

FUSION PROCESS FOR CONDUIT

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates generally to systems for fusing or joining conduit or piping sections, such as polyvinyl chloride piping and, in particular, to a fusion process for effectively and permanently joining a first conduit portion to a second conduit portion.

Description of Related Art

[0002] Conduit systems are used in many applications throughout the world in order to transfer or convey material, such as water and other fluids, from location to location for distribution throughout the system. For example, extensive conduit systems are used to distribute water to both residences and businesses for use and further processes. Typically, such conduit or piping systems are located underground, as aboveground piping would be both unsightly and intrusive.

[0003] In general, water conduit systems transport material through piping manufactured from various materials, e.g., cast iron, ductile iron, reinforced concrete, cement-asbestos, etc. The pipes are buried underground, with the branches extending in various directions in order to reach the end user. Normally, after many years of use, or for some other reason, the in-ground piping fails and begins to leak, thereby reducing line pressure and unnecessarily allowing water to leak into the area surrounding the piping. Such leaks not only affect the system, but also increase the processing costs of the supplier, which, in turn, increases the end user costs. Therefore, these leaks must be quickly repaired and preventative measures taken to ensure that further leakage is prevented.

[0004] Due to the underground position of the conduit system, repairing a leaking pipe is particularly labor intensive and time consuming. Trenches must be dug along the pipeline to locate the leak and effectively repair it prior to putting the pipe back in service. Various lining systems have been developed according to the prior art in an attempt to seal a leaking pipe or a pipe that has fallen into disrepair, whether to repair a present crack or to preventatively ensure against future cracks or breaks. In addition, a method whereby a much smaller diameter pipe within the larger diameter cracked or broken pipe has been used. However, this merely replaces the problem of a cracked outer pipe with a cracked or otherwise leaking inner pipe. Still further, using such a pipe-in-pipe system drastically

reduces the flow through the conduit system and evidences unwanted and varying pressure parameters.

[0005] To that end, a pipe liner and method of installation have been developed, as disclosed in U.S. Patent No. 5,794,662 to St. Onge et al., specifically directed to pressurized pipeline applications. The St. Onge patent is directed to a method of relining sewer lines, water lines or gas lines, and uses a segmented liner of reduced size relative to the pipe being relined. However, as opposed to merely leaving the small diameter liner conduit within the large diameter outer conduit, the method of the St. Onge patent uses heat and/or pressure to mold the reduced size pipe to the shape of the pipe being relined. In particular, the inner or liner conduit is a thermoplastic pipe, typically a polyvinyl chloride (PVC) pipe that, when exposed to heat or pressure, expands and molds against the inside of an existing conduit to effect the relining of it. This process allows for both the lining of the entire length of pipe or only a portion of it that is damaged, which is typically referred to as "spot repair."

[0006] According to the St. Onge patent, once the length of the liner conduit is inserted into the existing or host conduit, the liner conduit is plugged at either end and exposed to steam under pressure to heat the liner conduit along its length and apply pressure, which urges it to expand and contact the interior walls of the surrounding host conduit. Once the liner conduit has fully expanded to conform to the interior surface of the existing conduit, it is cooled and the plugs are removed. The resulting expanded liner conduit conforms to the walls of the host conduit, thereby preventing any further leakage. Also, the method of the St. Onge patent requires only trenches to be dug at either end of the section to be repaired.

[0007] While the St. Onge patent represents an advance in the art of relining or repairing underground conduit systems, there is room in the art for additional improvements and advancements. Specifically, in order to transport and insert the liner conduit within the host conduit, the liner conduit must be manufactured in sections or portions, which are typically much shorter in length than the final and intended liner conduit length. Therefore, portions of the liner conduit must be connected onsite as the liner conduit is fed into the host conduit. In addition, there is a need for the ability to connect multiple lengths of the liner conduit via a joint having the strength of the original conduit and which does not increase the diameter of the joint area beyond the original conduit diameter. The use of multiple and connectable conduit pieces is useful in many different applications beyond the above-discussed expansion application. For example, the use of multiple and fused conduits is particularly useful in the case of sliplining, wherein a slightly smaller diameter fused conduit is inserted into a larger pipe that is in need of rehabilitation, but that does not require a full capacity for flow. In this

case, the conduit is pulled in and left in place, but is not expanded. In most cases, the space between the conduit and the host pipe is filled with a low-strength grout to hold the new line in position. However, the sliplining process may require the use of lines that could accommodate a larger diameter coupling or mechanical joint.

