

PATENT SPECIFICATION

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COMPLETE SPECIFICATION

DRAWINGS ATTACHED

Method and Apparatus for applying Plastic Linings to Pipelines in-situ

We, CEMENT LININGS PTY. LIMITED, a Company registered under the laws of the State of New South Wales, of Monier Square Villawood near Sydney, New South Wales, Commonwealth of Australia, do hereby declare the invention for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

The invention relates to the reconditioning of pipelines, for example, sewer mains, in situ by providing a plastic lining inside the pipes.

Methods of reconditioning such pipes are known using grouting methods for sealing leaks or to protect or restore inner pipe surfaces.

These methods are, however, unsatisfactory under certain conditions, where, for example, soil movement will create new defects or where the internal surface of the pipeline is eroded, or corroded by chemicals, such as hydrogen sulphide gas (H_2S), which would similarly corrode such protective lining or seal. In addition, sealing with conventional methods may in some cases require a prolonged interruption of services, which would make these methods rather unsuitable for the repair of certain pipelines.

The invention overcomes these disadvantages by introducing into the pipeline a tube made from expandable material which may be a natural or synthetic polymer or elastomer, expanding the tube inside the pipeline and bonding the tube to the inner wall by a suitable bonding material, which at the same time seals any cracks or leaks in the pipes.

The term "bonding material" as used in the context of this patent specification, refers to any material introduced between the lining and the inner surface of the pipeline for

the purpose of maintaining a bond between the two.

Thus, if cement mortar or grout is used in conjunction with a lining possessed of undercut ribs, the mortar or grout is a bonding material in the sense that it maintains the lining in the desired fully-inflated position, in intimate contact with the inside surface of the pipeline.

Some of the other materials which may be used as bonding materials are: epoxy resins, polyurethanes, polyesters and the solvent or emulsion based adhesives.

Typical of the epoxy resin class of adhesives found to be effective, is Concrete Industries Adhesive BZ44, which is a two-component solvent-free liquid system, which, after proportionate mixing of the components A & B, polymerises to a strong solid material with good adhesion to both the lining material and the inner surface of the pipe.

The invention is particularly useful for pipelines of a diameter which is too small for the entry of persons.

The invention in one form makes use of the known property of certain plastic materials referred to as "plastic recovery" or "plastic memory". These plastics when heated, deformed and allowed to cool off will retain the deformed shape. However, on heating the deformed shape again it will return, usually without any aid, to the original shape before deformation and if allowed to cool will retain its shape as if it had never been deformed. Therefore, if a tube of say 4" nominal diameter is heated and stretched, its diameter will be reduced as desired to, say, 3 1/4" diameter and if allowed to cool, will retain this "shrunk" or deformed diameter. If this tube is now inserted in a 4" internal diameter pipe and heated again it will expand to its original 4" nominal dia-

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meter with corresponding longitudinal shrinkage and if allowed to cool it will remain in that shape indefinitely. Similarly, if a 3½" diameter tube is inserted in a 4" internal diameter pipe, then heated to a temperature sufficient to soften the tube, inflated to the 4" internal diameter of the pipe and allowed to cool, it will retain its inflated diameter.

- 10 The heating and expansion can be carried out in one operation, for example using steam under pressure, hot water, hot air or other suitable hot fluid.

- The temperature and pressure required will depend on the type of plastic employed, but the type of plastic must be suitable for the medium conveyed by the pipeline. E.g., if the pipeline is to convey industrial effluent at say 80°C., the strength, rigidity and chemical resistance of the tube must be adequate at 80°C. In addition, the pressure employed to expand the tube must not exceed the pressure which can with safety be exerted on the tube and the walls of the pipeline.

- 25 In applying the first mentioned principle to the invention, a tube is extruded by normal manufacturing methods with an external diameter the same or slightly more than the internal diameter of the pipeline to be lined. After extrusion the tube is heated, stretched out to some smaller diameter, allowed to cool in that stretched shape and coiled onto a drum for transport. The outside surface of the extruded tube may have longitudinal ribs for example, with undercut sides, to assist in bonding the tube to the internal walls of the lined pipeline. It is also advantageous to mark the tube prior to stretching in predetermined length so that the length of the tube after recovery can be predetermined from the markings on the tube in the stretched condition.

- 45 In applying the second principle mentioned above, the tube is extruded in the normal manner with an external diameter less than the internal diameter of the pipeline to be lined. The tube can be provided as mentioned above with longitudinal ribs, for example, with undercut sides, to assist in bonding to the internal wall of the pipeline.

