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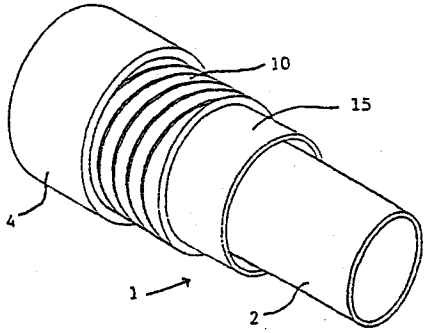
(54) Titre : Device for arresting the propagation of a buckle in a wound double-walled pipe.

(57) Abrégé : The invention concerns a device for limiting propagation of deformation in a double-walled tube. The invention is characterised in that it consists of an element rotating and deformable in a transverse direction relative to said longitudinal axis, said deformable element (10) being arranged in the annular space (6) and comprising an outer surface (11) which is in contact with the inner wall (12) of the external tube (4) over at least two points, and an inner surface (13) spaced apart from the internal tube (2). The invention is particularly applicable to pipes used in the oil industry.



Device for arresting the propagation of a buckle in a wound double-walled pipe

The present invention relates to a device for arresting the propagation of a buckle in a double-walled pipe wound onto a reel and more particularly in a rigid pipe used for transporting fluids such as hydrocarbons.

A rigid pipe or tube is laid on the seabed usually from what is called a pipelaying vessel. The laying is called S-laying when the pipe adopts the shape of an S between the pipelaying vessel and the seabed and it is called J-laying when the pipe adopts the shape of a J. In the latter case, a guide ramp is provided on the pipelaying vessel, which ramp may sometimes be partially immersed in the water.

The rigid pipe to be laid is stored on the pipelaying vessel either in pipe sections of a given but relatively short length, the pipe sections being joined together as the laying progresses, or it is wound as a great length on a reel, the pipe then being unreeled from the said reel during the laying operation. These laying operations are described in the API (American Petroleum Institute) document "Recommended Practice 17 A" from 1987.

When the pipe has left the vessel and while the said pipe is being laid, it is important that the latter undergoes no plastic deformation in bending, which would result in ovalization of the pipe, the said ovalization causing a "weak singularity" which would be conducive to the initiation of a collapse. Moreover, when the pipe is laid on the seabed at great water depths (typically greater than 300 m and possibly up to 2000 m and more), the hydrostatic pressure exerted on the pipe may be sufficient to initiate a buckle which has a tendency to propagate along the pipe, in both directions. Of course, the buckle will form

preferentially at a "weak singularity" when one exists on the pipe. When the buckle occurs, it is then necessary to replace at least that section or portion of the pipe comprising the buckled or collapsed region.

To prevent the propagation of a local buckle or buckles, it has been proposed to provide the pipe with certain devices or means, called buckle arrestors.

Such buckle arrestors are described in the US patents No. 2,425,800, 3,747,356, 3,768,269 and 4,364,692.

The process in US 3,747,356 consists in linking a cylinder to a cable, in lodging the cylinder inside a pipe section and then in simultaneously unreeling the pipe and the cable so as to keep the cylinder in the pipe section while the latter is being laid, until the pipe comes into contact with the seabed. The cylinder is then brought back up so as to be lodged in another pipe section to be laid, which is joined to the previous section. Consequently, any buckle likely to occur, when laying the pipe, between the pipelaying vessel and the seabed is immediately arrested and therefore not allowed to propagate along the pipe sections. However, such an arrangement provides no solution to or any effectiveness in arresting buckles likely to be propagated after the pipe has been finally laid on the seabed.

US 3,768,269 proposes to locally increase the stiffness of the pipe by placing, at regular intervals, for example at intervals ranging between 100 m and 500 m, reinforcing collars whose length ranges between 1 m and 2.5 m. Such a solution is valid only for pipes laid in sections since the reinforcing collars can be mounted and fastened in the factory to the pipe sections and then transported by the pipelaying vessel to the laying site. When the pipe is long and wound onto a storage

reel, it then becomes virtually impossible to wind the pipe with its reinforcing collars onto a reel since they would result in straight or almost straight portions that cannot be deformed when winding the pipe onto the storage reel. In order to mitigate this difficulty, it is conceivable to mount and fasten the reinforcing collars during the laying operations. However, it would then be necessary to interrupt the laying, at regular intervals, so as to mount and fasten the reinforcing collars.

In order to allow the pipe to be wound onto a reel, US 4,364,692 proposes to wind a rod tightly around the pipe so as to form a certain number of turns which can be welded at their ends to the rod itself and/or to the pipe.