[0008] Fused conduit is also required in various other applications, such as in a rehabilitation application, wherein the fused joint is used in connection with a horizontal directional drilling process. This method drills a pilot hole in the ground and can be steered in a precise manner to control elevation and alignment. After the pilot hole is complete, the drill hole is reamed to a larger diameter and filled with drill mud to hold the larger hole open. The drill casing is then pulled through the drill mud resulting in a conduit in place. However, this process requires a larger drill to accommodate the mechanical couplings and joints manufactured from PE or HDPE.

[0009] Further, fused conduit is useful in a pipe bursting application. Pipe bursting uses a large hydraulic or pneumatic cutter head to break apart old pipe and force the pieces into the surrounding soil. This allows a new pipe of equal or larger diameter in the existing line to be pulled in. This process is used where the new line capacity must be substantially increased. Also, of course, fused pipe is equally useful in a direct-bury application.

[0010] Fusion processes for pipe or conduit have been developed that utilize mechanical joints, embedded wires at or near the fusion joint or resistive heating elements for joining conduit sections together. For example, see U.S. Patent Nos.: 6,398,264 to Bryant, III; 6,394,502 to Andersson; 6,156,144 to Lueghamer; 5,921,587 to Lueghamer; 4,684,789 to Eggleston; and 4,642,155 to Ramsey. Polyethylene pipe (PE or HDPE) has been routinely fused for many years. For example, see U.S. Patent Nos: 3,002,871 to Tramm et al.; 4,987,018 to Dickinson et al.; 4,963,421 to Dickinson et al.; and 4,780,163 to Haneline, Jr. et al. and U.S. Patent Publication No. 2003/0080552 to Genoni. Accordingly, preexisting fusion equipment is available. However, this equipment must be modified in its use and operating parameters for fusion of polyvinyl chloride-based conduit. Unlike polyethylene pipe, which is generally joined by heat fusion techniques, PVC pipe has normally been limited to applications that can be serviced by bell-and-spigot joints. This limitation has restricted the use of PVC pipe in sliplining rehabilitation applications. Therefore, there is a need in the art to provide an essentially single piece of PVC liner conduit starting stock with no mechanical joints, which does not increase the diameter of the starting stock as a mechanical coupling would. Such a coupling or fused joint must have similar strength characteristics as the original conduit and preclude infiltration in joints, by eliminating such

mechanical joints. In addition, it may be preferable to provide a coupling that is capable of withstanding a subsequent expansion process for eventual use in a pressurized conduit system.

SUMMARY OF THE INVENTION

[0011] It is, therefore, an object of the present invention to provide a fusion process for PVC conduit that overcomes the deficiencies of the prior art. It is another object of the present invention to provide a fusion process for PVC conduit that allows for the onsite connection of multiple lengths of PVC conduit. It is a still further object of the present invention to provide a fusion process for PVC conduit that results in a joint that equals the strength of the original conduit and does not increase the diameter of the joint area beyond the original conduit diameter. It is a further object of the present invention to provide a fusion process for PVC conduit that provides a single piece of starting stock with no mechanical joints, which precludes infiltration through these joints. It is yet another object of the present invention to provide a fusion process for PVC conduit that produces a joint that is capable of subsequent expansion and use in pressurized conduit system. It is another object of the present invention to provide a fusion process for PVC that produces a joint that is consistent and has high strength characteristics. It is a further object of the present invention to provide a fusion process and apparatus that can be effectively used in connection with fused pipes and joints in sliplining applications, horizontal directional drilling applications, pipe bursting applications and direct-bury applications.

[0012] The present invention is directed to a fusion process for conduit. The fusion process includes an apparatus and a method of fusing a first conduit portion to a second conduit portion. The method includes the steps of: (a) removably positioning a first terminal edge of a first conduit portion in an opposing relationship with a first terminal edge of a second conduit portion; (b) facing the first terminal edge of the first conduit portion and the first terminal edge of the second conduit portion; (c) aligning the first terminal edge of the first conduit portion with the first terminal edge of the second conduit portion; (d) melting at least a portion of the first terminal edge of the first conduit portion and the first terminal edge of the second conduit portion; (e) engaging the melted terminal edge of the first conduit portion with the melted terminal edge of the second conduit portion; and (f) maintaining pressure between the engaged terminal edge of the first conduit portion and the terminal edge of the second conduit portion, thereby creating a fused joint area. This method is employed where one or both of the first conduit portion and the second conduit portion are manufactured from a polyvinyl chloride (PVC) material. The present invention also discloses

the novel operating parameters of a fusion apparatus for use in connecting a first conduit portion to a second conduit portion.