- 50 As mentioned above, it is an object of the invention to provide a continuous lining for protecting the inner surfaces of a pipeline from deterioration and at the same time to prevent entry of ground water, or soil or loss of conveyed liquid through defects, and the strength of the lining is intended to be only sufficient to achieve this object and to resist damage during maintenance operations such as cleaning, or to resist external ground-water pressure.

- 60 In most cases the pipeline, while defective, will have sufficient strength to withstand stresses exerted upon it by the weight of soil,

superloads, pressures of conveyed liquid, etc. In some cases, however, additional strength may be required, for instance, when the factor of safety in the strength of the defective pipeline has been greatly reduced due to deterioration, or has not been provided for in the design or when it is desired to increase the strength of the pipeline to provide for anticipated increase of stresses. In some cases it may not be possible to provide a satisfactory bond between the lining and the walls of the pipeline and the lining must be self-supporting. Additional strength, or rigidity can be provided by the use of sufficient thickness of a suitable material, either as a bonding medium or as a filler, between the lining and the walls of the pipeline, or by successive insertion of two or more linings, with a bonding material between them, so as to produce a strong, self-supporting "laminated" cross-section. The filler may be a suitable woven, knitted or felted fabric or other material and may be used by applying bonding material to the filler as well as to the tube or the pipe. The filler fabric may be wrapped or wound, spirally or otherwise around the tube, or fitted over it as a ready made sleeve prior to insertion. The before mentioned steps can also be applied together. As the lining will, in almost all cases, reduce the diameter of the pipeline, the building up of the wall thickness for provision of strength, will depend on how much of the designed diameter can be sacrificed. In most cases, however, appreciable reduction of diameter would be possible, being offset by the greatly improved hydraulic properties of the lined pipe. In the case of defective sewers, reduction in diameter can be afforded, not only because of improved hydraulic properties, but also because provision for the so-called "allowable infiltration" can be much smaller in pipelines reconditioned with a jointless lining.

Two ways of carrying out the invention will be described hereinafter with reference to the accompanying drawings as applied to the lining of sewer pipes.

Figure 1 shows schematically a cross-section of part of a sewer pipeline and the gear required for the first steps in the reconditioning method according to the invention;

Figure 2 shows a further step in the method expanding the tube employed for re-lining the pipe section;

Figure 3 is an enlarged cross-section of the tube end shown in Figure 2;

Figure 4 is a cross-section of a branch pipe showing the method of opening the pipe lining in the main pipe to give access to the branch pipe;

Figure 5 is a cross-section through a pipeline reconditioned according to the invention showing a particular form of tube employed for relining the pipe.



The lining process is carried out in pipe sections between individual manholes and one such section is shown in Figure 1. The pipe section 1 extends between the manholes 2 and 3. After the section 1 has been temporarily isolated from the adjacent sections by means of plugs 4 and 5, the section 1 is cleaned and prepared for reconditioning. A tube 6 of the pre-stretched type referred to above is pulled through the pipe section 1 by means of a rope 7 and winch 8, the tube 6 being taken off a drum 9. In one form of the invention the bonding material is applied to the inner wall of the pipe section 1 by means of one or more delivery hoses 10 which are connected with a pump 11 for the bonding material and are drawn into the pipe section 1 together with the tube 6 by means of the rope 7 and winch 8. A suitable bonding material is then pumped through these hoses 10 by the pump 11 while they are slowly withdrawn from the pipe section 1 so that the bonding material is evenly distributed over the length of the internal pipe surface. Alternatively, the tube 6 or the filler surrounding the tube as mentioned above may be pre-coated with bonding material.

The pulled-through end of the tube 6 is then heated, expanded, slipped over an anchor plug 12 (Figures 2 & 3) and allowed to cool. The plug 12 with the tube 6 slipped over it is then inserted tightly into the end of the pipe section 1 anchoring the end of the tube 6 in position.

In one form of the invention in which a pre-stretched tube of the "recovery" type is used, a ball 13 of diameter slightly smaller than the nominal internal diameter of the tube 6 is inserted in the expanded end of the tube, the plug 12 is fitted and closed off with a screw-on disc 14 having an inlet port 15, and a hose 16 from a steam producing plant 17 is connected with the screw-on disc 14 to communicate with the tube 6. The ball 13 may be perforated to aid internal circulation of heating fluid and facilitate expansion. Hot air, hot water, or other hot medium could be used. The other end of the tube 6 remains coiled on the drum 9 on the ground surface.

