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The present invention relates to a process for internally lining a conduit by adhesive application with a resin, for example, to the inner wall of the conduit, of an inner sealed lining sleeve, by the action of a pressurized fluid on the inner wall of the sleeve.

Such a process is advantageous from the technical and economical point of view for preventing or repairing damage to the conduit or for obtaining a smooth inner wall and/or a wall resisting different chemical products. The sleeve may be adapted to any configuration of the section of the conduit. Conduits of great length up to 300m and more may be lined in this way. The sections of the conduits may vary from approximately 50cm² to sections of several m². The conduits may be of any kind and of any material and may, for example, be conduits buried in concrete or similar.

15 In the known process, since the material used for the sleeves is not resilient, the dimensions of the sleeve and particularly of its section must be very accurate so as to allow suitable application of the outer wall of the sleeve to the inner wall of the conduit. In known processes, either the outer wall of the sleeve or the inner wall of the conduit is coated with a resin, this resin being polymerized when the sleeve is applied against the conduit. Since the polymerization of a resin generally takes place at an optimum temperature maintained substantially constant for a given length of time, the known processes have not solved the problem of permanently controlling the temperature during the period of application of the sleeve against the conduit. Furthermore, since the sleeve (or conduit) is generally coated in situ, the thickness of the resin is not equal and the adhesive application of the sleeve takes place in an uneven and inaccurate way.

SUMMARY OF THE INVENTION

30 The present invention aims at remedying these drawbacks and creating

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a process for internally lining a conduit, remarkable in that it comprises the following steps:

- (a) cleaning the inner wall of the conduit;
- (b) preparing an inner lining sleeve from a single flexible and fluidtight sheet whose surface intended to be the inner wall is smooth and whose surface intended to be the outer wall is fibrous, with the length of said sheet being substantially equal to the conduit to be lined, with the width of this sheet being equal to or slightly greater than the periphery of the inner section of said conduit and with the section and/or the diameter of the sleeve formed in this latter case having to be able to vary such as to increase when a pressure is applied to the inner wall thereof;
- (c) coating the inner wall of the conduit with a first resin;
- (d) introducing a light, flexible and fluidtight envelope, provided with at least one closable pipe at each of its ends, into the sleeve either before formation of the latter or after formation thereof, so that each of the ends of the envelope extends beyond the corresponding end of the sleeve and with the section of the envelope being such that when it is inflated it may exert a pressure on the sleeve so as to apply it against the conduit;
- (e) coating the outer fibrous wall of the sleeve with a second resin;
- (f) introducing the assembly formed by the resin-coated sleeve and envelope into the conduit whose inner wall is coated with the first resin;
- (g) sliding a cap, formed from a strong flexible material, and comprising a tubular portion and a bottom, over each of the ends of the envelope, with the length of said tubular portion being substantially greater than the outer diameter of the bottom of the cap and with this latter being slightly less than the diameter of the formed sleeve so that, when the envelope is inflated, the tubular portion of said cap is firmly applied against the sleeve, and said cap being maintained in position by the frictional force between the outer wall of said tubular portion

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and the inner wall of the sleeve;

(h) introducing a first pressurized fluid into the envelope through a first pipe disposed at a first end of said envelope, whilst the pipe or pipes disposed at the other end of the envelope is (are) closed, so as to inflate the envelope until the sleeve is firmly applied against the inner wall of the conduit with the first and second resin coatings there between,

(i) deflating the envelope, when the inner lining sleeve has become firmly bonded by the resin coatings to the inner wall of the conduit, and withdrawing the envelope from the sleeve,

Preferably in step (h) the envelope is maintained inflated until complete polymerisation of the resins has taken place.

If desired, a step (j) is carried out between steps (h) and (i) in which a second hot fluid is introduced under pressure into the envelope, before polymerization of the resin(s), through a first or through a second pipe disposed at said first end of said envelope, with the pipe or pipes disposed at said second end of the envelope being maintained sufficiently open to allow the first fluid to escape at least partially, until a sufficiently high temperature is reached in the envelope to cause polymerization of the resin(s) disposed between the outer wall of the sleeve and the inner wall of the conduit, and a step (k) carried out after step (i) in which step (k) water which has accumulated in the envelope during step (j) is removed.