[0013] The present invention is also directed to a fusion apparatus for fusing a first conduit portion to a second conduit portion. The apparatus includes a first clamping mechanism for engaging and positioning the first conduit portion and a second clamping mechanism for engaging and positioning the second conduit portion. A drive mechanism is in operable communication with one or both of the first and second clamping mechanisms for driving them in a longitudinal direction. A facing mechanism is positionable between a terminal edge of the first conduit portion and a terminal edge of the second conduit portion. The facing mechanism "faces" or shaves these terminal edges. A heater mechanism heats and melts one or both of the terminal edges of the conduit portions. One or both of the conduit portions are manufactured from a polyvinyl chloride (PVC) material.

[0014] The present invention, both as to its construction and its method of operation, together with the additional objects and advantages thereof, will best be understood from the following description of exemplary embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Fig. 1 is a schematic view of a method for a fusion process for conduit according to the present invention;

[0016] Fig. 2 is a schematic view of an apparatus and system for a fusion process for conduit according to the present invention;

[0017] Fig. 3 is a side sectional view of a fused joint area resulting from the fusion process for conduit according to Fig. 1; and

[0018] Figs. 4-9 are charts setting forth optimal operating parameters at an interfacial pressure of about 140 psi for the fusion process for PVC conduit according to Fig. 1, with specific quantities representing nominal pipe diameter, outside pipe diameter, inside pipe diameter, surface area, gauge pressure and/or dimension ratio.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] For purposes of the description hereinafter, the terms "upper", "lower", "right", "left", "vertical", "horizontal", "top", "bottom", "lateral", "longitudinal" and derivatives thereof shall relate to the invention as it is oriented in the drawing figures. However, it is to be understood that the invention may assume various alternative variations and step sequences, except where expressly specified to the contrary. It is also to be understood that the specific devices and processes illustrated in the attached drawings, and described in the

following specification, are simply exemplary embodiments of the invention. Hence, specific dimensions and other physical characteristics related to the embodiments disclosed herein are not to be considered as limiting.

[0020] Various numerical ranges are disclosed in this patent application. Because these ranges are continuous, they include every value between the minimum and maximum values. Unless expressly indicated otherwise, the various numerical ranges specified in this application are approximations.

[0021] The present invention is directed to a fusion process for conduit, preferably a polyvinyl chloride (PVC) conduit, including a method for fusing a first conduit portion 10 to a second conduit portion 12, as illustrated in schematic form in Fig. 1, and a fusion apparatus 14 for employing this method. In a preferred embodiment, the method and fusion apparatus 14 may be used in connection with a conduit expansion process and system, whereby a liner conduit 16, which is formed from multiple conduit portions, e.g., the first conduit portion 10 and the second conduit portion 12, is positioned within a host conduit for later expansion. However, the method and fusion apparatus 14 may be used in any application that requires successive fusion of conduit portions. As set forth above, the liner conduit 16 is manufactured from a thermoplastic material, such as PVC. However, it is envisioned that any material having the appropriate expansion characteristics can be used and connected according to the method of the present invention. The fusion process for PVC conduit will work effectively with other similar expandable polymeric-based materials and thermoplastics.

[0022] ASTM standards for PVC pipe are available for ranges of additives to PVC resin that have various properties within the allowable bands of additives. However, not all the possible combinations of additives will work in the conduit expansion process. That is to say that not all PVC water pipe will fuse to the strength of the pipe material of the liner conduit and not all PVC pipe will expand to the size of the pipe material of the liner conduit.

[0023] Since the conduit expansion process occurs at remote locations, the liner conduit 16 must be transported in sections for later installation. Therefore, while the present invention specifically discusses the connection and fusion of the first conduit portion 10 to the second conduit portion 12, the method and fusion apparatus 14 are equally useful in connecting any number and length of liner conduit 16 portions. Therefore, in a further preferred and non-limiting embodiment, the fusion apparatus 14 is mobile and can be used onsite to employ the presently invented method.

