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METHOD OF FILLING A CASING

This application claims the benefit of the filing date of Canadian Patent Application No. 2,647,972 filed December 19, 2008 under the title METHOD OF FILLING A CASING.

The content of the above patent application is hereby expressly incorporated by reference into the detailed description hereof.

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The present invention relates to method and apparatus for foam filling a cavity in a joint between insulated pipe lengths.

Such method and apparatus are known, for example, from our U.S. Patent No. 6,355,318 issued March 12, 2002.

Known methods and apparatus of which the applicant is aware employ relatively sturdy heat shrinkable casings for surrounding the foam filling that are designed to withstand the stresses to which the casings are subjected in use, for example the stress that the foam exerts on the casing as it expands to fill the cavity in the course of foam filling the joint.

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The use of heavy weight heat-shrinkable casings may not always be desirable or economically advantageous, however.

One aspect of the invention relates to a method wherein foam filling may be pre-formed before applying a

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casing around the filling. In this aspect, the invention provides a method of foam filling a cavity in a joint between insulated pipe lengths, comprising wrapping around the cavity a mold sheet comprising a fibre reinforced plastic sheet and having opposing ends overlapped to form a cylindrical mold; introducing a curable foam precursor in said cavity; the mold sheet having tensile strength that resists ballooning of the foam filling on expansion thereof from curable foam precursor; applying securing elements on the mold to resist circumferential separating movement of the overlapped ends upon expansion of the filling; allowing said precursor to foam and cure; and removing said securing elements and said mold sheet. The fibre reinforced plastic sheet provides the advantages of offering excellent resistance to ballooning while being of relatively light weight.

A further aspect of the invention relates to providing a casing around the cavity before foam filling. In this aspect the invention provides a method of foam filling a cavity in a joint between insulated pipe lengths, comprising applying a casing around the cavity, wrapping at least one flexible tensile member around the casing; introducing a curable foam precursor in said cavity through an opening in the casing; allowing said precursor to foam and cure; the flexible member having tensile strength that resists ballooning of the casing on expansion of the foam filling from the curable foam precursor; including the step of applying a securing element on the flexible member to resist girthwise extension of the flexible member on

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expansion of the filling; and removing said flexible member and said securing element.

5 The at least one flexible tensile member may comprise two or more strap elements, for example conventional polypropylene or nylon webbing straps woven from, for example, multifilament yarn.

10 In one preferred form, the flexible member is a flexible sheet having opposing ends overlapped.

15 In a further aspect, the invention provides apparatus for foam filling a cavity in a joint between insulated pipe lengths, comprising a fibre reinforced plastic sheet having opposing ends that can be overlapped to form a cylindrical mold wrapped around the cavity, and securing elements that apply on the sheet to resist circumferential separation of the overlapped ends of the sheet on expansion of the filling.

20 The above aspects of the present invention allow a relatively thin walled casing to be employed, if desired, since it need not be capable of withstanding the pressure of the expanding foam, as that function is performed by the sheet or flexible tensile member.

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 The fibre reinforced plastic or other sheet provides a particularly convenient way of providing a stress-resisting mold around the insulated pipeline joint cavity.

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The tensile strength required for the sheet or flexible member to resist ballooning when the foam expands may be readily determined in any given case by simple trial and experiment.

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"Ballooning" refers to expansion of the sheet or of the casing that is visible to the eye.

In preferred forms, the sheet or flexible member has a
10 Young's modulus, as measuring by ASTM D638 (or ASTM D6775-02 in the case of textile webbing) of at least 5-25 GPa, more preferably at least 15 GPa.

The invention will be more fully described, by way of
15 example only with reference to the accompanying drawings, in which:

Figure 1 shows a side view, partly in cross-section
through a joint between insulated pipe lengths, and the
20 cavity therebetween.

Figures 2 to 5 are perspective views and figures 6 to
8 are schematic side views, partially in cross-section,
illustrating steps in forming a foam insulation filling in
25 the cavity, according to one embodiment of the invention.

Figures 9 through 14 are schematic side views,
partially in cross-section, illustrating steps in forming a
foam filling in such cavity according to a second
30 embodiment of the invention.

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Figure 14A is a cross-section taken on the lines A-A in Figure 14, and

Figure 15 is a schematic side view, partially in section illustrating a third embodiment of ballooning resistant structure in accordance with the invention.

Figure 1 shows a cavity 10 between adjacent ends of pipe line lengths 11 and 12 each comprising a pipe 13, insulation material 14 and a cylindrical pipe jacket 16, usually of polymer material.

