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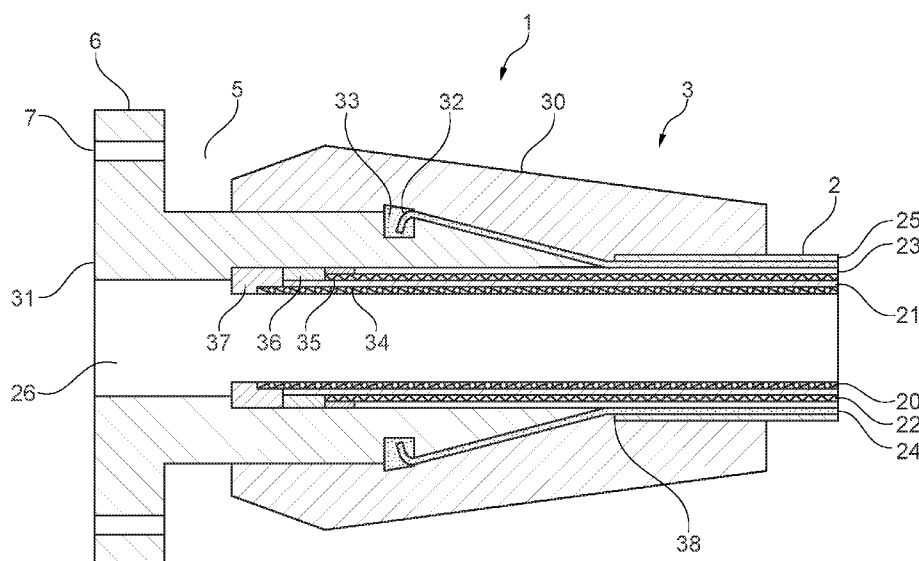


Fig. 2

(57) Abstract: The present invention relates to an assembly (1) comprising an unbonded flexible pipe (2) and an associated end-fitting (3). The unbonded flexible pipe (2) comprises an internal pressure sheath (21) defining a bore (26), a thermal barrier layer (23) outside the internal pressure sheath (21) and at least one tensile armor layer (24) outside the thermal barrier layer (23), wherein the end-fitting (3) comprises a fixation area (34) for the thermal barrier layer (23) and a fixation zone (33) for the tensile armor layer (24), wherein at least part of the thermal barrier layer (23) at least extends along the length of the tensile armor fixation zone (33) in the end-fitting (3).



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AN ASSEMBLY COMPRISING AN UNBONDED FLEXIBLE PIPE AND AN ASSOCIATED END-FITTING

TECHNICAL FIELD

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The present invention relates to an assembly of an unbonded flexible pipe and an end-fitting, where the flexible pipe comprises a plurality of layers and is suitable for offshore and subsea transportation of fluids like hydrocarbons, CO₂, water and mixtures hereof.

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BACKGROUND

Unbonded flexible pipes as well as end-fitting therefore and assemblies thereof are well-known in the art and are for example described in "Recommended Practice for Flexible Pipe", ANSI/API 17 B, fourth Edition, July 15 2008, and the standard "Specification for Unbonded Flexible Pipe", ANSI/API 17J, Third edition, July 2008.

Such pipes usually comprise an internal pressure sheath also often called an inner sealing sheath, an inner liner or an inner sheath, which is the innermost sealing sheath and which forms a barrier against the outflow of the fluid 20 which is conveyed in the bore of the pipe, and one or more armoring layers. Often the pipe further comprises an outer protection layer which provides mechanical protection of the armor layers. The outer protection layer may be a sealing layer sealing against ingress of sea water into the armor layers. In certain unbonded flexible pipes, one or more intermediate layers are 25 arranged between armor layers.

The armoring layers usually comprise or consist of one or more helically wound elongated armoring elements, where the individual armor layers are not bonded to each other directly or indirectly via other layers along the pipe.

When the armor layers are wound at an angle larger than 55° relative to the pipe center axis, they are classified as pressure armor layers, whereas armor layers wound with an angle of less than 55° are classified as tensile armor layers. By using un-bonded wound elements, the pipe becomes bendable and sufficiently flexible to roll up for transportation. The unbonded flexible pipe may comprise a carcass which is an armor layer arranged on the inner side of the internal pressure sheath in the bore. The pipe also comprises one or more pressure armors and/or one or more tensile armors arranged on the outer side of the internal pressure sheath.

10 In this text, the term "unbonded" means that at least two of the layers including the armoring layers and polymer layers are not bonded to each other. In practice, the known pipe normally comprises at least two armoring layers located outside the internal pressure sheath and optionally an armor structure, a carcass, located inside the internal pressure sheath.

15 The end-fitting is usually coupled to the unbonded flexible pipe to terminate at least an outermost armor layer. In most situations, the end-fitting is coupled to the unbonded flexible pipe to terminate all of the layers of the unbonded flexible pipe. The end-fitting must be able to withstand both the internal pressure of the pipe and to transfer the axial forces from the pipe into the attached structure via a bolted connection. This requires high strength from a component partly or fully made from steel or another metal. As a consequence, the end-fitting is very rigid relative to the flexible pipe.