[0024] In particular, the present method includes the steps of: removably positioning a terminal edge 18 of the first conduit portion 10 in an opposing relationship with a terminal

edge 20 of the second conduit portion 12 (step 100); facing the terminal edge 18 of the first conduit portion 10 and the terminal edge 20 of the second conduit portion 12 (step 120); aligning the terminal edge 18 of the first conduit portion 10 with the terminal edge 20 of the second conduit portion 12 (step 130); melting at least a portion of the terminal edge 18 of the first conduit portion 10 and the terminal edge 20 of the second conduit portion 12 (step 140); engaging the melted terminal edge 18 of the first conduit portion 10 with the melted terminal edge 20 of the second conduit portion 12 (step 150); and maintaining pressure between the engaged terminal edge 18 of the first conduit portion 10 and the terminal edge 20 of the second conduit portion 12, thereby creating a fused joint area 22 (step 160). In a preferred and non-limiting embodiment, the method further includes the step of removing at least a portion of the resultant external bead 24 extending around the fused joint area 22 (step 170). This method is performed by the fusion apparatus 14, which is described in detail hereinafter.

[0025] Regarding step 100, the terminal edge 18 of the first conduit portion 10 is clamped or held in place and positioned by a first clamping mechanism 26, while the second conduit portion 12 is clamped and positioned by a second clamping mechanism 28. The first clamping mechanism 26 and the second clamping mechanism 28 are part of the fusion apparatus 14 and allow for the removable positioning of the first conduit portion 10 and the second conduit portion 12. Further, both the first clamping mechanism 26 and the second clamping mechanism 28 are capable of being driven in a longitudinal direction, designated as arrows A in Fig. 2. Therefore, a drive mechanism 30 is in operable communication with the first clamping mechanism 26 and/or second clamping mechanism 28 for providing the necessary driving force to move the first clamping mechanism 26 and/or the second clamping mechanism 28 into or out of an engaging position.

[0026] The terminal edge 18 of the first conduit portion 10 and the terminal edge 20 of the second conduit portion 12 must be faced in order to establish a clean and parallel mating surface. This facing is completed by a facing mechanism 32, which is positionable between the terminal edge 18 of the first conduit portion 10 and the terminal edge 20 of the second conduit portion 12. For example, the facing mechanism 32 may be laterally movable into and out of position between the terminal edges (18, 20), as designated by arrows B in Fig. 2. The facing mechanism 32 continues to grind or face the terminal edges (18, 20) until a minimal distance exists between the first clamping mechanism 26 and the second clamping mechanism 28. In a preferred and non-limiting embodiment, the facing mechanism 32 includes one or more blade portions 33. These blade portions 33 perform the actual cutting or facing operation with respect to the terminal edges (18, 20) of the conduit portions (10,

12). In a further embodiment, the blade portions 33 are carbide-tipped blades, which allows for better consistency and a cleaner facing process. Further, these carbide-tipped blades allow for more frequent usage of the blade portions 33 without wearing the cutting edge of the blade portions 33. Of course, the use of other strengthened blade tips, coatings, structures and materials is also envisioned.

[0027] It should be noted that both the first clamping mechanism 26 and the second clamping mechanism 28 need not be movable, only one of which is required to be movable to allow the first conduit portion 10 and the second conduit portion 12 to be engaged. In operation, one or both of the first clamping mechanism 26 and the second clamping mechanism 28 are moved, such that the facing mechanism 32 is locked firmly and squarely between the first clamping mechanism 26 and the second clamping mechanism 28. This operation provides for a substantially square face, perpendicular to the first conduit portion 10 and second conduit portion 12 centerline and with no detectable gap. Further, the facing mechanism 32 may include blades with various angular orientations. This will provide a smoother face on the conduit portions (10, 12).

[0028] Next, the first conduit portion 10 and second conduit portion 12 profiles must be rounded and aligned with each other in order to minimize any mismatch of the conduit walls. This may be accomplished by adjusting the first clamping mechanism 26 and/or the second clamping mechanism 28 until the outside diameter of the first conduit portion 10 matches the outside diameter of the second conduit portion 12. It is desirable that the first clamping mechanism 26 and the second clamping mechanism 28 not be loosened, which would result in either the first conduit portion 10 and/or the second conduit portion 12 slipping during the fusion process. The minimal distance requirement between the first clamping mechanism 26 and the second clamping mechanism 28 allows the first conduit portion 10 and/or the second conduit portion 12 to be rounded as close as possible to the intended joint area. The closer to the joint area that the conduit portions (10, 12) can be clamped, the better control the operator has in properly aligning the conduit portions (10, 12).