The ends of the pipes 13 are left bare to allow the ends to be welded together at 17.

In one form of the present invention, a resiliently flexible coil form sheet 18 is employed as shown in Fig. 2.

In the embodiment described below with reference to Figs. 2 to 8, a foam insulation body 30 is formed in contact with an inner surface of the sheet 18, which functions as a mold sheet.

As seen in Fig. 2 in a relaxed condition, the sheet 18 adopts a cylindrical coil condition. In one preferred embodiment of the present method, as seen in Fig. 3, the sheet 18 is partially uncoiled and is lowered over the joint and, as seen in Figs. 3 and 4 is positioned in an encircling position around the joint. The sheet 18 is selected so that its width provides an axial length such

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that its sides overlap the adjacent ends of the pipe jackets 16, as seen in Fig. 6.

In a preferred form, the resilient sheet 18 is
5 selected so that, in the relaxed condition, seen in fig. 2, its diameter is less than that of the jackets 16 while its circumferential length is such that, in the fitted position, shown in Fig. 4, the ends 19 and 21 overlap, with the sheet 18 in a resiliently expanded condition. In this
10 condition, the resilient reaction causes the sheet 18 to grip tightly around the adjacent end portions of the jackets 16 and is retained in position by the resultant frictional forces. As will be appreciated, the frictional gripping greatly facilitates positioning of the sheet 18
15 around the cavity 10 to form a mold.

While other similar resiliently flexible coil form sheet material may be employed, in one preferred form, the resiliently flexible coil form sheet 18 is a fibre
20 reinforced plastic sheet, such as that available from Clock Spring Company, Long Beach, California.

The preferred fibres used to form the composite resilient fibre reinforced plastic sheet 18 have a Young's
25 modulus of at least 50 GPa. Such fibres will include glass, aramid fibre (for example Kevlar (trade-mark) available from Dupont), carbon and steel fibres. The resin employed in making the composite may include epoxy, polyester, polyurethane, phenolics, nylons, and others
30 known to those skilled in the art.

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For example, a glass fibre filled epoxy resin sheet may be employed. Such sheet typically provides a Young's modulus of 10 GPa (as measured by ASTM D638). As a further example, a unidirectional glass fibre filled epoxy resin
5 sheet may be employed. Such sheet provides a Young's modulus of greater than 20 GPa (ASTM D638).

As seen in Figs. 4 and 5, securing elements, in the form of straps 22, are applied on the sheet 18, as seen in
10 Figs. 4 and 5. In this example, the straps 22 are passed around mold sheet 18 and their ends are provided with inter-engaging tensioning elements 23 allowing the straps 22 to be tensioned by adjustment of the tensioning devices 23. Various conventional forms of tensioning devices may
15 be employed. The tension in the straps 22 resists any tendency for circumferential separating movement of the overlapped ends 19 and 21 on expansion of the subsequently introduced foam filling.

20 Sheet 18 is provided with fill and vent openings 26 and 27. Employing a foam filling procedure that in itself is conventional, as seen in Fig. 6, a liquid precursor 29 of a foamable curable resin composition is introduced through the fill opening 26. A funnel 28 may be inserted
25 through the opening 26 to assist positioning of the precursor 29 within the cavity 10. The liquid precursor 29 may be, for example, be a two-part urethane foam composition that is mixed shortly before introducing it through the opening 26. The liquid precursor 29 expands
30 within the cavity, and cures to form a rigid foam filling 30. Once the composition is fully foamed and cured, the

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straps 22 are removed and the sheet 18 is stripped away, exposing the foamed and cured filling 30 in the form of an annular body of diameter substantially similar or equal to the diameter of the pipe casings 16.

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Desirably, the inside of the mold sheet 18 is coated with a release agent to make the sheet 18 readily cleanly strippable from the foam filling 30. This coating may be provided by, for example, a silicone release coating spray
10 or a brushed on coating of carnauba wax composition. Alternatively, the sheet 18 may be lined with a release liner sheet, for example wax paper or a polyolefin, for example, a polyethylene film coated with silicone.

15 A rubber gasket tape may be applied circumferentially over the pipe jackets 16 adjacent to the cavity and under the mold sheet 18 to prevent foam leakage from the cavity during expansion.

20 In the preferred form, the foam filling 30 is sealed in water tight fashion by applying tapes of a adhesive sealant 34 around the ends of the pipe jackets 16, and applying a heat shrinkable polymeric casing 36 over the sealant tapes 32 and 34, as seen in Fig. 8 and applying
25 heat, at least to the end portions of the casing 36 overlying the sealant tapes 32 and 34, to heat shrink the casing 36 in tight sealing engagement with the adhesive sealant tapes 32 and 34 and with the adjacent portions of the pipe jackets 16. In some instances the entire casing
30 36 may be heat shrunk over the joint.