According to another embodiment, the turns may be individual turns, by welding their two ends and regularly spacing them apart along that portion of the pipe to be reinforced. As long as the pipe is a single-walled pipe, the increase in the diameter in the reinforced portions may be acceptable. However, when the pipe is of the double-walled or pipe-in-pipe type, that is to say comprising an inner pipe, or liner pipe, and an outer pipe, or carrier pipe, which is slipped over the inner pipe, the increase in the diameter of the outer pipe is unacceptable when transporting and storing long lengths of double-walled pipes.

The object of the present invention is to provide a device for arresting the propagation of a buckle in a double-walled rigid tube or pipe that can be wound onto a reel intended to be stored on a pipelaying vessel or equivalent system, such as a barge, floating platform, etc.

The subject of the present invention is a device which consists of at least one element having symmetry of revolution and being deformable in a direction transverse to the longitudinal axis, said deformable element being placed in the annular space and having an external face which is in contact with the internal wall of the outer pipe, at least at two points, and an internal face which is spaced away from the inner pipe.

One advantage of the present invention lies in the fact that the double-walled pipe retains its external dimensions without any local increase in its outside diameter, while still being sufficiently flexible to be wound onto a take-up reel.

Another advantage is that it is possible to factory-mount the device in the outer pipe before it is positioned around the inner pipe.

Another advantage lies in the fact that the device according to the invention can be lodged in the annular space without modifying the internal arrangement of the double-walled pipe, which generally includes spacers and thermal insulation members.

According to another characteristic of the present invention, the deformable element consists of a core comprising a plastic sheath onto which is wound, with a short pitch, an interlocked or non-interlocked profiled wire, which may constitute a reinforcement similar to an internal carcass or to a pressure vault or a hoop, such as those used in what is called a "rough bore" or "smooth bore" flexible pipe depending on whether the innermost member of said flexible pipe consists of an inner polymeric sealing sheath or a metal carcass, the structures of such flexible pipes being well-known to experts and described in the API (American Petroleum

Institute) documents 17B or 17J from 1988 or 1997, these being included in the description as references.

One advantage of this feature is that it is unnecessary to manufacture a special core, as this is available at the flexible pipe manufacturers and all that is required is to cut the available cores to the desired length and to place them in the outer pipe at the manufacturing premises. In addition, the plastic of the sheath is carefully selected in order to form a thermal barrier, so as to improve the thermal insulation at the buckle propagation arrestor.

Further advantages and features of the present invention will become more clearly apparent on reading the description of several embodiments, together with the appended drawings in which:

- figure 1 is a schematic and partial cross-sectional representation of a double-walled pipe provided with the device according to a first embodiment of the invention;
- figure 2 is a schematic, partial and perspective view of the deformable element used without a polymeric sheath; and
- figure 3 is a partially cut-away perspective view of part of a double-walled pipe according to a second embodiment of the device according to the invention.

According to a first embodiment shown in figures 1 and 2, the rigid pipe 1 according to the invention, of longitudinal axis AA, is of the double-walled type and comprises a cylindrical inner pipe 2, the thickness of the wall 3 of which and the diameter and nature of the material of which are chosen according to the conditions of use, which are generally, without these being limiting, the temperature and the pressure of the fluid flowing in the inner pipe. An outer pipe 4 (or

carrier pipe) has a diameter large enough to allow it to slide over the inner pipe 1 and with a thickness of the wall 5 which is able to withstand the external or ambient pressure within the medium in which the rigid pipe is immersed. Typically, an annular space 6 is provided between the inner pipe 2 and the outer pipe 4 and is of the order of several centimeters measured radially from the external face of the inner pipe 2 to the internal wall of the outer pipe 4. In a double-walled rigid pipe like the one briefly described above, spacers are provided over the entire length of the rigid pipe, at regular intervals, between the inner and outer pipes. These spacers leave, at their upper end, that which is closest to the internal wall of the outer pipe, a small space 8 to allow the outer pipe 4 to slide over the inner pipe 2, within the manufacturing tolerances. Likewise, a thermal insulation is placed around the inner pipe 2, between the spacers.

According to the present invention, one or more flexible devices are provided over the entire length of the rigid pipe at predetermined intervals, these flexible devices being able to constitute members for arresting the propagation of a buckle likely to occur in the outer pipe 4. Each device comprises, in the embodiment shown in figures 1 and 2, at least one deformable element 10 which is placed in the annular space 6 and the external face 11 of which is in contact with the internal wall 12 of the outer pipe, at least at two points but preferably over the entire length of the external face 11, and the internal face 13 of which is a certain distance from the external wall 14 of the inner pipe 2. The device also includes a sheath, for example the polymeric sheath 15, which is applied to the internal face 13 of the deformable element 10, the thickness of the sheath 15 being such that a space 16 is left between its internal face 17 and the external wall 14 of the inner pipe 2. The sheath 15, which may

be impermeable, is used as a thermal barrier in order to provide improved thermal insulation.

