

SPECIFICATION**Fittings for fluid-tight connection to tubular members**

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 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 tubular elements.

One such fitting includes exterior ridges which, upon swaging, are transferred to the inner surface of the fitting. In other words, the inner surface of the fitting initially is of constant diameter except for small sealing grooves, while the exterior surface is provided with ridges. After the swaging operation, the exterior surface is of constant diameter and the ridges are transferred to the inner surface of the fitting to provide a connection with the tube.

This type of fitting relies upon the springback 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 aluminums, some titaniums, and the like, and do not exhibit appreciable springback upon compression. Tubes of this type are of relatively great wall thickness which 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 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, which may not be acceptable in the construction of submarines where silent operation is essential.

The present invention provides fittings 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 create little distortion in the internal wall of the tubes, so that pressure drop and noise difficulties are eliminated.

According to a principal aspect of this invention, a fluid fitting, for fluid-tight connection to one end of a tubular member, comprises 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, said second portion having at least one groove in the inner periphery thereof, and having a greater wall thickness than that of said first portion, and a sealing member in said groove, said sleeve including an additional

groove between said first and second portions for isolating said first and second portions from one another during swaging of said sleeve onto such a tubular member.

Preferably said ridge means has a wall facing said one end of said fitting which is inclined relative to the axis of said fitting, and a wall facing inwardly of said one end of said fitting which is more nearly perpendicular to said axis, whereby said ridge has a convergence to facilitate penetration into a member inserted therein, and a relatively wide base for enhancing the shear strength thereof.

The accompanying drawings show one fitting embodying the invention, by way of example. In these drawings:-

Figure 1 is a perspective view of the fitting;

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 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 swaging onto a tube;

Figure 6 is a further enlarged fragmentary longitudinal sectional view illustrating the sealing area following swaging;

Figure 7 is a fragmentary longitudinal sectional view showing the retention area following swaging; and

Figure 8 is an end elevational view of a modified fitting provided with longitudinal internal slots for resisting rotational loads.

The fluid fitting 10, as shown in Figure 1, is a 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 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 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.

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 Figures 2 and 3). Inwardly of the surfaces 15 and 16, the fitting has a larger external diameter as defined 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 has a

diameter comparable to that of the ridges 19 and 20 and is positioned between, and spaced from, the ridges 19 and 20.

The interior surface 26 of the fitting (Figure 2) prior to swaging is cylindrical in shape with counterbored ends 27 and 28 which form the entrances to the fitting. Relatively thin layers 29 and 30 of Teflon (R.T.M.) or of an elastomer such as silicone rubber line the entrances 27 and 28 of the fitting.

In the retention areas 11 and 12, grooves 32 and 33 are cut so as to produce helical ridges 34 and 35 throughout the lengths of these sections of the fitting (see also Figure 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 34 and 35 are mirror images of each other, each having a radial wall facing toward the centre of the fitting and an inclined wall facing toward the outer end of the fitting. For the ridge 35, shown in enlarged section in Figure 3, these surfaces are the radial wall 36 and the inclined wall 37. The angle of the inclined walls can range from 30° to 60° relative to the longitudinal axis of the fitting, preferably being 45°. The ridges have flat crests, the crest 38 being shown on the ridge 35. The pitch of the ridge is the same at both ends of the fitting and is a function of the diameter of the conduit which is to be retained by the fitting.

Between the retention areas 11 and 12 and the sealing areas 13 and 14 are relatively wide and deep cylindrical relief grooves 41 and 42 (Figures 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 sealing area and greater wall thickness than at the retention area. One function of the grooves 41 and 42 is to provide a runout for the tool forming the grooves 32 and 33.

Inwardly of the groove 41 (Figure 2), at the sealing area 12, and radially aligned with the external ridge 19, are sealing grooves 43 and 44, which are generally similar in shape to the relief groove 41, but more narrow and shallow than the relief groove. The inner groove 43 is not as wide as the outer groove 44. Similarly, for the sealing area 14 (Figures 2 and 3), there are grooves 45 and 46 which correspond in configuration to the grooves 43 and 44 respectively. The grooves 45 and 46 are beneath the exterior ridge 20. Seals 47 and 48 of elastomeric material such as silicone rubber fill the grooves 45 and 46 and similar seals occupy the grooves 43 and 44. Alternatively O-rings or metallic seals may be employed. For some purposes, only a single groove and seal need be provided at each sealing area.