When the pipe comprises one or more tensile armors, these armors are normally terminated in a fixation zone located in a fixation chamber in the end-fitting. The fixation chamber is normally formed between an inner casing and an outer casing of the end-fitting and when the end-fitting is terminating one or more tensile armors, the fixation chamber is filled with a solidifying solid such as a resin like epoxy or concrete.

When the unbonded flexible pipe is in use, e.g. as a riser transporting hydrocarbon fluids, these fluids may have relative high temperatures, which may challenge the materials in the pipe and in the end-fitting, as well as the adherence of the materials constituting the pipe to the end-fitting.

5

DISCLOSURE OF THE INVENTION

An object of the present invention is to provide an assembly comprising an unbonded flexible pipe and an associated end-fitting with reduced temperature in the tensile armor fixation zone hereby improving the long-term properties of the anchoring between the end-fitting and the unbonded flexible pipe.

The present invention relates to an assembly comprising an unbonded flexible pipe and an associated end-fitting having a through-going opening with a centerline and a front and a rear end, the unbonded flexible pipe comprises an internal pressure sheath defining a bore with a centerline, the pipe comprises a thermal barrier layer outside the internal pressure sheath, and the pipe comprises further at least one tensile armor layer outside the thermal barrier layer, wherein the end-fitting comprises a fixation area for the thermal barrier layer and a fixation zone for the tensile armor, wherein at least part of the thermal barrier layer at least extends along the length of the fixation zone in the end-fitting.

According to the invention, at least part of the thermal barrier layer at least partly extends along the length of the fixation zone in the end-fitting, and thus reducing the heat flux from the bore towards the fixation zone. The thermal barrier is terminated in a fixation area which preferably is outside the fixation zone. However, in an embodiment the fixation area may be within the fixation zone. The fixation area is the area in the end-fitting, where the thermal barrier layer is fixed, e.g. by squeezing. Depending on the extension of the thermal barrier layer, the end-fitting may comprise more than one

fixation area. The end-fitting may comprise two fixation areas if the thermal barrier layer is only present in the end-fitting.

The internal pressure sheath forms the bore and is substantially fluid-tight. By substantially fluid-tight is meant that substantially all the fluid transported in the bore will remain in the bore when transported from one end to another. However, minor amounts of gasses, such as carbon dioxide, hydrogen sulfide, methane and water vapor might be able to migrate through the fluid barrier formed by the internal pressure sheath. The internal pressure sheath is formed by an extruded polymer, such as e.g. polyethylene, polyamide or polyvinylidene fluoride.

The term "substantially" should herein be taken to mean that ordinary product variances and tolerances are comprised.

It should be emphasized that the term "comprises/comprising" when used herein is to be interpreted as an open term, i.e. it should be taken to specify the presence of specifically stated feature(s), such as element(s), unit(s), integer(s), step(s), component(s) and combination(s) thereof, but does not preclude the presence or addition of one or more other stated features.

The centreline of the pipe corresponds to the longitudinal center axis of the pipe or the axis of the pipe.

The thermal barrier layer is a non-metallic layer and preferably applied between the pressure armor and the tensile armor of pipe. The thermal barrier layer may be either permeable or semipermeable and may be produced either by winding, extrusion or a combination hereof. The thermal barrier layer has a thermal conductivity lower than about $2 \text{ W}/(\text{m} \cdot \text{K})$, such as lower or equal to $1 \text{ W}/(\text{m} \cdot \text{K})$ and a thickness of at least about 4 mm, such as between about 4 mm to about 50 mm, such as between about 5 mm to about 25 mm.

The term "about" is generally used to include what is within measurement uncertainties. When used in ranges, the term "about" should herein be taken to mean that what is within measurement uncertainties is included in the range.

- 5 The unbonded flexible pipe enters the end-fitting at the front end and the layers of the pipe are preferably terminated in the end-fitting in a known manner.

The flexible pipe comprises at least one pressure armor layer. The pressure armor layer may be made from strips forming elongate armor elements of
10 metallic materials, such as carbon steel, stainless steel, or fibre reinforced polymer material, such as fibre reinforced polyamide or epoxy. The elongate armor elements forming the pressure armor are wound around the pipe with a winding angle in the range with a relative steep angle to the longitudinal center axis of the pipe, e.g. of about 70 degrees or higher, such as about 75
15 degrees to about 89.9 degrees.

The elongate armor elements forming the pressure armor layers may be interlocked or non-interlocked. "Interlocked elongate armor element" means herein that the helically wound elongate armor element is interlocked with itself or to an adjacent elongate armor element in respective adjacent
20 windings thereof. The elongate armor elements can be inter-locked by use of e.g. a U-shaped or Z-shaped cross-section.

"Non-interlocked elongate armor element" means herein that the helically wound elongate armor element is not interlocked to itself or to an adjacent elongate armor element in respective adjacent windings thereof.

- 25 In a preferred embodiment, the unbonded flexible pipe comprises at least one tensile armor layer, however, the pipe may comprise two or more tensile armor layers. The tensile armor may also be made from strips forming elongate armor elements of metallic material, such as carbon steel, stainless steel, or fibre reinforced polymer material, such as fibre reinforced polyamide.