The deformable element 10 is, for example, made from an interlocked or non-interlocked profiled wire such as that shown in figure 2, the consecutive turns 18 and 19 leaving between them an inter-turn gap 20 which helps the deformable element 10 to deform in curvature while the rigid pipe 1 is being wound onto a reel (not shown).

The length of the deformable element 10 is between 0.5 m and 5 m and may be bounded by two correctly spaced stops 7.

The deformable element 10/sheath 15 assembly constitutes a core which is used, in standard flexible pipes, as a pressure vault and inner sheath. Consequently, this core, which is available at flexible pipe manufacturers, can be used, cut to the desired length, inserted into the outer pipe 4 and then fastened by any suitable means to the internal wall 12 of said outer pipe 4. Among suitable fastening means, at least one end turn and preferably the first and last turns of the deformable element 10 can be welded to the internal wall 12 of the outer pipe 4.

In another embodiment shown in figure 3, the arrestor device according to the invention may consist of a spring 21 which is wound around the inner pipe 2 without any contact with the latter, at least some of the turns 22 of the spring 21 being in permanent contact with the internal wall of the outer pipe 4. The spring 21 may be placed in the annulus 6 of the rigid pipe 1 in a variety of ways. In one example, it is preferable to mount the spring 21 in the outer pipe 4 by welding at least two of the turns, especially the outermost turns, to the internal wall of the outer pipe

4 and then to slide the latter, with its uniformly distributed springs, over the inner pipe 2 in the usual manner. It would also be possible to insert the springs 21 one after another in prestressed form into the outer pipe so that, on relaxing, each spring 21 comes into contact with the internal wall of the outer pipe 4 and without any possibility of it slipping when the rigid pipe 1 is being wound onto the take-up reel.

It would also be possible for the deformable element to constitute a reinforcement which would be twisted before its insertion into the annular space and which, after insertion, would be capable of resuming its initial state so that the external face comes into permanent contact with the internal wall of the outer pipe, said reinforcement consisting of a helical winding of an interlocked or non-interlocked profiled wire, of the type used to produce a pressure vault, an internal carcass or a hoop.

To keep said reinforcement in place, several means may be envisioned. As previously, it is possible to let the reinforcement relax and come into permanent contact with the internal wall of the outer pipe or to weld one or both end turns of the reinforcement to said internal wall. Another means consists in fastening, at predetermined points on the internal wall, blocks on which at least one of the end turns of the reinforcement will bear.

CLAIMS

1. A device for arresting the propagation of a buckle occurring on an outer pipe of a double-walled rigid tube or pipe (1) of longitudinal axis (AA), said outer pipe being placed around an inner pipe, said outer (4) and inner (2) pipes being separated by an annular space (6), characterized in that the device consists of at least one element having symmetry of revolution and being deformable in a direction transverse to said longitudinal axis, said deformable element (10) being placed in the annular space (6) and having an external face (11) which is in contact with the internal wall (12) of the outer pipe (4), at least at two points, the element (10) being without contact with the inner pipe (2).

2. The device as claimed in claim 1, characterized in that the internal face (13) of the deformable element (10) is at least partially covered with a sheath (15).

3. The device as claimed in claim 1 or 2, characterized in that the profiled wire consists of an interlocked wire.

4. The device as claimed in claim 1 or 2, characterized in that the profiled wire consists of a non-interlocked wire.

5. The device as claimed in one of claims 1 to 4, characterized in that the deformable element (10) consists of a spiraled winding of a profiled wire,

at least one end turn of which is fastened to the internal wall (12) of the outer pipe (4).

6. The device as claimed in claim 2, characterized in that the sheath (15) is a polymeric sheath constituting a thermal barrier.

7. The device as claimed in one of claims 1 to 6, characterized in that the length of the deformable element (10) is between 0.5 and 5 m.

8. The device as claimed in claims 2 to 6, characterized in that an annular gap is left between the sheath (15) and the inner pipe (2), said gap being sufficient to allow said inner pipe (2) to slide in the outer pipe (4).

9. The device as claimed in claim 1, characterized in that the deformable element (10) consists of a radially expandable spring (21) lodged around the inner pipe (2) in the annular space (6), the expansion of the spring causing at least some of the turns to be permanently in contact with the internal wall of the outer pipe.

10. The device as claimed in claim 1, characterized in that the deformable element consists of a reinforcement which is twisted before it is inserted into the annular space and which, after insertion, is capable of recovering its initial state so that the external face comes into permanent contact with the internal wall of the outer pipe.

11. The device as claimed in claim 10, characterized in that it includes bearing blocks which are fastened to the internal wall of the outer pipe at predetermined points and on which at least one end turn of said reinforcement bears.