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, using a radial swaging tool. This tool, as shown in Figure 4, includes opposed segmented die sets 55 and 56, which extend around the fitting when the swaging operation is to take place. The upper set of dies 55 is supported by a removable restraining head 57 which remains fixed as the tool is actuated. The lower dies 56 are 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 dies 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 (see Figure 6). This in turn causes the seals 47 and 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 47 and 48. The seals 47 and 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. Constriction of the centre portion of the fitting would exert an axial force tending to push the tube 53 out of the fitting and is undesirable. 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 47 and 48, isolating 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. The annular land 61, between the relief groove 42 and the sealing groove 44, digs into the outer surface of the tube 53 in response to the swaging of the sealing area 14. This provides a metal-to-metal seal at this location which assists the elastomeric seals 47 and 48 in retaining the fluid during use of the hydraulic system.

After swaging of the sealing areas 13 and 14, the retention areas 11 and 12 of the fitting are swaged. Each retention area is swaged in one operation in smaller-sized fittings; while for larger fittings it may be necessary to position the

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swaging tool at two or three locations along each retention area for separate operations. Upon the compression of the fitting at the retention areas, the ridges 34 and 35 are pressed into the outer surfaces of the tubes 52 and 53 (see Figure 7). The retention areas 11 and 12 have less wall thickness than the sealing areas 13 and 14 and are compressed inwardly a greater distance when swaged. A mechanical lock is provided because of the ridges 34 and 35 penetrate the surfaces of the tubes, and the material of the tubes is forced into the grooves 32 and 33 that separate the ridges 34 and 35. The convergence of the ridges 34 and 35 towards their crests helps them to penetrate the outer surfaces of the tubes upon swaging. The radial inwardly facing ridge walls (e.g. the wall 36) provide abutment surfaces that effectively resist forces tending to pull the tubes out of the fitting. The inclined outwardly facing walls (e.g. the wall 37) result in increased cross sections for the ridges at their bases, giving them good shear strength.

When the retention area is swaged in two or more operations, better results are obtained if there is a narrow gap left unswaged between the zones separately swaged. This occurs because there is a shorter portion of the tube deflected as a beam by each swaging operation, such deflection tending to lessen the penetration of the ridge into the tube.

The relief grooves 41 and 42 again isolate the sealing areas from the retention areas as the retention areas are swaged. The wall of the fitting wall 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 (R.T.M.) or rubber coatings 29 and 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. That is to say, it does not create stress concentrations, such as might accelerate corrosion; and it does not damage any exterior coating or plating on the tubes. Also, the coatings 29 and 30 do not themselves exert any corrosive action.

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 Figure 8 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. The relief groove 42 provides a runout for the broaching tool that forms the grooves 62.

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

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,

said second portion having at least one groove in the inner periphery thereof, and

having a greater wall thickness than that of said first portion,

and a sealing member in said groove, said sleeve including an additional groove

between said first and second portions for isolating said first and second portions from one another during swaging of said sleeve onto such a tubular member.

2. A fitting as recited in claim 1, in which said ridge means is provided with a wall facing inwardly of said one end of said fitting which is in a substantially radial plane, and a wall facing towards said end of said fitting which is inclined relative to the axis of said fitting.

3. A fitting as recited in claim 2, in which said inclined wall is at an angle within the range of 30° to 60° relative to the longitudinal axis of said fitting.

4. A fitting as recited in claim 3, in which said wall is at an angle of 45° relative to the longitudinal axis of said fitting.

5. A fitting as recited in any of claims 1 to 4, in which said ridge means has a wall facing said one end of said fitting which is inclined relative to the axis of said fitting, and a wall facing inwardly of said one end of said fitting which is more nearly perpendicular to said axis, whereby said ridge has a convergence to facilitate penetration into a member inserted therein, and a relatively wide base for enhancing the shear strength thereof.