Steam or other hot medium is then applied to the inside of the tube 6 under pressure. The pressure forces the ball 13 against the constriction 18 of an unexpanded part of the tube 6, so that hot fluid is retained in a short section between the inlet port 15 and the ball 13. As the tube 6 becomes heated the forces created by the "Plastic Recovery" begin to act, causing the tube 6 to expand to its nominal diameter. The purpose of the ball 13 is to ensure that the heating and expansion is taking place progressively along the pipe. If expansion were to take place along the full length at once,

then when the tube expands to nearly its nominal diameter, friction between the tube wall and the pipe wall could become too great to be overcome by the "plastic recovery" forces.

Another purpose of the ball 13 is to ensure that the bore after lining is true and uniform.

During heating and expansion the ball 13 is gradually pushed through the tube 6 by the pressure of the hot fluid. This pressure also aids "plastic recovery" forces in overcoming any resistances during expansion. The bonding material 19 previously distributed along the inner surface of the pipe section 1 is squeezed around the tube by the expansion process, and bonds the lining to the walls of the pipeline, at the same time filling any defects, such as cracks, leaking joints and pitting created by erosion or corrosion. Any excess material is finally expelled from the end of the pipe section.

As expansion progresses the tube 6 shrinks longitudinally and is fed as required from the drum 9 on the surface.

On completion of a section, or when the ball reaches the far end of the pipeline to be lined, the tube is crimped to prevent further expansion and the pressure inside the tube is maintained until the bonding material sets. Pressure is then released, the far end of the tube cut off and the ball removed. At the other end the steam hose and anchor plug are removed and the lining is completed.

To improve the bond between the tube and the inner wall of the pipe section, the tube can be provided with longitudinal ribs as shown in Figure 5. The ribs 20 of the tube 6 are preferably undercut as shown so that the bonding material 19 gets a firm grip at the tube 6 and at the same time penetrates all cavities and other irregularities of the inner wall of the pipe section 1.

In an alternative form of the invention the ball 13 is heated electrically and drawn or pushed through the pipe section. In this case the end of the tube 6 is not closed by the screw-on disc 14, and the ball 13 is mounted on a string of so-called sewer rods and connected by electric cable with a suitable source of electric power. The ball is then pushed through the tube, progressively heating it so that it expands accordingly to the required diameter. After the whole length of the pipe section has been traversed the ball and the sewer rods are removed. If necessitated by the setting time of the bonding medium both ends of the expanded tube are closed off and air or water is pumped into it, for example, through the port of the screw-on disc which is now screwed on to the anchor plug, and the tube is held in the expanded shape until the bonding medium hardens. Instead of the ball 13 a body of conical shape, having its apex pointing to-





wards the expandable tube can be used to achieve the abovementioned result.

In another form of the invention an expandable tube is used having in its normal state a diameter smaller than the internal diameter of the pipe section. As described before the plug 12 holding the tube 6 is closed off with a screw-on disc 14 having an inlet port 15 as mentioned before, and a hose 16 from a steam producing plant 17 is connected with the screw-on disc 14 to communicate with the tube 6.

Steam is then applied to the inside of the tube 6 under pressure, the tube being closed at the other end. The tube becomes heated until it reaches a temperature at which it will be softened sufficiently to expand to the required diameter, when further expansion will be arrested by the walls of the pipeline. In an alternative form, water under pressure is used as the expanding medium and heat is supplied to the water electrically.

The other extremity of the tube is crimped while heating and expansion is carried out. When the tube is finally expanded to the desired diameter, the pressure is maintained until the bonding material, which had been introduced previously, sets. Pressure is then released, the tube cut off at one end, the anchor plug removed at the other end and the lining is completed.

It must be understood that the method described earlier in which a ball or cone is employed in expanding a pre-stressed tube can also be applied in the case in which a tube is used which in its normal state has a diameter smaller than the internal diameter of the pipe section.

In all forms of the invention described above the type of bonding material is selected according to the degree and type of deterioration of the pipeline and the kind of tube used. Cement mortar, or epoxy resins can be used, particularly where restoration of the original wall thickness is required.

If required, the bonding material can be prepared of such a consistency that it will stick to the external surface of the tube when the latter is immersed therein, lying on the bottom of the pipeline before expansion, and is then spread against the internal wall of the pipeline when the tube is expanded. It is also possible to cover the tube prior to insertion as mentioned above with a bonding material which will soften under heat and become adhesive when the tube is expanded.

In the case of a pipeline containing one or more house service branches as shown schematically in Figure 4, the branch openings 21 of the pipeline 1 will be closed off by the tube 6 on completion of the lining of the main pipe section and will have to be opened up again. This can be done by any mechanical means or in the following manner. Access to the top of the vertical part

of the branch 22 is excavated and, on completion of the lining 6 of the main pipe section 1 an implement 23 incorporating an electrically heated element 24 is lowered down the branch 22 until the element 24 comes in contact with the tube 6. The element 24 is connected to an electrical current generator indicated by cable 25. When the current is switched on the coil is heated, the tube 6 in contact with the element 24 melts and a hole of the internal diameter of the branch 22 is "burned" out.