Cleaning of the conduit is effected by projecting under pressure a detergent or grease-remover onto the inner wall followed by rinsing with sprayed water at a temperature in the range of from 60°C to 85°C, at a pressure in the range of from 120 to 140 bar.

According to one characteristic of the invention, the sleeve is formed from said sheet having a width equal to the periphery of the inner section of said conduit by folding thereof along its width over the whole of its length so as to create an edge-to edge joint, with a fixed connection being provided between

the edge: at the joint, such as by welding, adhesion, or application of a butt-strip.

Alternatively the sleeve may be formed from said sheet having a width slightly greater than the periphery of the inner section of the conduit by folding thereof along its width over the whole of its length so as to create a flanged joint, with a fixed connection between the outer wall of the sleeve and the inner wall thereof at the flange being formed by means of a sealing compound which allows the sleeve to increase its section when deformed under the action of the first pressurized fluid on the inner wall of the sleeve until the resin-coated outer wall of the sleeve is firmly applied against the resin coated inner wall of the conduit.

The material of the envelope is flexible and light such, for example, polyethylene, polyvinyl or butyl. The envelope may be inflated without undergoing an elastic deformation. Its section may be at least equal to the inner section of the formed sleeve.

The second fluid preferably is hot sprayed water having a temperature in the range of from 55°C to 85°C.

During polymerization of the resin(s), the temperature in the envelope preferably is maintained at a value in the range of from 20°C to 60°C by appropriate adjustment of the amount and temperature of the hot water injected into the envelope and by controlling the quantity and/or pressure and the temperature of the fluid removed through the pipe disposed at said second end of the envelope.

For a better understanding of the present invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 shows schematically in cross-section an inner lining sleeve for use in the process of the invention during assembly thereof,

Figure 2 shows schematically in cross-section to a larger scale a conduit against the inner wall of which a sleeve is applied according to the invention by means of a sealed and

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flexible envelope subjected to the pressure of at least one fluid, and

Figure 3 shows schematically, in longitudinal section, a conduit against the inner wall of which a sleeve is applied according to the invention by means of a flexible and fluid proof envelope subjected to the pressure of at least one fluid.

In the process of the invention for lining a conduit 1, an inner wall of the conduit is first cleaned, for example mechanically by brushing, scraping, etc. or by chemical means. One efficient cleaning method consists in projecting a detergent or grease-remover, such as diluted soda, over the whole of the inner wall of the conduit. This operation may, for example, be carried out by feeding the diluted soda under pressure from a reservoir into a pipe and projecting it radially for example by means of a propeller device or similar from the inlet point towards the inner wall of conduit 1, the projecting device advancing in the conduit to be lined from one of its ends to the other either by mechanical or manual traction, or else by means of a self-propelled carriage. The same system and possibly the same fluid-projecting apparatus may be used for the rinsing operation which is effected subsequently at a pressure of 120 to 140 bars with sprayed water at a temperature between 65°C and 85°C.

The same system - and possibly the same apparatus - may subsequently be used for projecting a first resin onto the inner wall of conduit 1.

An inner lining sleeve 2 is prepared from a single impervious and flexible sheet, for example made from an appropriate synthetic material, whose surface intended to be the inner wall 2_2 is smooth and whose surface intended to be the outer wall 2_1 is fibrous (Figure 1). The length of this sheet 2 is substantially equal to the length of the conduit 1 to be lined. The width of sheet 2 is slightly greater than the periphery of the inner section of conduit 1. To form the inner lining sleeve 2,

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the sheet is folded, for example as is shown in Figure 1, along its width, over the whole of its length so as to form a flanged joint. For that, the outer wall of one end of the width of the sheet is fixed to the inner wall of the other end of the width of the sheet by means of a sealing compound 3 which may undergo plastic deformation. Thus, during assembly of sleeve 2, compound 3 has the approximate shape of a rectangular-based parallelepiped over the whole length of the joint. When, after sleeve 2 has been introduced into conduit 1, this latter is subjected to an inner pressure p so that its outer wall is applied against the inner wall of conduit 1, the section of sleeve 2 may increase due to the plastic deformation of the sealing compound joint 3. The vertical walls of joint 3 slope so that this latter assumes the shape of a parallelepiped with a substantially rhomboidal base (Figure 2).

