(11) Application No. AU 2003247985 B2

(19) AUSTRALIAN PATENT OFFICE

(54) Title

Tubing Connection Arrangement

(51)[6] International Patent Classification(s)

E21B 17/042 (2006.01)
E21B 17/043 (2006.01)
E21B 43/10 (2006.01)
F16L 15/08 (2006.01)
E21B 17/042 20060101AFI2005100 8BMEP **E21B**
17/043 20060101ALI2005100 8BMEP **E21B**
43/10 20060101ALI2005100 8BMEP F16L
15/08 20060101ALI2005100 8BMEP

(21) Application No: 2003247985

(22) Application Date: 2003.09.16

(30) Priority Data

(31) Number	(32) Date	(33) Country
0221585.3	2002.09.17	GB

(43) Publication Date : 2004.04.01

(43) Publication Journal Date : 2004.04.01

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(56) Related Art

WO 2000/008301
WO 2002/001102
US 5924745

ABSTRACT

TUBING CONNECTION ARRANGEMENT

There is disclosed a tubing connection arrangement and a method of coupling expandable tubing sections together. In one embodiment, there is disclosed a tubing connection arrangement (10) comprising a first expandable tubing section (12) defining a male portion (16); a second expandable tubing section (14) defining a female portion (18), the first and second expandable tubing sections (12,14) being engageable with one another; one of the first and second expandable tubing sections (12,14) including a restraining member (40) for restraining part of the other expandable tubing section (12,14); and the first expandable tubing section (12) including a tapered shoulder (42,44) for co-operating with a corresponding tapered shoulder (46,48) of the second expandable tubing section (14).

TUBING CONNECTION ARRANGEMENT

FIELD OF INVENTION

This invention relates to a downhole tubing connector, and in particular to an arrangement for ensuring the integrity of a sand screen or other filter medium at a connection between two lengths of expandable tubing utilised to support or form a sand screen or filter. The invention also relates to methods of coupling expandable tubing sections together.

BACKGROUND OF INVENTION

In many well bores where a liquid, for example oil, passes from a surrounding formation into the well bore, the liquid will often carry entrained sand particles. If this sand is permitted to pass into the well bore a number of problems may arise, including the requirement to separate the sand from produced well fluids; an increased likelihood of the well bore becoming blocked or restricted; and the sand may cause downhole tools to stick or jam, or wear prematurely. Accordingly, it is preferred that the sand particles are retained in the formation. This is achieved by providing screens or a filter around the borehole-lining tubing or production tubing.

International Patent Application No. WO 97/17524 (Shell), the disclosure of which is incorporated herein by reference, describes a radially expandable assembly in

which overlapping filter sheets are sandwiched between inner expandable support tubing and outer expandable protective tubing, the expandable tubing featuring large numbers of overlapping longitudinal slots. When an expansion tool is forced through the assembly, the inner and outer tubing is expanded radially, the slots extending to form diamond-shaped openings. The initial degree of overlap between the screens is selected such that, although the screens move circumferentially relative to one another during expansion, the edges of the screens remain in overlapping relation. Such an arrangement can be readily constructed over cylindrical sections of slotted tubing or pipe. However, at the connections between tubing sections, where the inner tubing sections are coupled together, it is difficult to maintain a Asand-tight@ join.

A proposed connector assembly for connecting expandable slotted tubing is disclosed in the Applicant=s earlier International Patent Publication No. WO96/37681. The connector assembly comprises tubular first and second slotted parts mounted on the ends of respective lengths of slotted tubing. The free end of the first part defines a male portion and the free end of the second part a female portion, the free ends engaging one another to permit expansion of the coupled parts in a corresponding manner to the slotted tubing.

A modified tubing connection arrangement is disclosed

in the Applicant=s International Patent Publication No. WO00/08301, suitable for coupling expandable tubing assemblies of the type disclosed in WO97/17524. The connection arrangement comprises two expandable tubing sections, each section including a filter screen sandwiched between inner and outer expandable tubing. The filter screen of one tubing section overlaps the filter screen of the other tubing section and the outer expandable tubing of at least one of the tubing sections extends over the overlapping filter screens. On expansion of the tubing sections, the overlapping filter screens, restrained by the outer tubing, ensure the integrity of the filter between the tubing sections.

It is amongst the objects of embodiments of the present invention to provide an improved connection arrangement.

SUMMARY OF INVENTION

According to a first aspect of the present invention, there is provided a tubing connection arrangement comprising:

a first expandable tubing section defining a male portion;

a second expandable tubing section defining a female portion, the first and second expandable tubing sections being engageable with one another; and

a restraining member extending from an axial end of

the second expandable tubing section for restraining part of the first expandable tubing section, the restraining member including a hinge about which the restraining member is adapted to bend on expansion.

The restraining member can comprise a sleeve adapted to extend in an axial direction around an outer surface of part of the first expandable tubing section.

The hinge can be integral with the restraining member.

The hinge can be defined by a zone of weakness in the restraining member.

The zone of weakness can comprise an area of relatively thin cross-sectional thickness than a remainder of the restraining member.

The restraining member can comprise a separate component coupled to the respective expandable tubing section to form the hinge therebetween.

The restraining member can comprise a sleeve or wherein the restraining member can comprise a plurality of arms.