The elongate armor elements forming the tensile armor are wound around the pipe with a winding angle in the range with a relative steep angle to the longitudinal center axis of the pipe, e.g. of about 15 degrees to about 55 degrees.

- 5 The tensile armor layer may comprise two or more helically wound elongate armor elements.

The elongate armor elements forming the pressure armor or the tensile armor may have different or substantially the same cross-sections.

- 10 The fixation zone is the zone in which the axial loading of the tensile armor is gradually transferred from the armor element to the end fitting structure. At the end of the fixation zone, the axial strain in the tensile armor element is essentially zero. Thus, the tensile armor elements may extend beyond the fixation zone. The fixation zone is preferably arranged between an inner casing and an outer casing of the end-fitting, and basically the fixation zone
- 15 serves to fix or fasten the tensile armor in the end-fitting. Typically, the tensile armor is fixed in the void formed between an inner casing and an outer casing of the end-fitting, denoted the fixation zone, and typically the tensile armor is fixed by a solidifying moldable compound such as a resin or concrete. The temperature of the fluids transported in the flexible pipe which
- 20 is terminated in the end-fitting, and which fluids will pass through the end-fitting, may be rather high, e.g. in the range of about 100°C to about 150°C. Such high temperatures may have an impact on the mechanical properties of the fixing composition as well as on the elongate tensile armor elements resulting in deterioration of the fixation and eventually lead to damage and
- 25 failure of the pipe. Thus, it is desired to shield the fixation zone from thermal loads, i.e. in this context temperature above about 80°C to about 100°C.

According to the present invention, the thermal barrier layer of the pipe is continued into the end-fitting serving as a temperature shield keeping the fixation zone at an acceptable temperature level.

The thermal barrier layer may be the same layer along its entire length or the thermal barrier layer may change either abruptly or gradually along its length. In an embodiment, the thermal barrier layer comprises slits or openings. The slits or openings may serve to facilitate removal of gasses from the pipe or to contain load bearing elements that transfer forces through the pipe, e.g. to the inner casing of the end-fitting. The thermal barrier layer may comprise slits or openings all in the entire length or the slits or openings may only be present in the portion of the thermal barrier layer which is present in the end-fitting.

- 10 To avoid harmful build-up of gases or gas pocket formation, the invention provides an embodiment in which the thermal barrier layer is porous. The pores in the thermal barrier layer form through-going channels with a substantially circular cross-section in the thermal barrier layer and the pores may have an average diameter in the range of about 0,01 mm to about 0,1 mm.

In an embodiment, the thermal barrier layer is fluid-tight. The fluid-tight thermal barrier layer may serve to prevent undesired ingress of fluid into e.g. the pressure armor. This may be an advantage if the pressure armor is made from metallic material.

- 20 The thermal barrier layer is in an embodiment made from polymer material. Polymer material has good properties in respect of thermal barrier properties. The polymer materials include for example thermoplastic polymers like polyketones or polyolefins, such as polypropylene. Such materials have good thermal barrier properties, and also good properties in respect of mechanical stability.

Other types of polymer materials which may be used are e.g. thermosets like polyurethane.

A part or the whole of the thermal barrier layer may be a resin such as a polymer or a polymeric mixture, preferably an extrudable polymer. In

embodiments, a part of or the whole of the polymer or polymeric mixture is a homopolymer or a copolymer comprising at least one of the materials in the group comprising polyolefins, e.g. polyethylene or polypropylene (PP), such as stiff linear copolymer PP with a branched homopolymer PP;

5 polyoxyethylenes (POE); cycloolefin copolymers (COC); polyamides (PA), e.g. polyamide-imide, polyamide-11 (PA-11), polyamide-12 (PA-12) or polyamide-6 (PA-6)); polyimide (PI); polyurethanes such as polyurethane-isocyanurate; polyureas; polyesters; polyacetals; polyethers such as polyether sulphone (PES); polyoxides; polysulfides, such as polyphenylene sulphide (PPS);

10 thermoplastic elastomers, such as styrene block copolymers, such as poly(styrene-block-butadiene-block-styrene) (SBS) or their selectively hydrogenated versions SEBS and SEPS; thermoplastic polyolefins (TPO) e.g. comprising SEBS and/or SEPS; polysulphones, e.g. polyarylsulphone (PAS); polyacrylates; polyethylene terephthalates (PET); polyether-ether-ketones (PEEK);

15 polyvinyls; polyacrylonitrils (PAN); polyetherketoneketone (PEKK); copolymers of the preceding; fluorous polymers e.g. polyvinylidene difluoride (PVDF), homopolymers or copolymers of vinylidene fluoride ("VF2"), homopolymers or copolymers of trifluoroethylene ("VF3"), copolymers or terpolymers comprising two or more different members selected from VF2,

20 VF3, chlorotrifluoroethylene, tetrafluoroethylene, hexafluoropropene, or hexafluoroethylene; compounds comprising one or more of the above mentioned polymers, and composite materials, such as a polymer e.g. one of the above-mentioned polymers compounded with reinforcement such as solid or hollow microspheres, e.g. made from glass, polymer or silica, and/or

25 fibres, such as glass fibres, carbon fibres, aramide fibres, silica fibres such as basalt fibres, polyethylene fibres, polypropylene fibres, mineral fibres, and/or any combination thereof. As it is known to the skilled person, the resin may be added various strength enhancing filler materials, additives, activators, lubricants, plasticizers, complexing agents, processing aids, compatibilizing

30 agents and the like.