6. A fitting as recited in any of claims 1 to 5, in which said ridge means is constituted by an internal annular ridge, said ridge being interrupted to provide a plurality of separate segments for penetrating the periphery of said tubular member.

7. A fitting as recited in any of claims 1 to 6, in



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swaging tool at two or three locations along each retention area for separate operations. Upon the compression of the fitting at the retention areas, the ridges 34 and 35 are pressed into the outer surfaces of the tubes 52 and 53 (see Figure 7). The retention areas 11 and 12 have less wall thickness than the sealing areas 13 and 14 and are compressed inwardly a greater distance when swaged. A mechanical lock is provided because of the ridges 34 and 35 penetrate the surfaces of the tubes, and the material of the tubes is forced into the grooves 32 and 33 that separate the ridges 34 and 35. The convergence of the ridges 34 and 35 towards their crests helps them to penetrate the outer surfaces of the tubes upon swaging. The radial inwardly facing ridge walls (e.g. the wall 36) provide abutment surfaces that effectively resist forces tending to pull the tubes out of the fitting. The inclined outwardly facing walls (e.g. the wall 37) result in increased cross sections for the ridges at their bases, giving them good shear strength.

When the retention area is swaged in two or more operations, better results are obtained if there is a narrow gap left unswaged between the zones separately swaged. This occurs because there is a shorter portion of the tube deflected as a beam by each swaging operation, such deflection tending to lessen the penetration of the ridge into the tube.

The relief grooves 41 and 42 again isolate the sealing areas from the retention areas as the retention areas are swaged. The wall of the fitting wall 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 (R.T.M.) or rubber coatings 29 and 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. That is to say, it does not create stress concentrations, such as might accelerate corrosion; and it does not damage any exterior coating or plating on the tubes. Also, the coatings 29 and 30 do not themselves exert any corrosive action.

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 Figure 8 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. The relief groove 42 provides a runout for the broaching tool that forms the grooves 62.

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

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,

said second portion having at least one groove in the inner periphery thereof, and having a greater wall thickness than that of said first portion,

and a sealing member in said groove, said sleeve including an additional groove between said first and second portions for isolating said first and second portions from one another during swaging of said sleeve onto such a tubular member.

2. A fitting as recited in claim 1, in which said ridge means is provided with a wall facing inwardly of said one end of said fitting which is in a substantially radial plane, and a wall facing towards said end of said fitting which is inclined relative to the axis of said fitting.

3. A fitting as recited in claim 2, in which said inclined wall is at an angle within the range of 30° to 60° relative to the longitudinal axis of said fitting.

4. A fitting as recited in claim 3, in which said wall is at an angle of 45° relative to the longitudinal axis of said fitting.

5. A fitting as recited in any of claims 1 to 4, in which said ridge means has a wall facing said one end of said fitting which is inclined relative to the axis of said fitting, and a wall facing inwardly of said one end of said fitting which is more nearly perpendicular to said axis, whereby said ridge has a convergence to facilitate penetration into a member inserted therein, and a relatively wide base for enhancing the shear strength thereof.

6. A fitting as recited in any of claims 1 to 5, in which said ridge means is constituted by an internal annular ridge, said ridge being interrupted to provide a plurality of separate segments for penetrating the periphery of said tubular member.

7. A fitting as recited in any of claims 1 to 6, in



which said second portion has an annular external ridge radially outwardly of said groove.

8. A fitting as recited in any of claims 1 to 7, in which said sleeve includes

5 a third portion intermediate said first and second portions,
said third portion having a greater wall thickness than said first portion and a lesser wall thickness than said second portion, and including
10 said additional groove in the inner surface thereof.

9. A fitting as recited in any of claims 1 to 8, in which said additional groove is wider and deeper than said groove in said second portion.

10. A fitting as recited in any of claims 1 to 9, in which
15 said first portion includes an enlarged entrance at said one end of said fitting,
said ridge means being inwardly of said entrance,

20 and including a sealing material around the surface of said entrance for engaging the surface of a tubular member attached to said fitting.