[0029] Next, the terminal edge 18 of the first conduit portion 10 and the terminal edge 20 of the second conduit portion 12 are heated or melted to the required temperature, interface pressure and time duration. In doing so, the heat will penetrate into the first conduit portion 10 and second conduit portion 12 and a molten "bead" of material will form at the terminal edges (18, 20). This heating process is effected by a heater mechanism 34, which heats and melts both terminal edges (18, 20) simultaneously. This simultaneous heating can be accomplished by the use of a first heating plate 36 and a second heating plate 38, a single

dual-faced heating plate or other means of simultaneous heating of both terminal edges (18, 20). As with the facing mechanism, the heater mechanism 34 should be capable of moving into position between the terminal edges (18, 20), until such time as the heating process is complete, at which point the heater mechanism 34 should be removed. Therefore, the heater mechanism 34 should also be movable, such as laterally movable between the terminal edges (18, 20), as designated by arrows C in Fig. 2. In a further preferred and non-limiting embodiment, the heater mechanism 34 provides for zone heating with respect to the surface of the heater mechanism 34, the first heating plate 36 and/or the second heating plate 38. Accordingly, various portions of the heating surface, for example, the upper and the lower surface, may have different temperatures. This, in turn, allows for a more uniform melting of the terminal edges (18, 20), due to the natural physics of the heating process, wherein heat rises and provides a differential heating interface across the terminal edges (18, 20). Therefore, the zone heating would provide for a uniform profile across the terminal edges (18, 20). It is also envisioned that the heater mechanism includes multiple zones that are controlled or controllable by a control mechanism 40. This control mechanism 40 would provide for the individual control of each zone to maximize the efficiency and accuracy of the heater mechanism 34, with a resultant more uniform profile across the terminal edges (18, 20). The speed of removal of the heater mechanism 34 after the heating process, together with the speed of clamping the terminal edges (18, 20) together is also important. The time interval is preferably short, e.g., 3 to 4 seconds.

[0030] It is also envisioned that the control mechanism 40, typically integrated with one or more measurement devices, is employed by the fusion apparatus 14 to control the components. For example, the first heating plate 36 and/or the second heating plate 38 may be equipped with thermometers to measure plate temperatures with an accompanying control for setting and holding these temperatures. However, it may be that these thermometers can only be used as general indicators due to the inaccuracies between a thermometer and the actual surface temperature of the terminal edges (18, 20). In this regard, a pyrometer or other surface temperature-measuring device may be integrated with the control mechanism 40 and used periodically to ensure proper temperature of the first heating plate 36 and/or the second heating plate 38. It is further envisioned that any of the control mechanism 40, the thermometers or other surface temperature measuring devices are digital devices, that provide a more accurate measure and control of the heat applied by the heater mechanism 34. Such digital control is especially beneficial when the fusion apparatus 14 is used in connection with PVC conduit, as the physical chemistry of PVC, including its melting temperature and

curing temperature require much more precision than the use of such a fusion apparatus 14 in connection with PE or HDPE. Therefore, this digital control, in combination with the zone heating, provides enhanced control characteristics to the fusion apparatus 14 of the present invention.

[0031] Further, the surfaces of the heating plates (36, 38) should be kept clean, and any coating on the heating plates (36, 38) should not be scratched or damaged in any way. After the terminal edges (18, 20) have been heated for the proper time and to the proper temperature, as discussed hereinafter, the heater mechanism 34 is removed and the molten terminal edges (18, 20) are brought together with sufficient pressure to properly mix the conduit materials to form a homogenous joint, referred to as a fused joint area 22.

[0032] The fused joint area 22 must be held immobile under pressure until cooled adequately to develop the appropriate strength. The hydraulic pressure provided by the first clamping mechanism 26 and the second clamping mechanism 28 should accomplish this. Allowing proper times under pressure for cooling prior to removal from the first clamping mechanism 26 and the second clamping mechanism 28 is important in achieving joint integrity.