The thermal barrier layer may be secured in the end-fitting by means of pins, screws or other fastening devices, however, in an embodiment the thermal barrier layer is fixed in the end-fitting by clamping means. Clamping means provide an easy and efficient way to secure the thermal barrier layer in the end-fitting. The thermal barrier layer may also be secured in the end-fitting and the pipe simply by the squeezing action of e.g. the pressure armor and the tensile armor.

Although the thermal barrier layer may have a thickness in the range from about 4 mm to about 50 mm, the thermal barrier layer has in an embodiment a thickness in the range from about 4 mm to about 25 mm, or about 5 mm to about 25 mm. This range provides a thermal barrier layer with sufficient strength and sufficient thermal barrier properties.

The thermal barrier layer can be applied to the pipe in several ways. In one embodiment, the thermal barrier layer is an extruded layer. When the thermal barrier layer is applied as a continuous layer, it may be able to function as a fluid-tight layer.

In an embodiment, the thermal barrier layer is a tape wound onto the pipe. A tape may be applied to the pipe in an easy and uncomplicated process. The tape may be applied with windings with overlap or the tape may be applied with a distance between neighboring windings. When the thermal barrier layer is applied as a tape, the tape may have width in the range from about 40 mm to about 150 mm and thickness in the range from about 0.5 mm to about 40 mm as stated above. When the tape is wound with an overlap the overlap may be in the range from about 0.5 mm to about 50 mm, the overlap will also depend on the width of the tape. When the tape is wound with a distance between neighboring windings, it is preferably wound with a distance between neighboring windings in the range from about 0.5 mm to about 30 mm.

The thermal barrier layer may also be a combination of wound tapes and extruded layers. Thus, in an embodiment the, thermal barrier layer comprises one or more layers of wound tape and one or more extruded layers. The embodiment offers great freedom to design the thermal barrier. For example, sections of the thermal barrier layer may be an extruded layer only, while other sections may be wound tape only, and some sections be constituted by an extruded layer and wound tape.

The thermal barrier layer may be present in the entire length of the unbonded flexible pipe. The thermal barrier layer may alternatively be present in sections only, including the portion of the pipe which is terminated in the end-fitting. Such sections may have a length in the range from 1 m to 500 m, such as in the range from 2 m to 200 m. In an embodiment, the invention provides an unbonded flexible pipe where the thermal barrier layer only is present in the length of the flexible pipe which is fixed in the end-fitting. In this embodiment, the thermal barrier layer only serves to facilitate the temperature control in the end-fitting and in particular the temperature in the fixation zone.

Although the thermal barrier layer provides a shield towards temperature impact on the fixation zone, the pipe may comprise additional means to control the temperature and in an embodiment the pipe further comprises an insulating layer. The distinction between the thermal barrier layer and an optional insulating layer is that the thermal barrier layer mainly serves to protect the fixation zone towards excessive heat impact. An insulating layer will mainly serve to reduce heat loss from the fluid transported in the bore of the pipe to avoid that the fluid becomes too viscous and eventually block the pipe.

The insulating layer may in particular serve to control the temperature in a portion of the pipe which is outside the end-fitting. In an embodiment, the insulating layer has thickness in the range from about 5 mm to about 100 mm, such as in the range from about 10 mm to about 50 mm. Insulating

layers with thickness in this range provide a good insulation in the flexible pipe. The insulation layer is preferably made from polymer material and may appear as a syntactic foam, foamed or solid material. The insulating layer may e.g. be an extruded layer or a layer wound from tape. Polymer material
5 for the insulating layer may e.g. be selected from polyethylene, polypropylene or polyurethane.

The thermal barrier layer serves as the primary shield to protect the fixation zone from prohibitively high temperatures, however, the insulating layer may at least partly provide a secondary shield against the thermal impact on the
10 fixation zone. And in an embodiment, the insulating layer extends at least partly along the length of the fixation zone in the end-fitting parallel with the centerline of the end-fitting, thereby at least partly serving to control the temperature in the fixation zone.

For the purpose of maintaining the tensile strength of the flexible pipe, the
15 pipe is provided with at least one tensile armor. It is also necessary to protect the pipe against sudden pressure changes, such as sudden increased pressure in the bore, thus, the flexible pipe also comprises a pressure armor.

When the pipe comprises a pressure armor, the thermal barrier layer may be arranged outside or inside the pressure armor. Thus, in an embodiment of
20 the assembly according to the invention, the thermal barrier layer is arranged on the outer side of the pressure armor. In this embodiment, the pressure armor is arranged between the internal pressure sheath and the thermal barrier layer.

