are pressed into the outer surfaces of the tubes 52 and 53. A mechanical lock is provided because the ridges 35 penetrate the surfaces of the tubes, and the material of the tubes is forced into the grooves 33 that separate the ridges 35. The convergence of the ridges 35 towards their crests helps them to penetrate the outer surfaces of the tubes upon swaging. The radial inwardly facing ridge walls 36 provide abutment surfaces that effectively resist forces tending to pull the tubes out of the fitting. The inclined outwardly facing walls 37 result in increased cross sections for the ridges at their bases, giving them good shear strength.

The relief grooves 42 again separate the

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sealing and retention areas as the retention areas are swaged. The wall of the fitting will bend at the relief grooves when the retention areas are swaged, leaving the sealing areas undisturbed.

Even though a strong attachment is made, there is little distortion of the inner surface of the tube. In other words, most of the change in the contour of the tube occurs along its outer surface and not along its inner surface where the fluid is engaged. This, in turn, minimizes pressure drop and hydraulic noise as the fluid is transmitted through the system.

The outer ends of the fitting are compressed by the swaging so that the Teflon (RTM) or rubber coatings 30 at the entrances to the fitting engage the surfaces of the tubes 52 and 53. This is a light interference condition which does not adversely affect the corrosion resistance of the tubes. The result is an external seal which protects against entry of fluids or other materials into the retention areas, thereby protecting the tubes and fitting against corrosion exteriorly. This also provides a resilient cushion which greatly improves the life of the tubes and fitting upon flexing of the tubes.

When substantial torsional loads may be applied to the tubes, it is preferred to make additional axial cuts through the retention areas to separate the ridges into separate teeth. This is shown in Fig. 6 where axially extending grooves 62 are cut through the ridge 35 through the length of the retention area 12. As a result, the material of the tube will enter the grooves 62 upon the swaging operation, which will prevent the tube 53 from unscrewing through the helical ridge 35 under torque loads.

An alternative, the fitting may be constructed with only one end intended for swaging and the other made compatible with some other kind of fitting or device.

Figs. 7 to 9 show a fitting in which the shape of the sealing grooves 65 is in accordance with the present invention. Such grooves take the place of the pairs of grooves 46 in Figs. 2, 3 and 5. Because of the depth of the groove, this invention normally finds its primary use in larger sizes of fittings where the wall thickness is greater.

As best seen in Fig. 7, at the right-hand portion of the fitting 64 is a single internal sealing groove 65, which is of stepped configuration. That is to say, the groove 65 includes a relatively deep portion 66 defined by an inner circumferential wall 67 which connects to opposed radial side walls 68 and 69. Shallower side portions 70 and 71, positioned one on either side of the central portion 66, complete the groove 65. A relatively sharp corner 72, with an included angle of 90°, is formed where the rearward radial sidewall 68 of the central groove portion 66 meets the inner circumferential wall 73 of the rearward

shallower groove portion 70. Similarly, the inner circumferential wall 74 of the forward relatively shallow groove portion 71 meets the forward radial sidewall 69 of central groove portion 66 to form a sharp 90° corner 75.

Outwardly in the axial direction from the forward shallow groove portion 71 is a land 76 separating the groove 65 from the relief groove 77, which is similar to the relief groove 42 in Figs. 2, 3 and 5.

An elastomeric O-ring 78 is positioned within the central groove portion 66.

On the exterior of the fitting 64, the cylindrical surface 79 that extends from over the relief groove 77 to the central portion of the fitting is interrupted by a ridge 80 positioned radially outwardly of both the sealing groove 65 and the land 76. In the example shown, the rearward edge of the cylindrical portion of the ridge 80 is aligned with the terminus of the rearward shallow sealing groove portion 70. The forward end of the ridge 80 extends just beyond the land 76.

The fitting 64 illustrated in Figs. 7 to 9 is for connecting two pipes or tubes and so has the same configuration at both ends. Accordingly, in the left-hand portion of the fitting, as shown in Fig. 7, there is a sealing groove 82 which is identical to the sealing groove 65 and receives an elastomeric O-ring seal 83 in its central portion 84. In the position of Fig. 7, a pipe 85 has been inserted into the left-hand end of the fitting 64, pressing the O-ring 83 outwardly into the central portion 84 of the groove 82. In this condition the O-ring 83 does not occupy the entire volume of the central groove portion 84.