[0033] After the fusion process, the fused joint area 22 evidences the external bead 24, as well as an internal bead 42, as a result of the applied pressure to the melted material. The external bead 24 extends away from the fused conduit external wall 44, and similarly, the internal bead 42 extends inward from the fused conduit internal wall 46. The external bead 24 should be removed prior to using the liner conduit 16 in the conduit expansion process and system. Specifically, the external bead 24 should be removed to allow for full expansion of the liner conduit 16 within the host conduit when subsequently used in an expansion process. The external bead 24 is typically substantially removed or machined to within 1/8 to 1/16 of an inch of the fused conduit external wall 44. Typically, the internal bead 42 need not be removed and does not provide unnecessary adverse conditions within the liner conduit 16. However, if such a bead 42 would be deemed adverse to the flow of material, the internal bead 42 may also be removed.

[0034] If the fusion process is unsuccessful or otherwise faulty, the fused joint area 22 may be simply cut and removed, and the process repeated. However, the reasons the fused joint area 22 was faulty should be logged, for example, in the control mechanism 40. Fusion process diagnostics and data may also be processed, analyzed and presented by the control mechanism 40.

[0035] With respect to the fusion process operating parameters, the typical formula used in calculating fusion apparatus 14 gauge pressure using PVC liner conduit 16 is:

$$MGp = \frac{\pi(OD^2-ID^2)}{4} \times \frac{Ip}{Ca}$$

Further, the formula for calculating conduit or pipe surface area (pSa) in square inches is:

$$pSa = \frac{\pi(OD^2-ID^2)}{4}$$

The formula for calculating gauge pressure (Gp) when the conduit or cylinder area is 1.00 square inch is:

$$Gp = pSa \times Ip$$

Finally, the formula for calculating machine gauge pressure (MGp), when pipe surface area, interfacial pressure and cylinder area of machine are known, is:

$$MGp = \frac{pSa \times Ip}{Ca}$$

As used hereinabove:

- MGp = Machine gauge pressure psi
- π = 3.1416 Circle formula
- OD² = Outside Diameter in inches x itself
- ID² = Inside Diameter in inches x itself
- Ip = Interfacial pressure ($\approx$ 140 psi) PVC
- Ca = Cylinder area of machine in sq. inches
- pSa = Pipe surface area in sq. inches
- Gp = Gauge pressure when cylinder area = 1.00

[0036] Through extensive testing and documentation, the charts in Figs. 4-9 have been created for quickly establishing various parameters for use in the above formulae when the interfacial pressure is about 140 psi. In these charts, nominal pipe diameter, outside pipe diameter, inside pipe diameter, surface area, gauge pressure and dimension ratio are all set forth. The cylinder area is based on 1.00. Further, in order to calculate the machine gauge pressure and psi using the charts in Figs. 4-9, the listed gauge pressure and psi should be divided by the cylinder area in square inches of the machine to be used. In order to establish proper gauge pressure using all types and sizes of machines, the noted gauge pressure in the charts and the figures should be divided by the effective cylinder area of the machine in use.

[0037] Pipe drag resulting from pipe weight and roller resistance must be added to the calculated gauge pressure and psi. Further, extreme weather conditions, e.g., wind, rain, heat, cold, snow, etc., must be allowed for and numbers adjusted appropriately. Weather shelters may be required for inclement conditions. Further, it is noted that, unlike polyethylene fusion, PVC fusion must be handled carefully, especially in axial lifting or bending. Spreader bars or "Y" slings should be used to handle the pipe safely. In addition, heating a long length of fused liner conduit 16 using a hot air blower or steam generator may result in the pipe becoming more flexible and safer to handle in cold weather.

[0038] In this manner, the present invention provides a method and apparatus for use in a fusion process that is particularly adaptable in fusing polyvinyl chloride conduit. The present method and apparatus allows for the connection of multiple conduit portions or lengths with a joint that equals the strength of the original conduit and does not increase the diameter of the joint area beyond the original conduit diameter. Still further, the present invention presently invented method and apparatus provide a single piece of liner conduit 16 starting stock with no mechanical joints.

[0039] This invention has been described with reference to the preferred embodiments. Obvious modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations.