In another embodiment, the pressure armor is arranged on the outer side of
25 the thermal barrier layer.

In some environments, it may be required that the flexible pipe comprises a protection to protect the internal pressure sheath, and in an embodiment the pipe comprises a carcass. The carcass may protect the internal pressure sheath from damage in case of pressure drop in the fluid transported in the

bore of the pipe, as well against crushing due to static external pressure or caterpillar squeeze during installation.

All the armor layers in the flexible pipe, e.g. one or more tensile armor layers, one or more pressure armor layers and the carcass can be made from a

5 metal, such as steel, such as carbon steel or an alloyed stainless steel.

Moreover, in an embodiment, the tensile armor and/or pressure armor can be made from a fibre reinforced polymer, such as a carbon fibre reinforced polymer (CFRP) or a glass fibre reinforced polymer (GFRP). Such an embodiment may provide a flexible pipe with lower weight.

10 The binding polymer in the carbon fibre reinforced polymer may e.g. be a thermoset resin such as epoxy or vinylester, but other thermoset or thermoplastic polymers, such as polyester, polyamide, or polyvinylidene fluoride may also be used.

The end-fitting is made from a metal, preferably steel, such as coated carbon
15 steel or stainless steel and the fixation zone is between an inner armor and an outer casing of the end-fitting. The inner armor may be either the pressure armor or an inner casing fitted partly or fully over the thermal barrier layer. The inner casing and the outer casing may be made from the same or different material, e.g. the same type of steel or different types of
20 steel. The tensile armor is locked in the fixation zone preferably by a resin, such as epoxy.

In an embodiment, the pipe comprises an outer protective sheath. The outer sheath serves to protect the pipe armor from wear. The outer protective sheath may e.g. be made of polymer materials, such as PE, crosslinked PE, PA,
25 PP or mixtures thereof.

In an embodiment, a load bearing structure or an inner casing is fitted over the thermal barrier to avoid transfer of hydrostatic pressure from the loadbearing zone into the thermal barrier layer. The loadbearing structure is

preferably made from steel or another metal and may be formed like a tube or multiple rings.

The outer protective sheath may be perforated, which will allow e.g. sea water to pass through the outer protective sheath and at least partly equalize
5 the pressure between the layers in the pipe.

The flexible pipe may also be adapted for electric heating (Joule heating). If this is the case, one or more of the metallic armor layers may be connected to an electric power source. The thermal barrier layer may thus, also serve as an electric insulating layer, while at the same time reducing the amount of
10 heat which reaches the fixation zone in the end-fitting.

DETAILED DESCRIPTION OF THE INVENTION

The invention will be explained more fully below with reference to the drawings in which:

15 Figure 1 shows an assembly comprising an unbonded flexible pipe and an associated end-fitting;

Figure 2 shows a cross section of an assembly comprising unbonded flexible pipe and an associated end-fitting according to the invention.

The figures are schematic and simplified for clarity, and they show only
20 details which are essential to the understanding of the invention, while other details are left out. The same reference numerals may be used for identical or corresponding parts.

Figure 1 illustrates an assembly 1 comprising an unbonded flexible pipe 2 and an associated end-fitting 3.

25 The unbonded flexible pipe 2 comprises, from the inside an out, a carcass 10, an internal pressure sheath 11, a pressure armor 12, a tensile armor 13 and an outer sheath 14.

The carcass 10 is made from elongate members of stainless steel wound with a winding angle of approximately 85 degrees in respect of the axis 15. The pressure armor 12 is made from an elongate member of carbon steel and wound around the internal pressure sheath 11 with a winding angle of approximately 85 degrees in respect of the axis 15. The tensile armor 13 is also made from an elongate member of carbon steel and wound around the pressure armor with a winding angle of approximately 45 degrees in respect of the axis 15.

In this embodiment, the internal pressure sheath 11 and the outer sheath 14 are both substantially fluid tight. The internal pressure sheath 11 is made from extruded polyethylene and the outer sheath 14 is made from extruded polyamide.

The end-fitting 3 comprises a body part 4, a channel 5 and a flange 6 for connection to a connector or another end-fitting. The flange 6 comprises holes 7 for bolts which may be used for the connection. The material of the end-fitting is carbon steel.

Figure 2 shows a cross section of an assembly 1 according to the present invention.

The flexible pipe 2 enters the end-fitting 3 at the front end and the layers of the pipe 2 are terminated in the end-fitting 3.

The pipe 2 comprises from the inside and outwards the following layers: A carcass 20, an internal pressure sheath 21, a pressure armor 22, a thermal barrier layer 23, a tensile armor 24 and an outer sheath 25.

The layers of the flexible pipe are all terminated in the end-fitting 3. The end-fitting 3 comprises an outer casing 30 and an inner casing 31. In a void 32 between the outer casing 30 and the inner casing 31, a fixation zone 33 is formed.

The tensile armor layer 24 of the flexible pipe 2 is terminated in the end-fitting 3 and anchored in the fixation zone 33. In this embodiment, the tensile armor layer 24 is fixed by means of an epoxy resin which fills the void 32 forming the fixation zone 33.

