JOINTS FOR LARGE DIAMETER PE100 PIPE

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ABSTRACT

PE100 has been established as the material of choice for rehabilitation and replacement of existing smaller diameter cast iron water mains in the UK and is increasingly being considered for larger mains up to 2 metres in diameter with a wall thickness of up to 100mm. This presents no difficulties in terms of reliability of the pipe material or where butt fusion welding may be used as the main jointing system, but there is growing concern about other jointing methods for larger diameter PE100 pipe. This paper discusses the concerns about large diameter electrofusion fittings, mechanical fittings and stub flanges and identifies the lack of adequate testing to establish that acceptable performance can be relied upon. Although appropriate test methods are specified and are available, there are insufficient sources of independent testing or advice and Bodycote PDL has resolved to change that situation. The aim is to investigate current problems experienced in the field, evaluate existing solutions and assist in the development of new solutions, thereby ensuring that large diameter PE100 pipe will remain as a viable option for larger diameter pipelines in the future. A summary of preliminary findings is presented of this long term investigation.

1. INTRODUCTION

PE100 is now increasingly used in pipe diameters up to 2 metres diameter with wall thickness up to 100mm. There are still very few instances of failures of the pipe material, which constitutes a unique record amongst pipe material options. In recent installations of larger diameter PE100 pipe, there have unfortunately been a number of instances where failures of joints have been observed and this has led to this investigation to be conducted.

Although concerns expressed in the past about butt fusion welding may be addressed relatively easily [1, 2], there are however always instances where the very reliable technique of butt fusion welding cannot be used and it is necessary to join both long strings of large diameter pipe together and to other devices (i.e. valves and hydrants) and in these instances the choice of reliable fittings and jointing methods is limited. All mechanical fittings including stub flanges suffer from the reliance on elastomeric seals to prevent leakage in combination with forces usually applied by steel bolts. The fundamental problem with this approach is that PE is a viscoelastic material unlike metal pipe materials for which this method is used successfully, which means that the initial

force or torque applied to the bolts will diminish to some extent with time and may lead to leakage and/or problems associated with applying too much initial torque.

One of the reasons why these problems have not been addressed is that insufficient testing is conducted on larger diameter fittings to establish the ability of the various jointing methods to cope with the problems identified. Although test methods have been available and are specified there are very limited sources of such independent testing. Bodycote PDL has therefore established a test facility capable of discriminating between good and bad fittings to:

- Investigate problems experienced in the field
- Investigate existing solutions to the problems
- Develop new solutions to the problems

In this report, preliminary work is presented in which several case studies are reported for actual problems experienced in the field, but this is balanced by relatively positive developments by two major manufacturers of mechanical fittings.

2. ELECTROFUSION

In the past year Bodycote PDL has reviewed 8 case studies of installations of larger diameter PE pipe where problems have been experienced with electrofusion (EF) welding. Although problems were not expected below 500mm diameter, the range of sizes in which problems had occurred was from 315mm to 710mm (Table 1).

Case	Diameter (mm)	Site Practice	EF Coupler	Pipe	Training
1	710	Poor	Question	Poor	Poor
2	560	Poor	OK	Poor	Poor
3	500	Poor	OK	OK	Poor
4	560	Poor	Question	Poor	Poor
5	400	Poor	Question	OK	OK
6	400	OK	Poor	OK	OK
7	315/500	Poor	Question	Poor	Poor
8	500	Poor	Question	OK	OK

Table 1: Summary of Problems in 8 Case Studies of EF Installation

Bodycote PDL were surprised to find that there had been some issue with the pipe in 4 installations, with either the external diameter being outside specification or the pipe had been deformed in some way and was probably due to improper storage. In these cases, training must have been inadequate because welding should not have proceeded if the pipe was outside specification. Poor training was also evident in other ways, whereby all the required techniques associated with installation in accordance with best practice had not been conveyed to the site personnel. Examples of poor site practice/ training which

were evident in nearly all of the cases observed included inadequate scraping, inadequate clamping and poor site hygiene (contamination). In one case the EF coupler itself was identified as the main cause of failure due to electrical problems during fusion, but in many (5) of the other cases there was some question about whether the coupler had been part of the reason for failure. This was generally impossible to prove, as the correct installation procedures had not been followed and these had clearly contributed to the observed failure.