It comes within the scope of the invention to form the inner lining sleeve by folding the sheet, along its width, over the whole of its length so as to form an edge-to-edge joint. For that, the width of the sheet is equal to the periphery of the inner section of conduit 1. The fixed connection between the edges is formed, in this case, in any appropriate way, such as by welding, bonding, application of a butt-strip, etc.

With sleeve 2 formed, a light, flexible and fluidtight envelope 4 is introduced into the sleeve.

It is also possible to dispose envelope 4 in the sleeve before formation of this latter by placing said envelope 4 on the smooth face of the opened-out sheet; envelope 4 remains in place during formation of the sleeve which is effected by folding back its edges.

The length of this envelope 4 is greater than that of conduit 1. Furthermore, the ends of envelope 4 extend beyond those of sleeve 2 and conduit 1. Each end of envelope 4 is connected to a pipe 6, 7 (Figure 3). These pipes 6, 7 are fixed by means of joints 13_1 , 13_2 to the front and rear ends of envelope 4. A part of each pipe may penetrate inside the

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envelope. Each pipe is provided with means for connecting to a closure valve 8, 9. A first pipe 6 mounted in a first end of envelope 4 serves for introducing at least one pressurized fluid p, whereas a second pipe 7 mounted in a second end of envelope 4 serves for at least the partial removal of at least one fluid during the operation for applying the sleeve against the conduit. Advantageously, at least said second pipe is provided with means for fitting to a pressure gauge and/or a thermometer. The section of envelope 4 is such that, when it is inflated, sleeve 2 is firmly applied to the inner wall of conduit 1.

10 Then the inner wall of conduit 1 is coated with a first resin by means of a propeller distributing apparatus such as mentioned above. It is furthermore possible to use the same apparatus for cleaning conduit 1 and for applying the resin on the inner wall thereof.

15 The fibrous outer wall 2₁ of sleeve 2 is also coated with a second resin.

The first resin and the second resin are preferably identical or complementary so as to form a single polymerizable layer.

20 The sleeve 2 and envelope 4 assembly is introduced into the conduit so that the ends of envelope 4 extend beyond the ends of conduit 1 and sleeve 2 which are substantially the same length.

At each end of envelope 4, over each of pipes 6, 7 a cap 12₁, 12₂ is slidably fitted and secured. Each of caps 12₁, 12₂ comprises a tubular portion and a bottom. The length of the tubular portion is substantially greater than the diameter of the bottom so that the frictional force between the tubular portion and the inner wall of the sleeve is at least equal to and preferably greater than the total pressure exerted on the bottom of the cap, when envelope 4 is completely inflated. The caps are consequently formed from a strong and flexible material.

It is now possible to fit the valves 8, 9.

30 A first fluid f₁ is introduced under a pressure of 0.2 to 2 bars into

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the envelope 4 through pipe 6. This fluid may be air at a temperature of about 20°C. But any other fluid may be used. During this time, pipe 7 on the outlet side of envelope 4 is closed by valve 9. The procedure for inflating envelope 4 is continued until sleeve 2 is firmly applied against the inner wall of conduit 1 with the layer of resin 5 therebetween.

The application pressure is maintained until polymerization of resin layer 5 is completed.

So as to obtain the optimum polymerization temperature for the resin and so as to maintain this temperature during the period of polymerization, a second hot fluid f2 is injected through pipe 6. Valve 9 is opened sufficiently to allow at least part of the first cold fluid to be removed and to ensure that the sleeve-applying pressure p and the temperature in envelope 4 remain substantially constant during polymerization of resin layer 5, the pressure and the temperature being checked by means of the pressure gauge 10 and thermometer 11 respectively. This second fluid is for example sprayed water which is injected into envelope 4 at an appropriate pressure to ensure rapid diffusion thereof over the whole length of envelope 4 and at a temperature between 55°C and 85°C. The droplets give up at least a part of their heat to the fluid, for example ambient air until the optimum temperature for polymerization of resin 5 has been reached. The procedure for injecting the two fluids is resumed and/or continued so as to maintain in envelope 4 a substantially constant temperature and pressure (for example 20°C to 60°C, and 0.5 to 2 bars) until complete polymerization of the resin. The time required for complete polymerization of the resin depends essentially on its composition and on the temperature in envelope 4.