Should there be an accumulation of water in the branch the plastic lining has first to be pierced by some mechanical means, water drained off and then burning out carried out as described above. During the lining process some of the bonding material may enter the branch and, if allowed to harden, would prevent, or make difficult the process of opening up house service branches by the above method. Depending on the type of bonding material used, the bonding material may be prevented from setting inside the branch by the introduction into the branch of a suitable material which, when mixed with the bonding material, will have the desired effect. For instance, in the case of cement mortar, sugar can be successfully used for this purpose. With other bonding agents the setting in the branch itself could be prolonged long enough so that when the lining is completed the unset bonding agent can be removed.

The invention has been described above in detail by way of examples only and modifications can be made to the method and apparatus without departing from the spirit of the invention.

Although the invention has been described in connection with the lining of pipes, it must be understood that it can be applied in the same manner to tubular holes in rock, heavy soils and the like, which constitute imperfect pipelines and which can be transformed into perfect non-leaking pipelines by the application of a plastic lining.

WHAT WE CLAIM IS:

1. A method for the reconditioning of pipelines in situ in which a tube is inserted into a pipe section of said pipeline, said tube being of expandable material and having an external diameter smaller than the internal diameter of said pipe section, in which a bonding material is introduced into the pipe section and in which heat is applied to said tube and said tube is expanded to a diameter substantially equal to said internal diameter of said pipe section and is firmly held in its expanded condition, whereby said bonding material provides a bond between the tube and the inner wall surface of the pipe section.

2. A method according to Claim 1 in which said tube is made from a material which is deformable under application of

its
wall



wards the expandable tube can be used to achieve the abovementioned result.

In another form of the invention an expandable tube is used having in its normal state a diameter smaller than the internal diameter of the pipe section. As described before the plug 12 holding the tube 6 is closed off with a screw-on disc 14 having an inlet port 15 as mentioned before, and a hose 16 from a steam producing plant 17 is connected with the screw-on disc 14 to communicate with the tube 6.

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1. A method for the reconditioning of pipelines in situ in which a tube is inserted into a pipe section of said pipeline, said tube being of expandable material and having an external diameter smaller than the internal diameter of said pipe section, in which a bonding material is introduced into the pipe section and in which heat is applied to said tube and said tube is expanded to a diameter substantially equal to said internal diameter of said pipe section and is firmly held in its expanded condition, whereby said bonding material provides a bond between the tube and the inner wall surface of the pipe section.

2. A method according to Claim 1 in which said tube is made from a material which is deformable under application of

heat and is maintained in its deformed shape by subsequent cooling.

3. A method according to Claim 2 in which the material of the tube returns under renewed application of heat from its deformed shape to its original shape.

4. A method according to any one of the preceding Claims in which the tube is made of an expandable material selected from the group consisting of natural polymers, synthetic polymers and elastomers.

5. A method according to any one of the preceding claims in which the tube has longitudinal ribs on its outer surface to assist in bonding said tube to said pipe wall.

6. A method according to any of the preceding claims in which the bonding material is applied to the tube prior to its insertion into the pipe section.

7. A method according to any of claims 1-5 in which a filler is placed around the tube prior to its insertion into the pipe section.

8. A method according to Claim 7 in which bonding material is applied to the filler prior to the insertion of the tube into the pipe section.

9. A method according to any one of the preceding Claims in which after insertion of the tube into the pipe section the inserted end of the tube is expanded under heat to receive an anchoring plug with a bore therethrough for anchoring said tube at one end of said pipe section.

10. A method according to Claim 9 in

which a ball is inserted in the expanded tube end prior to insertion of said anchoring plug, said ball having an external diameter slightly smaller than the internal diameter of the pipe section, said ball being heated and being gradually moved through said tube for expanding said tube.

11. A method according to Claim 10 in which the ball is heated electrically and is pushed through the tube by means of interlinking rods.

12. A method according to Claim 9 or 10 in which the bore in the anchoring plug is closed by a screw-on disc having a port therein, and in which a heated fluid is applied under pressure through said port to the interior of said tube.

13. A method according to any one of the preceding Claims applied to a pipe section having branch openings intermediate its ends and including the additional step of removing the part of the tubular lining covering said branch openings.

14. A method according to Claim 13 in which the lining is burnt out of the branch opening by an electrically heated element.

15. A method for the reconditioning of pipelines in situ substantially as described with reference to Figures 1 to 5 of the drawings.

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