- 5 The thermal barrier layer 23 extends along the fixation zone 33 and is terminated in the end-fitting 3 at fixation area 34. Thus, the thermal barrier 23 shields the fixation zone 33 from undesired heat impact from hot fluid transported in the bore 26 of the flexible pipe 2, and undesired softening of the epoxy resin in the fixation zone 33 is avoided.
- 10 The remaining layers of the flexible pipe 2 are terminated in the end-fitting 3 in a known manner. The pressure armor 22 is terminated in the end-fitting 2 at termination point 35. The internal pressure sheath 21 is terminated and fixed in the end-fitting by pressure means 36. The carcass 20 is terminated by the carcass ring 37. The outer sheath 25 is terminated in the end-fitting at
- 15 point 38 and fixed in the end-fitting by pressure means.

As previously mentioned, the figures are schematic and simplified for clarity, and they show only details which are relevant in respect of the present invention. For example, the end-fittings may comprise several other parts than shown in the figures, such as bolts and other connection means.

- 20 The unbonded flexible pipe may also comprise more layers than the layers indicated in the figures. The pipe may e.g. comprise two pressure armor layers and two tensile armor layers and optionally one or more intermediate layers such as anti-wear layers and insulating layers.

CLAIMS

1. An assembly comprising an unbonded flexible pipe and an associated end-fitting having a through-going opening with a centerline and a front and a rear end, the unbonded flexible pipe comprises an internal pressure sheath defining a bore with a centerline, the pipe comprises a thermal barrier layer outside the internal pressure sheath, and the pipe comprises further at least one tensile armor layer outside the thermal barrier layer, wherein the end-fitting comprises a fixation area for the thermal barrier layer and a fixation zone for the tensile armor, wherein at least part of the thermal barrier layer at least extends along the length of the tensile armor fixation zone in the end-fitting.
2. An assembly according to claim 1, wherein the thermal barrier layer has a thermal conductivity equal to or below $1 \text{ W}/(\text{m} \cdot \text{K})$.
3. An assembly according to claim 1 or 2, wherein the thermal barrier layer comprises slits or openings.
4. An assembly according to any one of the preceding claims, wherein the thermal barrier layer is porous.
5. An assembly according to any one of the preceding claims, wherein the thermal barrier layer is fluid-tight.
6. An assembly according to any one of the preceding claims, wherein the thermal barrier layer is made from polymer material.
7. An assembly according to any one of the preceding claims, wherein the thermal barrier layer is fixed in the end-fitting by clamping means.
8. An assembly according to any one of the preceding claims, wherein the thermal barrier layer has a thickness in the range 4 mm to 50 mm.

9. An assembly according to any one of the preceding claims, wherein the thermal barrier layer is an extruded layer.

10. An assembly according to any one of the preceding claims, wherein the thermal barrier layer is a tape wound onto the pipe.

5 11. An assembly according to any one of the preceding claims, where the thermal barrier layer comprises one or more layers of wound tape and one or more extruded layers.

12. An assembly according to any one of the preceding claims, wherein the thermal barrier layer only is present in the length of the flexible pipe which is
10 fixed in the end-fitting.

13. An assembly according to any one of the preceding claims, wherein the pipe further comprises an insulating layer.

14. An assembly according to any one of the preceding claims, wherein the insulating layer has thickness in the range 5 mm to 100 mm.

15 15. An assembly according to any one of the preceding claims, wherein the insulating layer extends at least partly along the length of the fixation zone in the end-fitting parallel with the centerline of the end-fitting.

16. An assembly according to any one of the preceding claims, wherein the thermal barrier layer is arranged on the outer side of the pressure armor.

20 17. An assembly according to any one of the preceding claims, wherein the thermal barrier layer is arranged between the internal pressure sheath and the pressure armor.

18. An assembly according to any one of the preceding claims, wherein a load bearing structure is fitted over the thermal barrier.

25 19. An assembly according to any one of the preceding claims, wherein the pipe comprises a carcass.

20. An assembly according to any one of the preceding claims, wherein the tensile armor is made from a fibre reinforced polymer.

21. An assembly according to any one of the preceding claims, wherein the tensile armor is made from carbon fibre reinforced polymer.

5 22. An assembly according to any one of the preceding claims, wherein the fixation zone is defined by an inner casing and an outer casing of the end-fitting.

23. An assembly according to any one of the preceding claims, wherein the tensile armor is fixed in the fixation zone by a moldable compound.

10 24. An assembly according to any one of the preceding claims, wherein the moldable compound is a resin, such as epoxy or vinylester resin.

25. An assembly according to any one of the preceding claims, wherein the moldable compound is an inorganic compound, such as cement or concrete.

15 26. An assembly according to any one of the preceding claims, wherein the pipe comprises an outer protective sheath.