The restraining member can include a plurality of axially spaced hinges about which the restraining member is adapted to pivot on expansion.

The hinge can be provided in the same axial position of the restraining member as a bending zone on the overlapped expandable tubing section.

The first expandable tubing section can include a first and second axially spaced tapered shoulder for co-operating with a corresponding first and second axially spaced tapered shoulder of the second expandable tubing section.

The shoulder can comprise a face formed on an axial end of the respective expandable tubing section.

The expandable tubing sections can include a radially extending shoulder member defining the shoulder.

The shoulders of the first and second expandable tubing sections can be adapted to define a gap between their respective tapered surfaces when the first and second expandable tubing sections are engaged and before expansion of the connection arrangement, wherein the gap is adapted to close on expansion of the connection arrangement to bring the tapered surfaces into contact.

The restraining member can be adapted to extend in an axial direction along an outer surface of part of the first expandable tubing section or the second expandable tubing section.

The restraining member can comprise a sleeve comprising slotted tubing.

The sleeve can define a number of separate arms or fingers.

The first expandable tubing section can define a threaded male portion and the second expandable tubing

section can define a threaded female portion, and a cross-sectional thickness of the first expandable tubing section can be greater in the region of the male threaded portion than at a point axially spaced from the male threaded portion.

The point can be spaced axially from the male portion in a direction away from an end of the first expandable tubing section defining the male portion, wherein the point comprises an area extending at least part way along a length of the first expandable tubing section immediately adjacent the male portion.

The first expandable tubing section can include a shoulder for co-operating with a corresponding shoulder of the second expandable tubing section and wherein the point can be immediately adjacent the shoulder of the first expandable tubing section.

The first expandable tubing section can define a threaded male portion and a threaded radial hole extending through the threaded male portion and adapted to receive a threaded locking member and the second expandable tubing section can define a threaded female portion and a bore extending through the threaded female portion and adapted to receive the threaded locking member when the threaded hole of the first expandable tubing section can be aligned with the bore of the second expandable tubing section, for restraining the sections against relative rotation.

The first expandable tubing section can include a perforated inner expandable tubing defining a continuous annular ring at an axial end thereof, the threaded radial hole being formed in the perforated inner expandable tubing with a solid unperforated tubing wall section extending axially between the hole and the ring.

Each expandable tubing section can comprise a filter screen mounted around inner expandable tubing.

Each expandable tubing section can comprise a filter screen sandwiched between inner expandable tubing and outer protective expandable tubing.

The inner and outer expandable tubings can comprise perforated tubing such as slotted tubing.

Each filter screen can comprise a plurality of overlapping sheets individually mounted to the respective inner expandable tubing by axially parallel fixings.

According to a second aspect of the present invention, there is provided a method of coupling expandable tubing sections together, the method comprising the steps of:

providing a first expandable tubing section defining a male portion;

providing a second expandable tubing section defining a female portion;

providing the second expandable tubing sections with a restraining member having a hinge about which the

2003247985 05 Nov 2009

restraining member is adapted to bend on expansion; and

coupling the first and second expandable tubing sections together such that the restraining member restrains part of said first expandable tubing section.

The coupling step can include engaging the first and second expandable tubing sections together to form a connection and expanding the connection.

During expansion of the connection the restraining member can bend radially outwards or radially inwards about the hinge.

The first expandable tubing section can define a respective tapered shoulder and the second expandable tubing section can define a respective tapered shoulder and the step of coupling the first and second expandable tubing sections together can bring the shoulders into engagement.

The first expandable tubing section can define a threaded male portion having a threaded radial hole extending therethrough and the second expandable tubing section can define a female portion having a bore extending therethrough, and the method can comprise the additional steps of:

aligning the threaded radial hole with the bore; and

locating a threaded locking member in the aligned radial hole and bore for restraining the sections against relative rotation.

The first expandable tubing section can include a

perforated inner expandable tubing defining a continuous annular ring at an axial end thereof and a threaded radial hole formed in the perforated inner expandable tubing with a solid unperforated tubing wall section extending axially between the hole and the ring, and the second expandable tubing section female portion can include a bore, and the method can comprise the additional steps of:

aligning the threaded radial hole with the bore; and

locating a threaded locking member in the aligned radial hole and bore for restraining the sections against relative rotation.

It will be understood that in a further aspect or aspects of the invention, the features of one of more of the above described aspects may be provided in combination.

In still further aspects of the invention, there are disclosed methods of coupling expandable tubing sections together corresponding to the above described tubing connection arrangements and as defined in the accompanying claims. Further features of the methods correspond to the further features defined above.

BRIEF DESCRIPTION OF DRAWINGS

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 is a perspective cut-away view of part of a tubing connection arrangement in accordance with a

preferred embodiment of the present invention;

Fig. 2 is a longitudinal part-sectional view of the part of the tubing connection arrangement shown in Fig. 1, drawn to a larger scale;

Fig. 3 is a view of the tubing connection arrangement of Fig. 1 showing filter screens and outer expandable tubing of first and second expandable tubing sections of the arrangement;

Fig. 4 is an enlarged view of the tubing connection arrangement shown in Fig. 2, drawn to a still larger scale; and

Figs. 5 and 6 are enlarged views of thread profiles of the connector arrangement of Fig. 1.