In the case where an exothermic polymerization resin is used, the heat released may be taken into consideration for adjusting the temperature and the pressure in envelope 4.

The injection of the second fluid may take place through a second

pipe disposed in envelope 4 or through pipe 6.

With the polymerization finished, envelope 4 is deflated and withdrawn from within sleeve 2. This latter is firmly applied against the inner wall of conduit 1. The water contained in envelope 4 is removed; envelope 4 may then be used again.

The process in accordance with the invention, as has been seen, enables an inner lining sleeve 2 to be secured to the inner wall of a conduit 1.

A large number of improvements and modifications may be made without departing from the scope of the invention as defined in the appended claims.

CLAIMS:

1. A process for internally lining a conduit, comprising the following steps:

- (a) cleaning the inner wall of the conduit;
- (b) preparing an inner lining sleeve from a single flexible and fluidtight sheet whose surface intended to be the inner wall is smooth and whose surface intended to be the outer wall is fibrous, with the length of said sheet being substantially equal to the conduit to be lined, with the width of this sheet being equal to or slightly greater than the periphery of the inner section of said conduit and with the section and/or the diameter of the sleeve formed in this latter case having to be able to vary such as to increase when a pressure is applied to the inner wall thereof;
- (c) coating the inner wall of the conduit with a first resin;
- (d) introducing a light, flexible and fluidtight envelope, provided with at least one closable pipe at each of its ends, into the sleeve either before formation of the latter or after formation thereof, so that each of the ends of the envelope extends beyond the corresponding end of the sleeve, and with the section of the envelope being such that when it is inflated it may exert a pressure on the sleeve so as to apply it against the conduit;
- (e) coating the outer fibrous wall of the sleeve with a second resin;
- (f) introducing the whole formed by the resin-coated sleeve and envelope into the conduit whose inner wall is coated with the first resin;
- (g) sliding a cap, formed from a strong and flexible material, and comprising a tubular portion and a bottom, over each of the ends of the envelope, with the length of said tubular portion being substantially greater than the external diameter of the bottom of the cap and with this latter being slightly less than the inner diameter of the formed sleeve so that, when the envelope is inflated, the tubular portion of said cap is

firmly applied against the sleeve, and said cap being held in position by the frictional force between the outer wall of said tubular portion and the inner wall of the sleeve;

(h) introducing a first pressurized fluid into the envelope through a first pipe disposed at a first end of said envelope, whilst the pipe(s) disposed at the other end of the envelope is (are) closed, so as to inflate the envelope until the sleeve is firmly applied against the inner wall of the conduit with the first and second resin coatings therebetween, and

(i) deflating the envelope, when the inner lining sleeve has become firmly bonded by the resin coatings to the inner wall of the conduit, and withdrawing the envelope from the sleeve.

2. A process according to claim 1, wherein in step (h) the envelope is maintained inflated, with the sleeve applied against the conduit inner wall via the resin coatings therebetween, until complete polymerization of the resins has taken place.

3. A process according to claim 1 or claim 2, including carrying out between steps (h) and (i), step (j) in which a second hot fluid is introduced under pressure into the envelope, before polymerization of the resin(s), through a first or through a second pipe disposed at said first end of said envelope, with the pipe or pipes disposed at said second end of the envelope being maintained sufficiently open to allow the first fluid to escape at least partially, until a sufficiently high temperature is reached in the envelope to cause polymerization of the resin(s) disposed between the outer wall of the sleeve and the inner wall of the conduit, and carrying out after step (i), step (k) in which water which has accumulated in the envelope during step (j) is removed.

4. A process according to claim 3, in which step (j) is continued until total polymerization of the resin(s) has taken place.

5. A process according to any one of claims 1 to 4, wherein cleaning of the conduit is effected by projecting under pressure a detergent or grease-remover onto the inner wall followed by rinsing with sprayed water at a temperature in the range of from 65°C to 85°C, at a pressure in the range of from 120 to 140 bars.