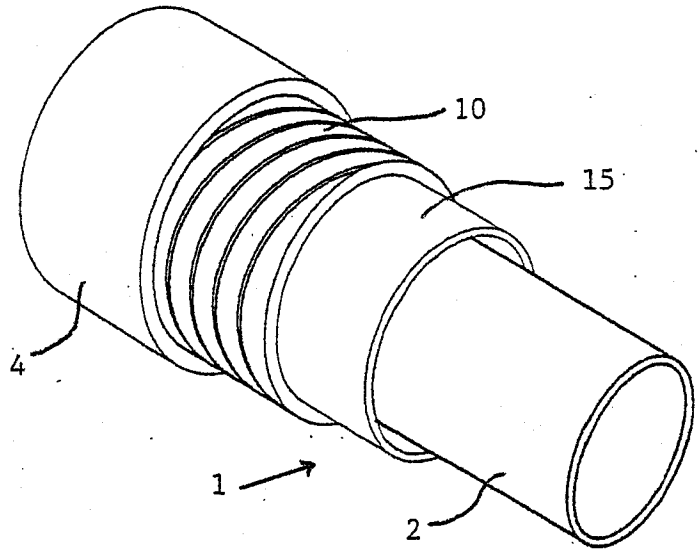


FIG. 1

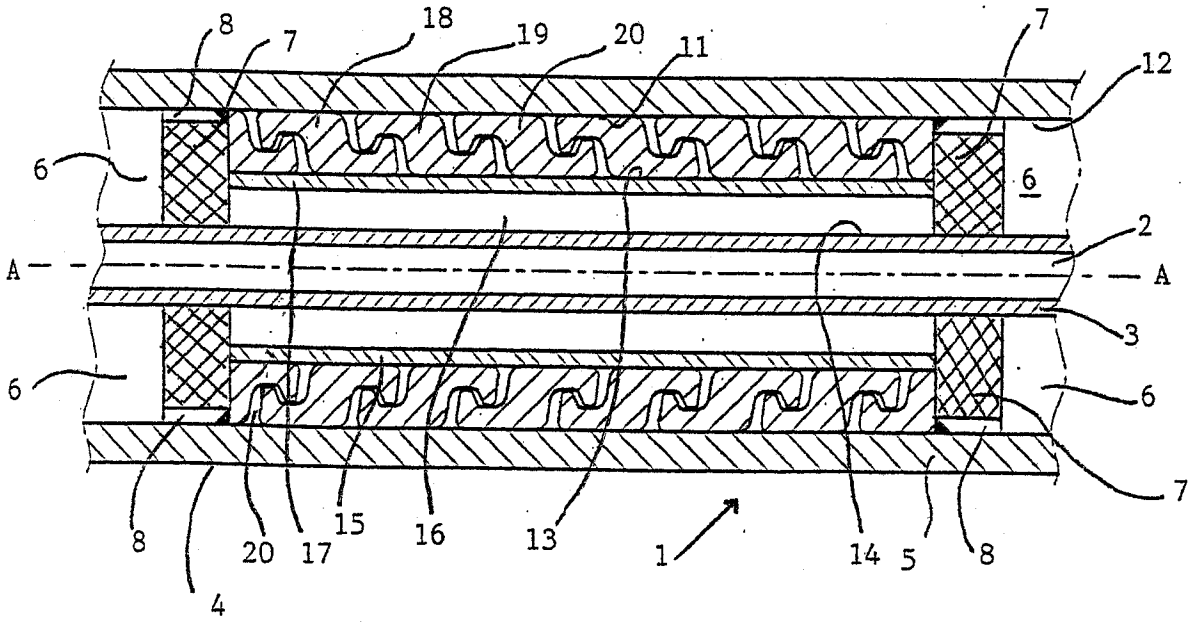


FIG. 2

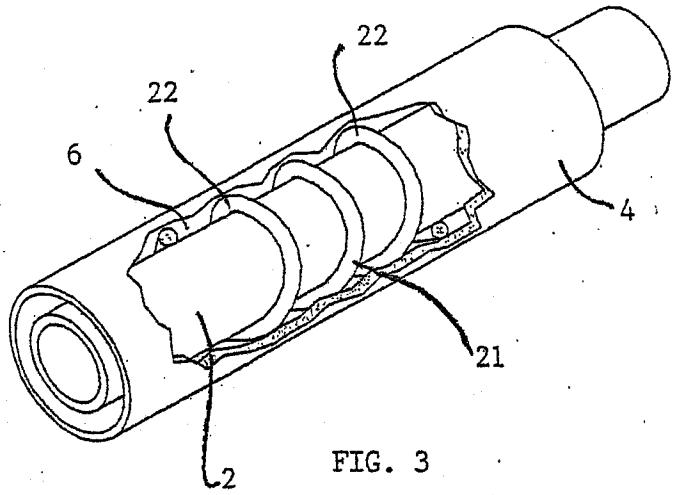


FIG. 3