11. A fitting for fluid-tight connection of two tubular members, the fitting comprising

25 a sleeve having opposite ends which are adapted to receive end portions of tubular members to be connected, said sleeve including a retention portion adjacent each of said ends thereof,

30 each of said retention portions including ridge means on the inner surface thereof, and having a substantially constant exterior diameter,

a duality of sealing portions, one of which is spaced inwardly from each of said retention portions,

35 each of said sealing portions including sealing means on the inner surface thereof and having an annular ridge means radially outwardly of said sealing means, said ridge means being of greater exterior diameter than that of said retention portion,

and a central portion intermediate said sealing portions,

45 said central portion having an annular ridge on the outer surface thereof which is spaced from and positioned between said annular ridges of said sealing portions,

50 said sleeve having groove means intermediate each of said retention portions and the adjacent one of said sealing portions.

12. A fitting as recited in claim 11, in which said ridge means of each of said retention portions is defined by a helical ridge.

13. A fitting as recited in claim 11, in which
55 said ridge means of each of said retention portions is defined by a plurality of circumferentially-continuous annular ridges.

14. A fitting as recited in claim 11, in which
60 said ridge means of each of said retention portions includes an internal ridge having interruptions therein for providing separate segments for penetrating a tube, for thereby resisting torsional loads.

15. A fitting as recited in claim 11, in which
65 said ridge means of each of said sealing portions

comprises an annular ridge on the exterior of said sleeve.

16. A fitting as recited in claim 15, in which said annular ridges have cylindrical outer surfaces.

70 17. A fitting as recited in any of claims 11 to 16, in which said sleeve includes a counterbore in each outer end thereof for providing an entrance to said ridge means, and including in addition a sealing material in each of said entrance portions.

75 18. A fitting for fluid-tight connection of two tubes, the fitting comprising
a metal sleeve having opposite ends and a central portion intermediate said ends, said sleeve including

80 a duality of spaced retention portions for attachment to tubes received in said sleeve,
one of said retention portions being adjacent one of said ends and the other of said portions being adjacent the other of said ends,

85 each of said retention portions including internal ridge means for penetration into the exterior of a tube received in said sleeve upon inward swaging of said retention portion, and having a first cylindrical exterior surface of a first diameter,

90 a duality of spaced sealing portions for sealing against the exteriors of tubes so received in said sleeve,

one of said sealing portions being adjacent and inwardly of one of said retention portions and the other of said sealing portions being adjacent and inwardly of the other of said retention portions,

95 said sleeve including at least one internal annular groove at each of said sealing portions

100 each of said sealing portions including a sealing member in said groove, and an annular external ridge radially outwardly of said groove and of greater diameter than said second exterior surface for concentrating an externally applied swaging force at said sealing member,

105 said sleeve having a second cylindrical exterior surface of a greater diameter than that of said first diameter intermediate said retention portions,

110 said sleeve including an additional external annular ridge intermediate and spaced from said annular ridges of said sealing portions and of greater diameter than the diameter of said second exterior surface for providing an increased wall thickness at said central portion of said sleeve,

115 said sleeve including an additional internal annular groove intermediate each of said sealing portions and the adjacent one of said retention portions for providing isolation between said sealing portions and said retention portions.

120 19. A fitting as recited in claim 18, in which said additional annular grooves are deeper and wider than said internal grooves of said sealing portion.

125 20. A fitting as recited in claim 18 or claim 19, in which

said sleeve includes a counterbore in each of said ends,

130 and including a sealing material in each of said counterbores for sealing against the exteriors of tubes received in said sleeve.



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21. A fitting as recited in any of claims 18 to 20, in which each of said internal ridge means includes a crest, and is convergent towards said crest for facilitating penetration of said ridge means into the surface of a tube received in said sleeve.
- 5 22. A fitting as recited in claim 18, in which each of said ridge means includes
- 10 a first wall facing towards said central portion of said sleeve,
- and a second wall facing towards the adjacent one of said opposite ends,
- said first wall being substantially perpendicular relative to the longitudinal axis of said sleeve,
- 15 said second wall being inclined relative to said axis, thereby providing said ridge means with a relatively broad base and a narrower crest.
23. A fitting as recited in claim 1, substantially as described with reference to Figures 1 to 7 or
- 20 Figures 1 to 8 of the accompanying drawings.