DETAILED DESCRIPTION OF DRAWINGS

Turning firstly to Fig. 1, there is shown a perspective view of a part of a tubing connection arrangement in accordance with a preferred embodiment of the present invention, the arrangement indicated generally by reference numeral 10. Part of the connection arrangement 10 has been removed for illustration purposes. Fig. 2 is a longitudinal half-sectional view of the connection arrangement 10 drawn to a larger scale.

The connection arrangement 10 includes a first expandable tubing section 12 and a second expandable tubing section 14. The connection arrangement 10 provides a connection between two lengths of expandable sand exclusion

tubing of the type disclosed in International Patent Publication No. WO97/17524. For clarity, only part of the expandable sand exclusion tubing is shown in Figs. 1 and 2. Fig. 3 shows further parts of the tubing and will be described below.

The first expandable tubing section defines a male portion 16 and the second expandable tubing section a female portion 18. The first and second tubing sections 12, 14 are coupled together by engagement of the male and female portions 16, 18 as shown in the figures.

The first and second tubing sections 12, 14 include respective inner expandable support tubes comprising expandable tubing 20,22 having a large number of longitudinal overlapping slots 21,23. The slotted tubes 20, 22 form connectors and are welded at respective ends 24, 26 to plain lengths of similar expandable tubing, to form lengths of sand exclusion tubing with male and female connectors at opposite ends.

Referring to Fig. 3, a filter screen 28 extends along the main inner tubing (not shown) of the sand exclusion assembly over the connector inner tubing 20. The filter screen 28 comprises a number of filter plates welded along an axial edge to the inner tubings. Also, an expandable outer protective tubing 30, slotted in a similar fashion to the inner tubing 20, is mounted around the filter screen 28.

In a similar fashion, a filter screen 32 extends over the inner expandable tubing 22 of the second tubing section 14, with an expandable outer protective tubing 34 mounted around the filter screen 32.

When the connection arrangement 10 is expanded downhole, the outer tubing 30, 34 resists expansion of the inner tubing 20, 22. This results in the outer tubing 30,34 providing an inward radial force which maintains the overlapping filter screens 28,32 in engagement and effects a sand-tight seal between the individual filter plates.

The connection arrangement 10 and its mode of operation will now be described in more detail. The connection arrangement 10 includes various features which, for illustration purposes, are shown in combination in the figures. However, it will be understood that each one of these features may be provided separately or in combination with other features in alternative connection arrangements.

As shown in particular in Fig. 4, which is an enlarged view of the connection arrangement 10 shown in Fig. 2, the male portion 16 of the first tubing section 12 defines a male thread profile 36, which engages with a female thread profile 38 of the female portion 18 of the second tubing section 14. The first tubing section 12 is coupled to the second tubing section 14 by mating the thread profiles 36, 38 together. This is achieved by stabbing the male portion 16, which defines a pin, into the female portion 18, which

2003247985 05 Nov 2009

defines a box, in a pin-down arrangement, and rotating the male portion.

A restraining member in the form of a weave support overlap sleeve 40 extends from an end of the female portion 18 and overlaps the filter screen 28 on the first tubing section 12, as shown in Fig. 3. The male portion 16 includes first and second axially spaced tapered shoulders in the form of a tapered axial end face 42 and a tapered lip 44. The female portion 18 includes a tapered axial end face 46 and a tapered lip 48, which engage with the lip 44 and end face 42, respectively, of the male portion 16. The end faces 42, 46 define respective surfaces 50, 52 and the lips 44, 48 define respective surfaces 54, 56.

During make up of the connection 10, the tapered surfaces 52, 54 and 50, 56 come into contact, acting as a guide for coupling the thread profiles 36, 38 together. Thus any initial misalignment is accommodated as the tapered surfaces centralise the male portion 16 within the female portion 18.

As shown particularly in Fig. 4, when connected and before expansion, small radial gaps 58, 60 are defined between the tapered surfaces 52, 54 and 50, 56, respectively. On expansion of the connection arrangement 10, these gaps 58, 60 are closed such that the respective tapered surfaces come into contact. The shape of the end faces 42, 46 and the lips 44, 48 provide increased

2003247985 05 Nov 2009

interlock strength between the male and female portions 16, 18 thus increasing the strength of the connection arrangement 10 compared to prior art arrangements.

Also, the female portion lip 48 engages with a groove 43 in the male portion 16. This engagement resists inward radial deflection of the female portion 18 when coupled to the female portion 16 and torqued up, and when subsequently expanded.

Furthermore, the radial thickness of the lip 44 is increased relative to prior proposals, typically to around 2.915mm, increasing lip strength and allowing provision of the tapered surface 52. This increase in thickness improves the tensile strength and robustness of the connection arrangement 10.

The thread profiles 36, 38 of the male and female portions 16, 18 have also been altered compared to prior proposals. Figs. 5 and 6 are enlarged views of the thread profiles 36, 38. Lead thread flanks 62 of the male thread profile 36 are disposed at a different angle from lead thread flanks 64 of the female profile 38. Typically, the lead thread flanks 62 are disposed at 45° with respect to a main axis 66 of the connector 10, whilst the lead thread flanks 64 are disposed at 43° with respect to the main axis 66. In this fashion, there is a narrow contact band or area 70 between the respective lead thread flanks 62, 64 when engaged as shown in Fig. 4. This reduced contact band

or area facilitates make-up of the connection.