THE INVENTION CLAIMED IS:

1. A method for fusing a first conduit portion to a second conduit portion, at least one of the first conduit portion and the second conduit portion comprising a polyvinyl chloride material, the method comprising:

applying a plurality of heat zones to at least a portion of at least one of a first terminal edge of the first conduit portion and a first terminal edge of the second conduit portion, the plurality of heat zones configured to provide a heat profile to at least a portion of at least one of the first terminal edge of the first conduit portion and the first terminal edge of the second conduit portion;

heating and melting at least a portion of at least one of the first terminal edge of the first conduit portion and the first terminal edge of the second conduit portion; and

fusing the first conduit portion and the second conduit portion by engaging the first terminal edge of the first conduit portion with the first terminal edge of the second conduit portion, thereby creating a fused joint area.

2. The method of claim 1, further comprising selecting engagement interfacial pressure, engagement gauge pressure, engagement time, heating interfacial pressure, heating gauge pressure, heating temperature, heating time or any combination thereof, such that the fused joint area exhibits substantially the same strength as at least one of the first conduit portion and the second conduit portion.

3. The method of claim 1, further comprising maintaining pressure of the engaged terminal edges of the first conduit portion and the second conduit portion for a time and at a temperature sufficient to provide a fused joint area of a desired strength.

4. The method of claim 1, comprising heating at least one of the plurality of heat zones at a different rate than at least one other of the plurality of heat zones.

5. The method of claim 1, comprising setting at least one of the plurality of heat zones to a different temperature than at least one other of the plurality of heat zones.

6. The method of claim 1, comprising automatically controlling at least one of the plurality of heat zones.

7. The method of claim 1, wherein prior to the heating and melting, the method further comprising:

facing at least one of the first terminal edge of the first conduit and the first terminal edge of the second conduit; and

aligning the first terminal edge of the first conduit portion with the first terminal edge of the second conduit portion.

8. The method of claim 1, further comprising removing at least a portion of at least one of a resultant external bead and a resultant internal bead extending around the fused joint area.

9. The method of claim 1, further comprising:

heating and melting at least a portion of at least one of a second terminal edge of the first conduit portion and a first terminal edge of a subsequent conduit portion; and

engaging the second terminal edge of the first conduit portion with the first terminal edge of the subsequent conduit portion, thereby creating a subsequent fused joint area.

10. The method of claim 1, wherein the heating and melting includes the simultaneous heating of both the first terminal edge of the first conduit portion and the first terminal edge of the second conduit portion.

11. The method of claim 1, wherein the gauge pressure for the engaging is calculated utilizing the following formula:

$$MGp = \frac{\frac{\pi (OD^2 - ID^2)}{4} \times Ip}{Ca}$$

wherein MGp is machine gauge pressure, π is 3.1416 circle formula, OD^2 is outside diameter in inches squared, ID^2 is inside diameter in inches squared, Ip is interfacial pressure and Ca is the cylinder area of machine in square inches.

12. A method for fusing a first conduit portion to a second conduit portion, at least one of the first conduit portion and the second conduit portion comprising a polyvinyl chloride material, the method comprising:

heating and melting at least a portion of at least one of the first terminal edge of the first conduit portion and the first terminal edge of the second conduit portion;

fusing the first conduit portion and the second conduit portion by engaging the first terminal edge of the first conduit portion with the first terminal edge of the second conduit portion, thereby creating a fused joint area; and

selecting engagement interfacial pressure, engagement gauge pressure, engagement time, heating interfacial pressure, heating gauge pressure, heating temperature, heating time or any combination thereof, such that the fused joint area exhibits substantially the same strength as at least one of the first conduit portion and the second conduit portion.

13. The method of claim 12, further comprising maintaining pressure of the engaged terminal edges of the first conduit and the second conduit for a time and at a temperature sufficient to provide a fused joint area of a desired strength.

14. The method of claim 12, wherein the heating and melting includes contact of at least a portion of at least one of the first terminal edge of the first conduit portion and the first terminal edge of the second conduit portion with a heat plate.

15. The method of claim 12, wherein the heating and melting includes applying a plurality of heat zones to at least a portion of at least one of the first terminal edge of the first conduit and the first terminal edge of the second conduit portion, the plurality of heat zones configured to provide a heat profile to at least a portion of the at least one of the first terminal edge of the first conduit and the first terminal edge of the second conduit portion.

16. The method of claim 15, comprising heating at least one of the plurality of heat zones at a different rate than at least one other of the plurality of heat zones.

17. The method of claim 15, comprising setting at least one of the plurality of heat zones to a different temperature than at least one other of the plurality of heat zones.