6. A process according to any one of claims 1 to 5, wherein

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the sleeve is formed from said sheet having a width equal to the periphery of the inner section of said conduit by folding thereof along its width over the whole of its length so as to create an edge-to-edge joint, with a fixed connection being provided between the edges at the joint.

7. A process according to claim 6, wherein the fixed connection is provided by welding, bonding or application of a butt-strip.

8. A process according to any one of claims 1 to 5, wherein the sleeve is formed from said sheet having a width slightly greater than the periphery of the inner section of the conduit by folding thereof along its width over the whole of its length so as to create a flanged joint, with a fixed connection between the outer wall of the sleeve and the inner wall thereof at the flange being formed by means of a sealing compound which allows the sleeve to increase its section when deformed under the action of the first pressurized fluid on the inner wall of the sleeve until the resin-coated outer wall of the sleeve is firmly applied against the resin coated inner wall of the conduit.

9. A process according to any one of the preceding claims, wherein the material of the envelope is flexible and light, with the envelope being able to be inflated without undergoing an elastic deformation.

10. A process according to claim 9, in which the material used for the envelope is polyethylene, polyvinyl or butyl.

11. A process according to claim 9 wherein the section of the envelope is at least equal to the inner section of the formed sleeve.

12. A process according to any one of the preceding claims, wherein said first resin and said second resin are the same material, or compatible with one another.

13. A process according to claim 12, wherein the polymerization of said resin or resins is exothermic.

14. A process according to any one of claims 1 to 13, wherein said first fluid is air under a pressure in the range of from 0.2 to 2 bars.

15. A process according to claim 3, wherein the second fluid is sprayed hot water at a temperature in the range of from 55°C to 85°C.

16. A process according to claim 3 or claims 14 or 15, when appended to claim 3, wherein the injection into the flexible envelope of said first fluid and of said second fluid is effected through the same pipe disposed at said first end of the envelope.

17. A process according to claim 15, wherein, during polymerization of the resin(s), the temperature in the envelope is maintained at a temperature in the range of from 20°C to 60°C by appropriate adjustment of the quantity and the temperature of the hot water injected into the envelope and by controlling the quantity and/or the pressure and the temperature of the fluid removed through the pipe disposed at said second end of the envelope.

18. A process according to any one of the preceding claims, wherein at least the second end of the envelope is provided with means for measuring the pressure and/or the temperature of the fluid(s) in said envelope.

19. An installation for implementing the process as claimed in claim 1, including;

(i) an inner lining sleeve for a conduit, said sleeve being formed from a single flexible and fluidtight sheet whose surface intended to be the inner wall is smooth and whose outer surface is fibrous, the length of said sheet being substantially equal to the conduit to be lined and the width of this sheet being at least substantially equal to the periphery of the inner section of said conduit; means being provided for allowing the diameter or the section of the formed sleeve to vary such as to increase when a pressure is applied to its inner wall;

(ii) a light, flexible and fluidtight envelope, provided with at least one closable pipe at each of its ends, the section of said envelope when inflated being at least equal to the inner section of the formed sleeve; and

(iii) two caps, made from a strong and flexible material intended to be disposed one on each of the ends of the envelope, each cap having a tubular portion and a bottom, with the length

said tubular portion being substantially greater than the outer diameter of the bottom of the cap, which is itself slightly less than the inner diameter of the formed sleeve.

20. An installation according to claim 19, wherein said sleeve formed from said sheet by folding along its width over the whole of its length so that a flanged joint is created, includes a sealing compound between the outer wall of the sheet and the inner wall thereof at the position of the flange, said sealing compound being deformable when a pressure is applied to the inner wall of the sleeve formed from said sheet.

21. A conduit provided with an inner lining sleeve formed according to the process as claimed in any one of claims 1 to 18.

22. A process for internally lining a conduit, substantially as hereinbefore described with reference to the accompanying drawings.

23. An installation for carrying out the process according to any one of claims 1 to 18 and 22, substantially as hereinbefore described with reference to the accompanying drawings.

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