Radially outwardly of the groove 82, and of the land 86 which is beyond the groove 82, is a circumferential ridge 87 for concentrating a swaging force at the sealing area.

At the left-hand and right-hand ends, respectively, of the ridge 88 are radial walls 89 and 90. A larger ridge 88 provides greater wall thickness and therefore increased strength at the central portion of the fitting, while the walls 89 and 90 provide stop surfaces for positioning the swaging tool as described below.

The swaging of the right-hand portion of the fitting 64 is illustrated in Figs. 8 and 9. After the insertion of the pipe 91 into the right-hand end of the fitting 64, the swaging tool 54, as in Fig. 4, is positioned around the fitting with the die halves 55 and 56 circumscribing the ridge 80. The die half 55 appears in Fig. 8, and the other die half 56 has the same configuration. The central portion 92 of the die half 55 is of a width comparable to that of the ridge 80 and is the portion of the die that exerts the inward swaging force when the die is actuated. A relief is provided on either side of the central portion to the surfaces 93 and 94. The two dies, therefore, define a larger diameter at the surfaces adja-

cent the central portion 92. Outwardly of the die surfaces 93 and 94 is a further relief to die surfaces 95 and 96. The latter surfaces are connected to the surfaces 93 and 94 by radial walls 97 and 98.

When the swaging tool is moved leftward over the fitting 64, as the components are illustrated in Fig. 8, the left radial die surface 97 is brought into engagement with the right-hand end surface 90 of the ridge 88, which limits the axial travel of the die. The parts are proportioned so that the central die portion 92 then is directly over the ridge 80 of the sealing area. The die surface 98 acts as the positioning stop to engage the ridge end 89 when the sealing area of the left end of the fitting is to be swaged. It is important that the swaging force be properly applied through the ridge 80 to the sealing area, and the positioning of the swaging tool through the means of the central ridge facilitates obtaining of the proper location of the tool to accomplish this.

After the tool has been positioned around the ridge 80, the die halves 55 and 56 are advanced towards each other to accomplish the swaging operation. This forces the material of the fitting inwards to the solid line position of Figs. 8 and 9. When the swaging beings, the inner circumferential surface 99 of the land 76 is forced against the outer surface of the pipe 91 and begins a ring cut. As swaging continues, the circumferential walls of the groove 65 are pressed inwards towards the pipe 91. This causes the sealing groove 65 to become distorted so that the central portion 66 becomes generally trapezoidal in shape. Thus, the bases of the sidewalls 68 and 69 are forced away from each other so that these walls become convergent in the radial outward direction. As this movement of the sidewalls 68 and 69 of the central groove portion takes place, the cylindrical surfaces 73 and 74 of the inner and outer shallow groove portions 70 and 71 are forced downwards adjacent to the central groove portion 66. This causes the corners 72 and 75 to bear against the outer surface of the pipe 91. As a result, these corners cut into the surface of the pipe completely around its periphery.

When the swaging operation at the sealing area is complete, the ridge 80 has become depressed below the level of the outer cylindrical surface 79. The relief at the die surface 93 ensures that there is no engagement of the fitting surface 79 between the ridges 80 and 88. Similarly, the die surface 95 clears the outer surface of the central ridge 88 so that there is no swaging of the central ridge.

As the sealing groove area is distorted as shown in Figs. 8 and 9, the O-ring 78 is forced tightly against the outer surface of the pipe 91 to form an effective seal. The O-ring 78 is selected so as to have a cross-sectional area which equals the cross-sectional area of the central groove portion 66 when the swag-

ing operation is complete. This ensures that the O-ring 78 will tightly bear against the surface of the pipe, yet at the same time it will not be forced outwardly of the central groove portion 66. This, in turn allows the corners 72 and 75 to dig into the surface of the pipe 92 without interference from the O-ring.

In addition to the seal accomplished by the O-ring 78, metal-to-metal seals are achieved through the engagement of the fitting and the pipe. One seal occurs at the land 76 where its inner cylindrical surface 99 cuts into the outer periphery of the pipe 91. A second metal-to-metal seal is formed where the corner 75 between the central sealing groove sidewall 69 and the forward shallow sealing groove wall 74 is caused to dig into the surface of the pipe around its periphery. In a similar manner, the corner 72 at the rearward end of the central sealing groove 66 cuts into the outer surface of the pipe 91 to form a third metal-to-metal seal.