Furthermore, the lead thread flank angles have been substantially increased over prior art connectors from around 30° to around 45°. This both reduces ratcheting during make-up (a tendency of the male portion threads to slip over the female portion threads) and reduces the radial force transmitted to the female portion during expansion of the connection arrangement.

Also, back thread flanks 72 of the male thread profile 36 and back thread flanks 74 of the female thread profile 38 have been located at an acute angle with respect to the main connector axis 66. This provides a hook profile better able to resist separation forces between the male and female portions 16, 18 during expansion. In the embodiment shown, the back thread flanks 72, 74 are each disposed at an angle of 83° with respect to the main connector axis 66.

The connection arrangement 10 also includes an axially deformable member in the form of a crush ring 76. The crush ring 76 is provided on the end face 46 of the female portion 18 and when the first and second tubing sections 12, 14 are engaged, the crush ring 76 abuts a face 80 of the lip 44. The crush ring 76 is integral with the female portion 18 and is elastically and plastically deformed during make-up of the connection arrangement 10. Thus as the arrangement is torqued-up, the crush ring is deformed.

This transmits a load back through the female portion 18 onto the back thread flanks 74, urging the flanks into secure face-to-face contact with the back thread flanks 72 of the male profile 36. Accordingly, there is a pre-loading on the threads 36, 38 enhancing strength and integrity of the connection during expansion.

The crush ring 76 is also dimensioned to allow a number of separate sequential deformations. For example, the crush ring may be dimensioned to allow sufficient crushing to break-out the connection between the male and female portions 16,18 at least once, and potentially a number of times, whilst still pre-loading the connection when the connection is made up again.

Furthermore, as will be described below, the crush ring 76 improves make-up of the connection arrangement 10. This is because the male portion 16 includes a plurality of threaded holes 82 which align with respective bores 84 in the female portion 18, to allow anti-rotation screws (not shown) to be located, for securing the first and second tubing sections 12, 14 against relative rotation.

During make-up of the connection arrangement 10, the arrangement is torqued-up to a desired mating torque. In prior art arrangements including anti-rotation screws, it has been necessary to back-off the main thread 36, reducing make-up torque, to allow location of anti-rotation screws. This may reduce integrity of the connection.

In the embodiment shown, to achieve subsequent alignment of the threaded hole 82 and bore 84, there is no need to back-off the thread and the connection can simply be further torqued-up, increasing deformation of the crush ring 76, until alignment is achieved.

Furthermore, the minimum wall thicknesses A, B (Fig. 4) of the male and female portions 16, 18 have been increased when compared to prior art arrangements, providing a relative increase in strength of the connection arrangement 10. A typical thickness A of the male portion 16 is around 4.28mm. A consequence of the increase in the thicknesses A, B, is the ability to provide the lips 44, 48 which are of relatively larger dimensions than in any prior art connector arrangements and allows provision of the tapered surfaces. As an additional function of the increase in thickness of the connection arrangement 10, it is possible to thread the hole 82 and to countersink the bore 84 as shown at 86. In this fashion, anti-rotation screws located in the aligned hole and bore are threaded into the male portion 16 and include screw heads which exert a clamping force between the male and female portions 16, 18. The screws also bottom-out on the countersunk portion 86.

During manufacture of the tubing sections 12, 14, the plates of the respective filter screens are welded to the inner expandable tubing. For example, as shown in Fig.3,

the filter screen 32 is welded to the inner tubing 22 and extends up over the female portion 18, abutting a first shoulder 41 of the overlap sleeve 40. The outer protective tubing 34 is welded to the filter screen 32 and extends over the female portion 18 to a second shoulder 43 of the sleeve 40. Holes 45 are then cut in the protective tubing 34 in the location of the bores 84, and matching holes 47 are punched in the filter screen 32. A washer (not shown) is then welded to the outer tubing 34 in the hole 45 to provide a smooth surface, for location of the anti-rotation screws when the first and second tubing sections 12, 14 are engaged.

The weave support overlap sleeve 40 has been increased in cross-sectional thickness to, typically, around 1.85mm. This provides increased strength of the overlap sleeve to assist in maintaining the sleeve in good contact with the filter screen 28 during and following expansion.

Furthermore, the overlap sleeve 40 includes a hinge 88 about which the overlap sleeve 40 bends on expansion. The hinge 88 is a living hinge formed in the overlap sleeve 40 by providing a zone or line of weakness in the sleeve of reduced cross-sectional thickness compared to a remainder of the sleeve. Thus an expansion wave passing down through the connection arrangement 10 (left to right in the figures) will expand the inner tubing 20, which is urged outwardly to expand the filter screen 28. As mentioned

above, the overlap sleeve 40 resists expansion maintaining sand-tight contact with the filter screen 28.

As the expansion wave passes through the connector, a free end 90 of the overlap sleeve 40 first experiences a radial force. In prior art arrangements, there may be permanent undesired plastic deformation due to bending at the free end 90. However, the provision of the hinge 88 ensures that the overlap sleeve 40 bends about the hinge 88, which is subsequently expanded radially outwardly. Thus following expansion, there is no undesired bending retained in the overlap sleeve 40.