A number of photographs are provided in figure 1 that indicate some of the problem joints from these case studies. In many cases, the gap between pipe and coupler appeared to be greater than could be accommodated. In some cases this may have been due to pipe being non-standard or lack of adequate clamping, but in some cases the size of the region affected by reversion at the end of the pipe also appeared to be a factor.

Reversion is generally expected to occur at the end of PE pipe and involves a local reduction in diameter when the pipe is cut as shown in figure 2. This can result in gaps between the pipe and EF coupler if reversion coincides with the fusion zone. Bodycote PDL has conducted a number of measurements on various pipe sizes and established that approximately 50% of reversion occurs instantaneously, with the remainder increasing with time after cutting (figure 3). It was also observed that reversion increases with pipe diameter (figure 4). With gaps above 5mm due to reversion, this is clearly likely to be an issue in design of large diameter EF couplers.

The ability of EF couplers to bridge any form of gap that occurs has been found to be a consistent issue in the cases observed and is likely to be of increasing importance in larger diameter fittings. Perhaps another form of fusion joint where the polymer melt is able to fill the gap more adequately would be more appropriate for large diameter pipe.

3. MECHANICAL FITTINGS

Two manufacturers were contacted with regard to availability of end-load resistant fittings for PE pipe. Both manufacture a range of fittings and generally these are made from cast ductile iron in smaller diameters (<400mm), but fabricated from steel in larger diameters.

3.1 VIKING JOHNSON

Viking Johnson (VJ) is an autonomous business unit in the Crane Group of companies and the major UK manufacturer of joints, with many considering that they set the industry standard. They are reputed to have a good turn-around time for fittings and are renowned for a high level of in-house expertise, with their own test facilities that include pressure, pull-out and AREL testing up to large diameters.

VJ openly admitted recent issues with large diameter mechanical fittings in which problems had been experienced with thick sections of PE in cold weather and dislodging of elastomer seals (figure 5). This has led to improved housing of the elastomer seals and the use of heater blankets on site, which has led to resolution of the difficulties.

VJ Aquagrip fittings are capable of Type 1 performance in accordance with the specification [3] up to 450mm SDR11, but only Type 2 in larger sizes. Bodycote PDL recommends Type 1 performance, but recognise that this is increasingly difficult to achieve in larger diameter mechanical fittings.

VJ has written procedures for installation of their fittings and robust heater blankets are available through MCA in the UK, who also provide appropriate training. Better performance has also been obtained on occasions by using re-rounding clamps on the pipe.

VJ also manufactures liners with wedge shaped actuators that may be useful in providing internal support to pipe and assist in producing better quality EF joints (figure 6)

3.2 NOVA SIRA

Nova Sira (NS) is a family owned business of 75 years standing based in Turin, with fittings distributed by R2M & Ham Baker in UK. The company is ISO 9001:2000 approved and the range of products includes end resistant fittings for PE. NS is able to achieve a good turnaround time for demand for fittings because of a high level of in-house flexibility, which also enables them to develop products as required. The local test facility is limited to pressure and pull-out testing, but they are keen to demonstrate performance in the AREL test.

NS fittings appear to have well anchored elastomer seals and the end load resistant fittings are considered to be capable of Type 1 performance, but this needs to be established in independent testing. The fittings have bolts that need to tightened all around the circumference, which may prove to be difficult to apply in some circumstances.

Other fittings of interest include 'Duofit', which may be used to completely encapsulate an existing joint and NS also supply liners with a wedge shaped actuator.

4 STUB FLANGES

Stub flanges may be butt fusion welded to pipe and used to make connections to other equipment or pipe materials and could be as effective as any other form of joint. However, the viscoelasticity of the PE100 pipe material and elastomer seal may be more of a factor in the long term performance of this type of joint than any other and the authors are pessimistic about the level of testing that has been completed to date on stub

flanges intended to be used for large diameter PE pipe. New generations of stub flanges [4] and reinforced seals [5] may provide more optimism in this respect, but it appears that there is very little evidence available currently to enable the right choice to be made and this will form part of the next phase of the work to be conducted at Bodycote PDL.