27. An assembly according to any one of the preceding claims, wherein the outer protective sheath is perforated.

1/2

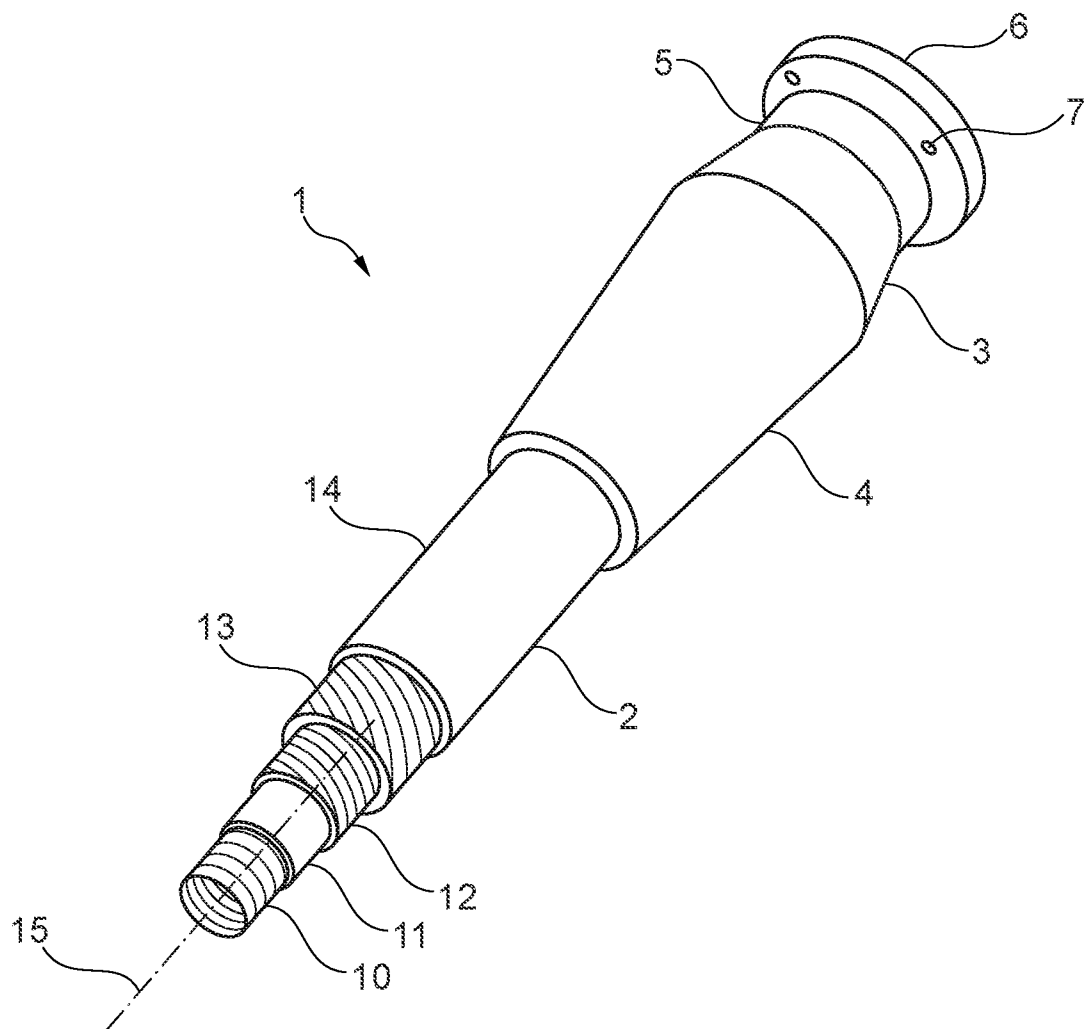


Fig. 1

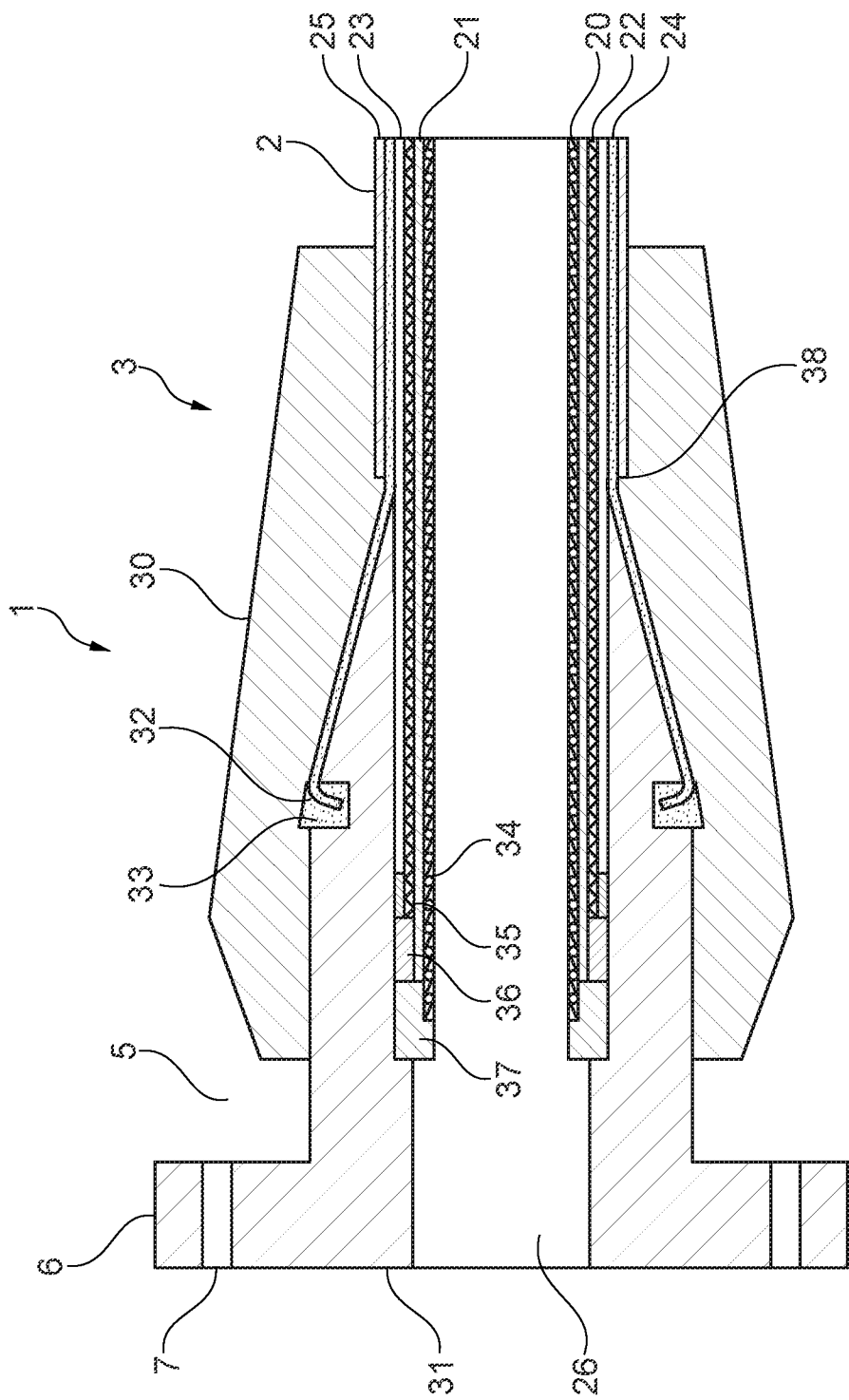


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK2018/050032

A. CLASSIFICATION OF SUBJECT MATTER F16L 33/01 (2006.01), F16L 33/28 (2006.01), F16L 33/34 (2006.01) According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC/CPC: F16L Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched DK, NO, SE, FI: Classes as above. Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPODOC, WPI, FULLTEXT (ENGLISH)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X; A	CN 204647583 U (RICHTECH INTERNAT ENGINEERING SHANGHAI CO LTD) 16 September 2015 See the figures	1; 2-27
X; A	JP H06174160 A (FURUKAWA ELECTRIC CO LTD) 24 June 1994 See the figures	1; 2-27
X; A	JPH 07167363 A (SEKYU KODAN) 4 July 1995 See the figures	1; 2-27
X; A	JPS 60215185 A (FURUKAWA ELECTRIC CO LTD) 28 October 1985 See the figures	1; 2-27
X;A	JPS 62274189 A (FURUKAWA ELECTRIC CO LTD) 28 November 1987 See the figures	1; 2-27
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents: “A” document defining the general state of the art which is not considered to be of particular relevance “E” earlier application or patent but published on or after the international filing date “L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) “O” document referring to an oral disclosure, use, exhibition or other means “P” document published prior to the international filing date but later than the priority date claimed “T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention “X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone “Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art “&” document member of the same patent family		