A cross-sectional thickness C of the male portion 16 has also been increased in the connection arrangement 10 such that the thickness is greater in the region of the male portion 16 than at a point axially spaced from the male portion. In particular, the thickness C is greater than a thickness of the first tubing section 12 in a direction spaced away from the axial end face 42, the thickness C being greater than the thickness D in this area. It is particularly desired to make the thickness in the region of the male portion 16 greater than a thickness axially beyond the interlock lip 44. In this fashion, bending experienced by the connection arrangement 10 during expansion occurs axially either side of the engaged thread profiles 36, 38, rather than across the section of the connected threads. The engaged threads 36, 38 are thus

2003247985 05 Nov 2009

expanded radially outwardly in a generally planar fashion, bending of the connection arrangement being substantially restricted to the areas beyond the engaged lip 44 and end face 46, and the lip 48 and end face 42.

The threaded holes 82 which receive the anti-rotation screws are provided in the male portion 16 adjacent the end face 42. A solid, unperforated tubing wall section is defined such that a solid ring 92 of material is provided at the end of the male portion 16. Location of the threaded holes 82 in this position improves the integrity of the connection between the male and female portions 16, 18. Furthermore, the threaded holes 82 and bores 84 extend through the respective male and female thread profiles 36,38 such that when the anti-rotation screws are located, they provide a clamping force to securely clamp the thread profiles together.

To improve rigidity of the connection between the male and female portions 16, 18 during expansion, the distance between the end face 42 and lip 44 of the male portion 16 has been minimised, to minimise bending. Furthermore, a majority, typically greater than half of the length of the male portion 16 defined between the end face 42 and the lip 44, is threaded. This assists in increasing the strength of the connection arrangement 10 and improves integrity of the connection during and following expansion. This is further improved in combination with the increase in wall

thickness C, as described above.

Further features of the connection arrangement 10 include that the weave support overlap sleeve 40 has been made as long as possible, to allow a large weave tolerance during fabrication. Conventionally, the filter screen 28 must axially overlap slots in the inner expandable support tubing in order to prevent sand ingress into the connector. To ensure this overlap is provided in the completed sand exclusion tubing, it is necessary to allow a certain degree of manufacturing tolerance in the length of the filter screen. Accordingly, the filter screen is conventionally made longer than required to account for shortening of the screen during welding, or a misalignment of the screen on the support tubing. However, in embodiments of the present invention, the length of the filter screen 28, and thus the tolerance, is restricted by the length of the overlap sleeve 40. The overlap sleeve 40 is therefore made as long as possible to allow the length of the filter screen 28, and thus the manufacturing tolerance, to be increased relative to prior assemblies.

Furthermore, this increase in length of the overlap sleeve 40 also reduces the angle which fingers 94 defined between circumferentially adjacent slots 23a, 23b (Fig. 1) of the sleeve 40 have to bend during expansion. This is because when slotted tubing of the type used for the inner support tubing 22 is expanded, the slots of the tubing open

out to form lozenge-shaped openings with straight sides and tapered ends. When the finger is relatively short, the angle between the side of the finger and the adjacent slot is relatively large following expansion. Making the overlap sleeve 40 as long as possible allows the overlap between the circumferentially adjacent slots 23a, 23b to be increased, enabling the length of the finger 94 to also be increased. Accordingly, when the connector 10 is diametrically expanded, this increase in length of the finger 94 reduces the angle defined at the roots 96, 98 of the slots 23a, 23b between the finger and the respective slot. This improves the strength and thus the integrity of the connector 10.

A rubber gasket (not shown) may be provided between the filter screen 32 and the inner support tube 22 of the second expandable tubing section 14. The gasket provides a further back-up to ensure sealing at the location of the overlap between the filter screen 32 and the slots 23b in the inner support tube 22, to ensure that sand ingress into the connection arrangement 10 is prevented. The gasket may be located adjacent the end face 41 of the weave support overlap sleeve 40, or may be axially spaced from the end face 41 by up to around 50mm.

The overall length of the connection arrangement 10 has also been increased, with a consequent reduction in the length of the inner expandable support tubes of the main

part of the sand exclusion tubing assembly sections. Typically, the first tubing section 12 has been increased in length from 150mm to 210mm whilst the second expandable tubing section has been increased in length from 195mm to 270mm. The effect of increasing the length of the connector has been to space the male and female portions 16, 18 and in particular the interlock end faces 42, 46 and lips 44, 48, away from weld profiles. As is known in the field of engineering materials, when welding, a Heat Affected Zone (HAZ) is created, which can alter the physical properties and characteristics of a material. Thus by spacing the weld profiles as far as possible from critical components of the connection arrangement 10, this reduces the potential effects on integrity of the connection.

Finally, whilst the connection arrangement 10 may be expanded in any desired fashion, in preferred embodiments, the connection arrangement 10 is expanded in a two-step procedure. Expanding in a single run to a maximum desired diameter introduces potential undesired bending in the connection. A two-step procedure allows an initial partial expansion, followed by a second, larger expansion to a desired final diameter. For example, an initial expansion with a solid cone or mandrel may be conducted, followed by expansion using the Applicant=s ACE (Trade Mark) expansion tool, disclosed in International patent

publication no. WO 03/048503. This may allow, for example, an initial 5.5" expansion followed by a subsequent expansion to 8.125". If desired, a three or more stage expansion procedure may be carried out to further reduce the likelihood of undesired bending. It will be understood that such a two or three step procedure is ideally conducted by running the cone and axially compliant expansion tool on a single string, but that the procedure may equally be carried out in separate runs.