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A second preferred embodiment is described below with reference to Figs. 9 through 14A.

Elements similar to those employed in the procedure
5 described above with reference to Figs. 1 to 8 are identified by the same reference numerals for the sake of convenience of description.

However, in this example, the adhesive sealant tapes
10 32 and 34 and heat shrinkable casing 36 are applied before applying the mold sheet 18, and the foam insulation body 30 is formed in contact with an inner surface of the casing 36. Further, the sheet 18 in this example functions as a flexible tensile member that resists ballooning of the
15 casing 36 on expansion of the foam precursor 29.

To prevent a tendency for the casing 36 to shrink down into the cavity 10, heat shielding bands 38, for example high temperature resistant heat insulating bands, such as
20 glass fibre fabric bands, are applied around the casing 36 axially inwardly adjacent the ends of the pipe jacket 16. The ends of the casing 36 are then shrunk down into tight sealing engagement with the sealant tapes 32, 34 and with the ends of the jackets 16, as seen in Fig. 11, for example
25 by applying a gas torch 35 on the ends of the casing 36.

Before or after shrinking, fill and vent openings 41 and 42 are formed through the wall of the casing 36, for example by drilling through the wall. These openings 41
30 and 42 positioned in registry with the fill and vent

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openings 26 and 27, respectively, in the subsequently applied sheet 18.

The procedure then generally follows that described
5 above with reference to figs. 2 to 6, except the sheet 18 is applied on an exterior side of the casing 36.

If desired, once a sufficient quantity of the foam precursor 29 has been introduced through the fill hole 41,
10 a temporary foaming plug 43 is inserted as a stopper within the opening 41, to encourage the foam to fill the cavity 10 within the casing 36 without excessive leakage of foam through the fill opening 41.

Once the foam has fully formed, and has filled the
15 cavity 10 within the casing 36 and has cured, the straps 22 and sheet 18 are removed. The temporary foaming plug 43 is removed, and polymeric filler plugs 44 and 46 are inserted within the fill and vent openings 41 and 42, respectively, and welded in place in order to seal the casing 36 in water
20 tight fashion.

In one preferred form, in order to facilitate welding of the plugs 44 and 46 to a crosslinked casing 36, the casing 36 may be formed with its wall having outer and
25 inner layers 36a and 36b, the inner layer 36b being uncrosslinked or crosslinked to a lesser degree of crosslinking than the outer layer 36a, which may be crosslinked to a substantially greater degree, so that the polymeric plugs 44 and 46a will weld readily to the
30 portions 36b bordering the holes 41 and 42 formed through

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the casing 36. This two layer structure for the wall of the casing 36 may be provided by laminating sheets of the materials 36a and 36b together to form a composite sheet, and forming a tubular sleeve from the composite sheet in
5 conventional fashion.

In the examples described above, the casing 36 may have a wall thickness which is constant across the width of the sleeve. If desired, however, a casing which has its
10 middle portion of greater wall thickness than its end portions, such as described in our above-mentioned U.S. patent 6,355,318 may be employed. The disclosures of U.S. Patent 6,355,318 are hereby incorporated by reference. The greater wall thickness of the middle portion reduces any
15 tendency for the casing to shrink into the cavity 10 in the course of heating the end portions of the casing as described above with reference to Figure 11. This eliminates the need for the use of heat shielding bands 38 to prevent shrinking of the casing into the cavity 10.

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As noted above, the sheet 18 in the above-described procedures allows a relatively thin-walled casing 36 to be employed, if desired, since the casing need not be in itself capable of withstanding the pressure of the
25 expanding foam during the course of forming and curing the film within the cavity 10. This function of withstanding the pressure of the foam is performed by the sheet 18.

For example, with known procedures before the present
30 invention, in the case of a large diameter insulated pipeline joint, having a jacket 16 of external diameter

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1000 mm, it was necessary to use a casing, similar to casing 36 shown in Fig. 10, of wall thickness greater than about 12 mm to avoid ballooning. In the same circumstances, using the procedure of one aspect of the invention as described above with reference to Figs. 9 to 14a, a casing 36 with wall thickness of 6 mm was employed on the 1000 mm joint. An anti-ballooning sheet 18 comprising glass fibre reinforced epoxy resin was employed. The foam filling 30 comprised polyurethane foam formed from a two-part urethane foam composition mixed together to provide the liquid precursor 29. After the precursor 29 had fully foamed and set, it was found the circumference of the casing had expanded less than 2%, with no visually perceptible ballooning.