18. The method of claim 15, comprising automatically controlling at least one of the plurality of heat zones.

19. The method of claim 12, wherein prior to the heating and melting, the method further comprises:

facing at least one of the first terminal edge of the first conduit and the first terminal edge of the second conduit; and

aligning the first terminal edge of the first conduit portion with the first terminal edge of the second conduit portion.

20. The method of claim 12, further comprising removing at least a portion of at least one of a resultant external bead and a resultant internal bead extending around the fused joint area.

21. The method of claim 12, further comprising:

heating and melting at least a portion of at least one of a second terminal edge of the first conduit portion and a first terminal edge of a subsequent conduit portion; and

engaging the second terminal edge of the first conduit portion with the first terminal edge of the subsequent conduit portion, thereby creating a subsequent fused joint area.

22. The method of claim 12, wherein the heating and melting includes the simultaneous heating of both the first terminal edge of the first conduit portion and the first terminal edge of the second conduit portion.

23. The method of claim 12, wherein the gauge pressure for the engaging is calculated utilizing the following formula:

$$MGp = \frac{\pi (OD^2 - ID^2)}{4} \times \frac{Ip}{Ca}$$

wherein MGp is machine gauge pressure, π is 3.1416 circle formula, OD^2 is outside diameter in inches squared, ID^2 is inside diameter in inches squared, Ip is interfacial pressure and Ca is the cylinder area of machine in square inches.

24. The method of claim 12, wherein the engagement interfacial pressure is between 50 psi and 250 psi.

25. The method of claim 12, wherein the time period between the heating and melting and the engaging is in the range of 3 to 4 seconds.

26. A fused joint area made in accordance with claim 12.

27. A fused conduit made in accordance with claim 12.

28. A horizontal directional drilling method, comprising:

drilling a pilot hole in the ground;

reaming the pilot hole to an appropriate diameter; and

inserting the fused conduit made in accordance with claim 85 into the pilot hole.

29. A pipe pressurization method, comprising pressurizing a fused conduit made in accordance with claim 27.

30. The method of claim 29, wherein prior to the pressurization, the method further comprises expanding the fused conduit within a host pipe, thereby creating an expanded, liner conduit.

31. A pipe bursting method, comprising:

breaking apart an existing, buried pipe, thereby creating an at least partially open conduit hole; and

inserting the fused conduit made in accordance with claim 27 into the conduit hole.

32. An underground pipeline installation method, comprising:
creating an at least partially open conduit hole; and
inserting the fused conduit made in accordance with claim 27 into the conduit hole.

33. A method of lining a host pipe, comprising inserting the fused conduit made in accordance with claim 27 into the host pipe.

34. A method for fusing a first conduit portion to a second conduit portion, at least one of the first conduit portion and the second conduit portion comprising a polyvinyl chloride material, the method comprising:

heating and melting at least a portion of at least one of the first terminal edge of the first conduit portion and the first terminal edge of the second conduit portion;

fusing the first conduit portion and the second conduit portion by engaging the first terminal edge of the first conduit portion with the first terminal edge of the second conduit portion, thereby creating a fused joint area; and

selecting engagement interfacial pressure, engagement gauge pressure, engagement time, heating interfacial pressure, heating gauge pressure, heating temperature, heating time or any combination thereof, such that the fused conduit is capable of withstanding pressure equal to the pressure capability of at least one of the first conduit portion and the second conduit portion.

35. An on-site method of fusing a first conduit portion and a second conduit portion, at least one of the first conduit portion and the second conduit portion comprising a polyvinyl chloride material, the method comprising: mobilizing at least one fusion apparatus to an on-site location, the fusion apparatus configured to: (i) heat and melt at least a portion of at least one of a first terminal edge of a first conduit portion and a first terminal edge of a second conduit portion, at least one of the first conduit portion and the second conduit portion comprising a polyvinyl chloride material; (ii) fuse the first conduit portion and the second conduit portion by engaging the first terminal edge of the first conduit portion with the first terminal edge of the second conduit portion, thereby creating a fused joint area; and selecting engagement interfacial pressure, engagement gauge pressure, engagement time, heating interfacial pressure, heating gauge pressure, heating temperature, heating time or any combination thereof, such that the fused joint area exhibits substantially the same strength as at least one of the first conduit portion and the second conduit portion.