In structural integrity tests of the connection arrangement 10 of the present invention compared to prior art structures, it has been ascertained that there is a substantial increase in strength of the connection 10 described herein. In particular, an increase in the failure tensile strength (the point at which extension of the unexpanded connector occurred) increased from 220000 lbf to around 300000 lbf. Torsional testing also demonstrates a substantial increase with a yield strength increase of from 2400 ftlb to around 3800 ftlb. However, torsional testing is difficult to conduct as the inner expandable tubings 20, 22 tend to deform and fail before any deformation in the region of the male and female portions 16, 18 is detected. It will be appreciated that the relatively increased strength connector disclosed requires a larger expansion force to be exerted on the connector to achieve expansion. However, the force

increase required is relatively small and is within the capabilities of commercially available expansion tools. Furthermore, this increase is offset by the many benefits afforded by the invention.

Various modifications may be made to the foregoing within the scope of the present invention.

2003247985 05 Nov 2009

CLAIMS

1. A tubing connection arrangement comprising:

a first expandable tubing section defining a male portion;

a second expandable tubing section defining a female portion, the first and second expandable tubing sections being engageable with one another; and

a restraining member extending from an axial end of the second expandable tubing section for restraining part of the first expandable tubing section, the restraining member including a hinge about which the restraining member is adapted to bend on expansion.

2. A tubing connection arrangement as claimed in claim 1, wherein the restraining member comprises a sleeve adapted to extend in an axial direction around an outer surface of part of the first expandable tubing section.

3. A tubing connection arrangement as claimed in any preceding claim, wherein the hinge is integral with the restraining member.

4. A tubing connection arrangement as claimed in any preceding claim, wherein the hinge is defined by a zone of weakness in the restraining member.

5. A tubing connection arrangement as claimed in claim 5, wherein the zone of weakness comprises an area of relatively thin cross-sectional thickness than a remainder of the restraining member.

6. A tubing connection arrangement as claimed in either of claims 1 or 2, wherein the restraining member comprises a separate component coupled to the respective expandable tubing section to form the hinge therebetween.

7. A tubing connection arrangement as claimed in claim 6, wherein the restraining member comprises a sleeve or wherein the restraining member comprises a plurality of arms.

8. A tubing connection arrangement as claimed in any preceding claim, wherein the restraining member includes a plurality of axially spaced hinges about which the restraining member is adapted to pivot on expansion.

9. A tubing connection arrangement as claimed in any preceding claim, wherein the hinge is provided in the same axial position of the restraining member as a bending zone on the overlapped expandable tubing section.

10. A tubing connection arrangement as claimed in any

2003247985 05 Nov 2009

preceding claim, wherein the first expandable tubing section includes a first and second axially spaced tapered shoulder for co-operating with a corresponding first and second axially spaced tapered shoulder of the second expandable tubing section.

11. A tubing connection arrangement as claimed in claim 10, wherein the shoulder comprises a face formed on an axial end of the respective expandable tubing section.

12. A tubing connection arrangement as claimed in claim 10 or 11, wherein the expandable tubing sections include a radially extending shoulder member defining the shoulder.

13. A tubing connection arrangement as claimed in any one of claims 10 to 12, wherein the shoulders of the first and second expandable tubing sections are adapted to define a gap between their respective tapered surfaces when the first and second expandable tubing sections are engaged and before expansion of the connection arrangement, wherein the gap is adapted to close on expansion of the connection arrangement to bring the tapered surfaces into contact.

14. A tubing connection arrangement as claimed in any one of claims 10 to 13, wherein the restraining member is adapted to extend in an axial direction along an outer

2003247985 05 Nov 2009

surface of part of the first expandable tubing section or the second expandable tubing section.

15. A tubing connection arrangement as claimed in any one of claims 10 to 14, wherein the restraining member comprises a sleeve comprising slotted tubing.

16. A tubing connection arrangement as claimed in claim 15, wherein the sleeve defines a number of separate arms or fingers.

17. A tubing connection arrangement as claimed in claim 1, wherein the first expandable tubing section defines a threaded male portion and the second expandable tubing section defines a threaded female portion, and a cross-sectional thickness of the first expandable tubing section is greater in the region of the male threaded portion than at a point axially spaced from the male threaded portion.

18. A tubing connection arrangement as claimed in claim 17, wherein the point is spaced axially from the male portion in a direction away from an end of the first expandable tubing section defining the male portion, wherein the point comprises an area extending at least part way along a length of the first expandable tubing section immediately adjacent the male portion.

2003247985 05 Nov 2009

19. A tubing connection arrangement as claimed in any one of claims 17 or 18, wherein the first expandable tubing section includes a shoulder for co-operating with a corresponding shoulder of the second expandable tubing section and wherein the point is immediately adjacent the shoulder of the first expandable tubing section.