When the fitting yield strength is less than that of the pipe received in the fitting, the metal-to-metal seals are adequate for hydraulic systems, at least in some applications, and the elastomeric seal may be omitted. If the yield strength of the pipe is equal to or less than that of the fitting, the elastomeric seal may be required because of the spring back of the fitting after swaging. It is preferred to use the elastomeric seal in all instances where gases are transmitted in the system.

CLAIMS

1. A fitting for fluid-tight connection to one end of a tubular member, the fitting comprising

a sleeve having
a first portion at one end thereof,
and a second portion inwardly of said end thereof, said first portion having ridge means on the inner periphery thereof adapted to penetrate the periphery of a tubular member inserted therein for forming a retention thereto,

the inner periphery of said second portion having a circumferential groove therein,
said groove having a relatively deep portion and a relatively shallow portion so that the wall of said groove defines a corner at the intersection of said relatively deep portion and said relatively shallow portion, whereby, upon application of an external radial force to said fitting, said corner is forced against the periphery of a tubular member received in said sleeve for forming a seal therewith.

2. A fitting as recited in claim 1, in which there are two of said relatively shallow portions positioned one on either side of said relatively deep portion,

said wall of said groove defining a corner at the intersection of each of said relatively shallow portions and said relatively deep portion,



cent the central portion 92. Outwardly of the die surfaces 93 and 94 is a further relief to die surfaces 95 and 96. The latter surfaces are connected to the surfaces 93 and 94 by radial walls 97 and 98.

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When the fitting yield strength is less than that of the pipe received in the fitting, the metal-to-metal seals are adequate for hydraulic systems, at least in some applications, and the elastomeric seal may be omitted. If the yield strength of the pipe is equal to or less than that of the fitting, the elastomeric seal may be required because of the spring back of the fitting after swaging. It is preferred to use the elastomeric seal in all instances where gases are transmitted in the system.

CLAIMS

1. A fitting for fluid-tight connection to one end of a tubular member, the fitting comprising

a sleeve having
a first portion at one end thereof,
and a second portion inwardly of said end thereof, said first portion having ridge means on the inner periphery thereof adapted to penetrate the periphery of a tubular member inserted therein for forming a retention thereto,

the inner periphery of said second portion having a circumferential groove therein,
said groove having a relatively deep portion and a relatively shallow portion so that the wall of said groove defines a corner at the intersection of said relatively deep portion and said relatively shallow portion, whereby, upon application of an external radial force to said fitting, said corner is forced against the periphery of a tubular member received in said sleeve for forming a seal therewith.

2. A fitting as recited in claim 1, in which there are two of said relatively shallow portions positioned one on either side of said relatively deep portion,

said wall of said groove defining a corner at the intersection of each of said relatively shallow portions and said relatively deep portion,



31

each of said corners being forced as recited against the periphery of a tubular member received in said sleeve upon the application of a radial external force.

- 5 3. A fitting as recited in claim 2, in which said relatively deep portion includes a circumferential wall and two opposed substantially radial walls, and each said relatively shallow portions includes a substantially radial wall,
- 10 and a circumferential wall connecting to one of said substantially radial walls of said relatively deep portion, thereby to define one of said corners.
- 15 4. A fitting as recited in any of claims 1 to 3, including in addition a sealing member solely in said relatively deep portion of said groove.
- 20 5. A fitting as recited in claim 4, in which said sealing member is an elastomeric O-ring.
- 25 6. A fitting as recited in claim 5, in which said sealing member occupies a volume less than that of said relatively deep portion prior to the application of said external force, and a volume substantially equal to that of said relatively deep portion following application of said external force.
- 30 7. A fitting as recited in any of claims 1 to 6, in which said sleeve includes a third portion axially inwardly of said second portion, said third portion having a greater wall thickness than said second portion, and an outside lateral dimension greater than that of an annular ridge around said second portion.
- 35 8. A fitting as recited in claim 1, substantially as described with reference to Figs. 7 to 9 of the accompanying drawings.