Date of the actual completion of the international search 06/04/2018		Date of mailing of the international search report 11/04/2018
Name and mailing address of the ISA Nordic Patent Institute Helgeshøj Allé 81 DK - 2630 Taastrup, Denmark. Facsimile No. + 45 43 50 80 08		Authorized officer Kim Hansen Telephone No. +45 43 50 81 13

Box No. I	Nucleotide and/or amino acid sequence(s) (Continuation of item 1.c of the first sheet)
	1. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international search was carried out on the basis of a sequence listing filed or furnished: a. ☐ forming part of the international application as filed: ☐ in the form of an Annex C/ST.25 text file. ☐ on paper or in form of an image file. b. ☐ furnished together with the international application under PCT Rule 13ter.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file. c. ☐ furnished subsequent to the filing date for the purposes of international search only: ☐ in the form of an Annex C/ST.25 text file (Rule 13ter.(a)) ☐ on paper or in the form of an image file (Rule 13ter.1(b) and Administrative Instructions, Section 713). 2. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished. 3. Additional comments:

INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK2018/050032

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:

because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:

because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:

because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK2018/050032

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/DK2018/050032

Patent document cited in search report / Publication date	Patent family member(s) / Publication date
CN 204647583 U 2015.09.16	None
JPH 06174160 A 1994.06.24	None
JPH 07167363 A 1995.07.04	None
JPS 60215185 A 1985.10.28	None
JPS 62274189 A 1987.11.28	None