20. A tubing connection arrangement as claimed in claim 1, wherein the first expandable tubing section defines a threaded male portion and a threaded radial hole extending through the threaded male portion and adapted to receive a threaded locking member and the second expandable tubing section defines a threaded female portion and a bore extending through the threaded female portion and adapted to receive the threaded locking member when the threaded hole of the first expandable tubing section is aligned with the bore of the second expandable tubing section, for restraining the sections against relative rotation.

21. A tubing connection arrangement as claimed in claim 20, wherein the first expandable tubing section includes a perforated inner expandable tubing defining a continuous annular ring at an axial end thereof, the threaded radial hole being formed in the perforated inner expandable tubing with a solid unperforated tubing wall section extending

axially between the hole and the ring.

22. A tubing connection arrangement as claimed in any preceding claim, wherein each expandable tubing section comprises a filter screen mounted around inner expandable tubing.

23. A tubing connection arrangement as claimed in any preceding claim, wherein each expandable tubing section comprises a filter screen sandwiched between inner expandable tubing and outer protective expandable tubing.

24. A tubing connection arrangement as claimed in claim 23, wherein the inner and outer expandable tubings comprise perforated tubing such as slotted tubing.

25. A tubing connection arrangement as claimed in claims 22 to 24, wherein each filter screen comprises a plurality of overlapping sheets individually mounted to the respective inner expandable tubing by axially parallel fixings.

26. A method of coupling expandable tubing sections together, the method comprising the steps of:

providing a first expandable tubing section defining a male portion;

2003247985 05 Nov 2009

providing a second expandable tubing section defining a female portion;

providing the second expandable tubing sections with a restraining member having a hinge about which the restraining member is adapted to bend on expansion; and

coupling the first and second expandable tubing sections together such that the restraining member restrains part of said first expandable tubing section.

27. The method of claim 26, wherein the coupling step includes engaging the first and second expandable tubing sections together to form a connection and expanding the connection.

28. The method of claim 27, wherein during expansion of the connection the restraining member bends radially outwards or radially inwards about the hinge.

29. The method of claim 26, wherein the first expandable tubing section defines a respective tapered shoulder and the second expandable tubing section defines a respective tapered shoulder and the step of coupling the first and second expandable tubing sections together brings the shoulders into engagement.

30. The method of claim 26, wherein the first expandable

2003247985 05 Nov 2009

tubing section defines a threaded male portion having a threaded radial hole extending therethrough and the second expandable tubing section defines a female portion having a bore extending therethrough, the method comprising the additional steps of:

aligning the threaded radial hole with the bore; and

locating a threaded locking member in the aligned radial hole and bore for restraining the sections against relative rotation.

31. The method of claim 26, wherein the first expandable tubing section includes a perforated inner expandable tubing defining a continuous annular ring at an axial end thereof and a threaded radial hole formed in the perforated inner expandable tubing with a solid unperforated tubing wall section extending axially between the hole and the ring, and the second expandable tubing section female portion includes a bore, the method comprising the additional steps of:

aligning the threaded radial hole with the bore; and

locating a threaded locking member in the aligned radial hole and bore for restraining the sections against relative rotation.