While fibre reinforced plastic sheet materials have been described above as examples of one form of sheet material 18 providing sufficient tensile strength to withstand the foam pressure and avoid any tendency for ballooning, other materials that perform this function may, of course, be employed. For example, the mold sheet may be a metal sheet. For example, an aluminum sheet, typically having a Young's modulus of 69 GPa, may be employed. A further example of material as equally effectively as the above-described fiber reinforced plastic sheet or metal sheet comprises flexible fabric sheets, for example, flexible fabric sheets formed of high tensile fibres such as para-aramid (trade-mark KEVLAR) or high tensile glass fibres.

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Such metal sheets and fabric sheets are employed in the same manner as the mold sheets 18, as described above with reference to Figs. 1 to 14, except in the case in which the sheets are not in the form of a resilient coil, 5 the sheets need to be supported once wrapped around the cavity 10, until secured in place by the straps 22.

Instead of applying an anti-ballooning sheet 18 around the casing 36, as described above with reference to Figs. 9 10 to 14a, in a further embodiment as illustrated for example in Fig. 15, flexible tensile members in the form of strap elements 51 are applied around the casing. The procedure is otherwise similar to that described above with reference to Figs. 9 to 14a. The strap elements 51 are tensioned 15 using conventional strap tensioning devices so that they engage snugly around the casing 36 before the foam filling precursor 29 is introduced.

The strap elements 51 may be, for example, conventional polypropylene or nylon webbing straps woven 20 from, for example, multifilament yarn.

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CLAIMS:

1. Method of foam filling a cavity in a joint between insulated pipe lengths, comprising wrapping around the
5 cavity a mold sheet comprising a fibre reinforced plastic sheet and having opposing ends overlapped to form a cylindrical mold; introducing a curable foam precursor in said cavity; the mold sheet having tensile strength that resists ballooning of the foam filling on expansion thereof
10 from curable foam precursor; applying securing elements on the mold to resist circumferential separating movement of the overlapped ends upon expansion of the filling; allowing said precursor to foam and cure; and removing said securing elements and said mold sheet.
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2. Method according to claim 1 wherein said foam forms in contact with an inner surface of the mold sheet.
3. Method according to claim 1 or 2 including applying a
20 casing around the cured foam after removal of the mold sheet.
4. Method according to claim 3 wherein said casing is at least partially heat shrinkable and including shrinking at
25 least portions of said casing into tight contact with the insulated pipe lengths adjacent the joint.
5. Method of foam filling a cavity in a joint between insulated pipe lengths, comprising applying a casing around
30 the cavity, wrapping at least one flexible tensile member around the casing; introducing a curable foam precursor in

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said cavity through an opening in the casing; allowing said precursor to foam and cure; the flexible member having tensile strength that resists ballooning of the casing on expansion of the foam filling from the curable foam precursor; including the step of applying a securing element on the flexible member to resist girthwise extension of the flexible member on expansion of the filling; and removing said flexible member and said securing element.

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6. Method according to claim 5 wherein said casing is at least partially heat shrinkable and including shrinking at least portions of said casing into tight contact with the insulated pipe lengths adjacent the joint.

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7. Method according to claim 5 or 6 wherein said at least one flexible member comprises at least two strap elements.

8. Method according to claim 5 or 6 wherein said at least one flexible member is a flexible sheet having opposing ends overlapped.

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9. Method according to claim 8 wherein said flexible sheet is a fibre reinforced plastic sheet comprising a resiliently flexible coil.

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10. Method according to claim 8 wherein said flexible sheet is a metal sheet.

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11. Method according to claim 8 wherein said flexible sheet is a flexible fabric sheet comprising high tensile fibres.

12. Method according to claim 11 wherein said fibres are
5 para-aramid or glass fibres.

13. Method according to any one of claims 3 to 12 wherein the casing comprises an inner layer and an outerlayer and the inner layer is uncrosslinked or is crosslinked to a
10 lesser degree than the outer layer.

14. Apparatus for foam filling a cavity in a joint between insulated pipe lengths, comprising a fibre reinforced plastic sheet having opposing ends that can be overlapped
15 to form a cylindrical mold wrapped around the cavity, and securing elements that apply on the sheet to resist circumferential separation of the overlapped ends of the sheet on expansion of the filling.

20 15. Apparatus according to claim 14 wherein said sheet has an opening in it through which a liquid precursor of a foam can be introduced.