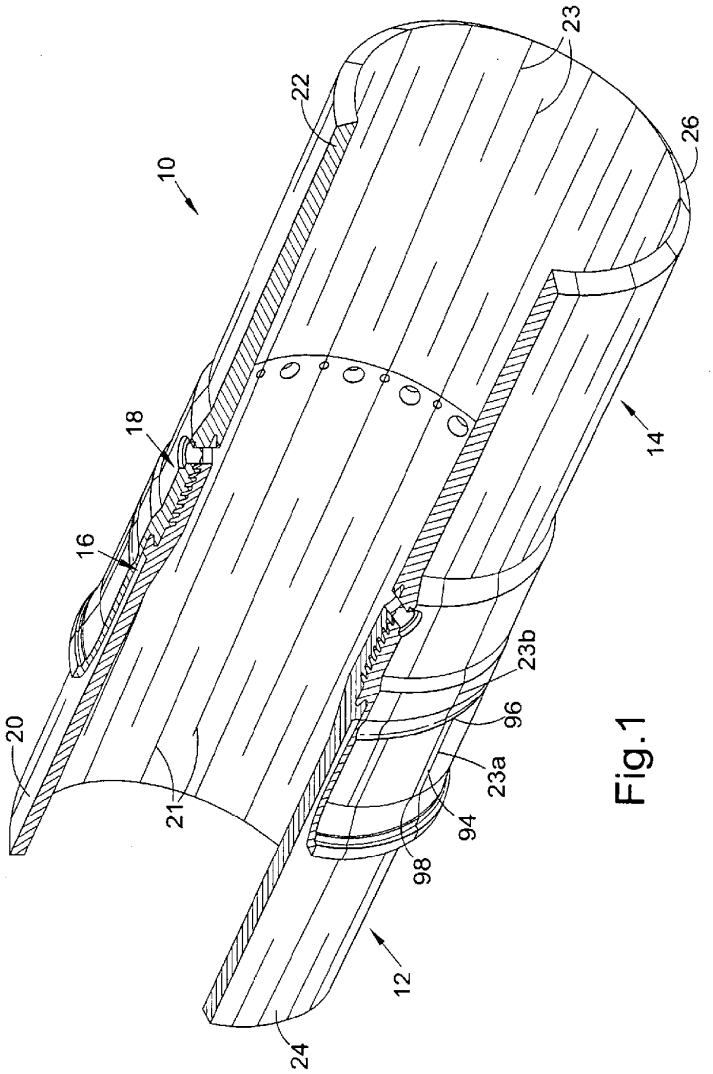

Fig.1

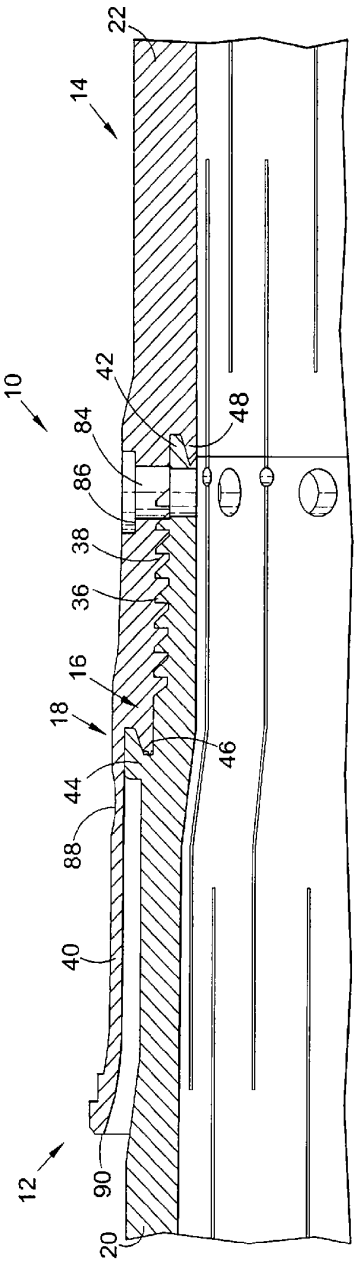

Fig.2

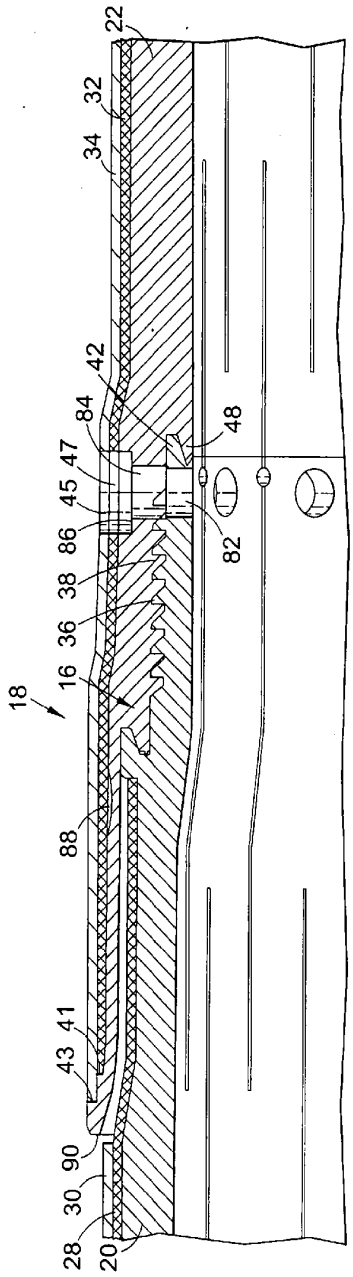

Fig.3

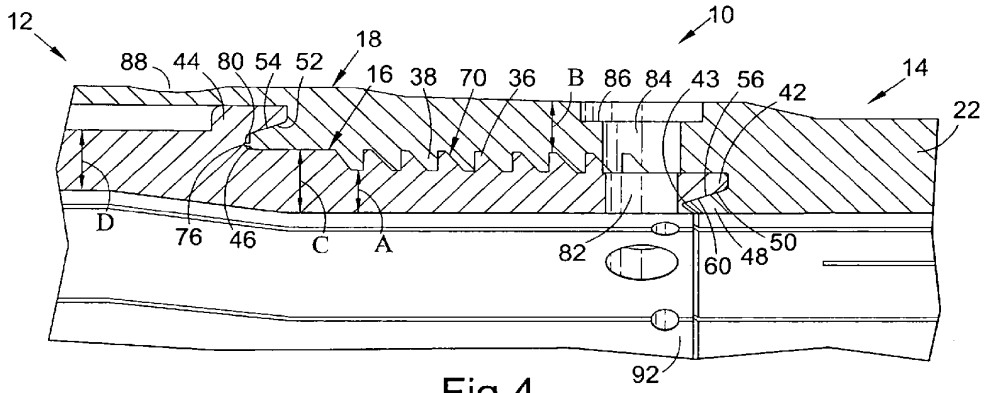

Fig.4

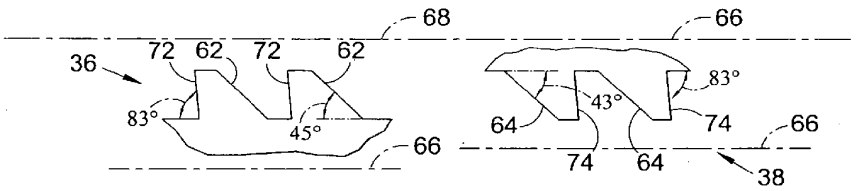

Fig.5 Fig.6