5 CONCLUSIONS

- There are concerns about the choices of joints available for large diameter PE100 pipe, which is now being made up to 2m diameter with up to 100mm wall thickness.
- Butt fusion welding is expected to be the most reliable method of making joints between lengths of PE pipe but other jointing methods will also be required for connecting to other devices and materials.
- The maximum diameter of EF joints that considered to be reasonably reliable is 710mm, but 8 case studies have demonstrated problems being encountered with EF fittings in the range of diameters 315-710mm.
- For larger diameter EF fittings, training is considered to be even more important and must be more specific than for smaller diameter fittings, but in the majority (5/8) of cases was found to be inadequate.
- Site practice in general was also found to be inadequate in these 8 cases, with evidence of inadequate scraping, clamping and site hygiene (contamination) in most cases.
- Surprisingly, there was also some evidence (4/8 cases) of pipe being outside specification and repeated question marks over whether the design of EF fittings could be improved, although in most cases this was impossible to verify due to other factors.
- The ability of EF couplers to bridge any form of gap that occurs has been found to be a consistent issue in the cases observed and is likely to be of increasing importance in larger diameter fittings. Perhaps another form of fusion joint where the polymer melt is able to fill the gap more adequately would be more appropriate for large diameter pipe.
- Viking Johnson and Nova Sira provide end-load resistant mechanical fittings for PE100, although those from Viking Johnson are only capable of Type 2 performance for sizes above 450mm SDR11.
- There are also concerns about the performance of stub flanges, due to viscoelasticity of the PE100 pipe materials and elastomer seals, but newer generation stub flanges and reinforced elastomer seals may provide more confidence.

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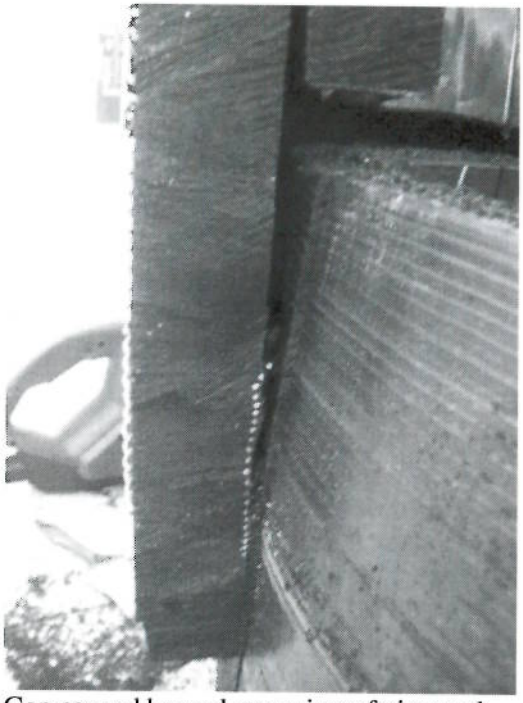
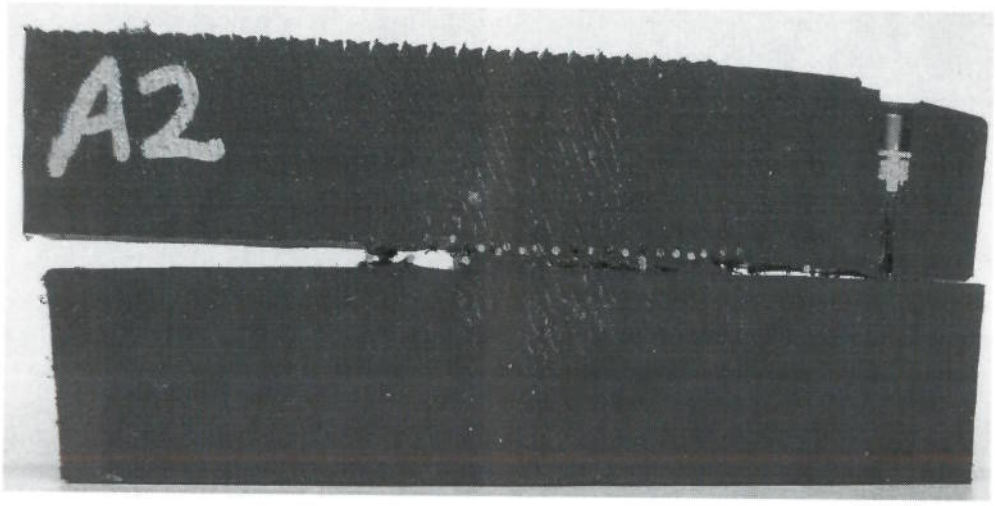


Gap caused by end reversion of pipe end

Excessive wire movement caused by gap between pipe and coupler due to ineffective clamping



Section through electrofusion coupler showing gap between pipe and fitting

Figure 1: Examples of Problems with Large Diameter Electrofusion Couplers

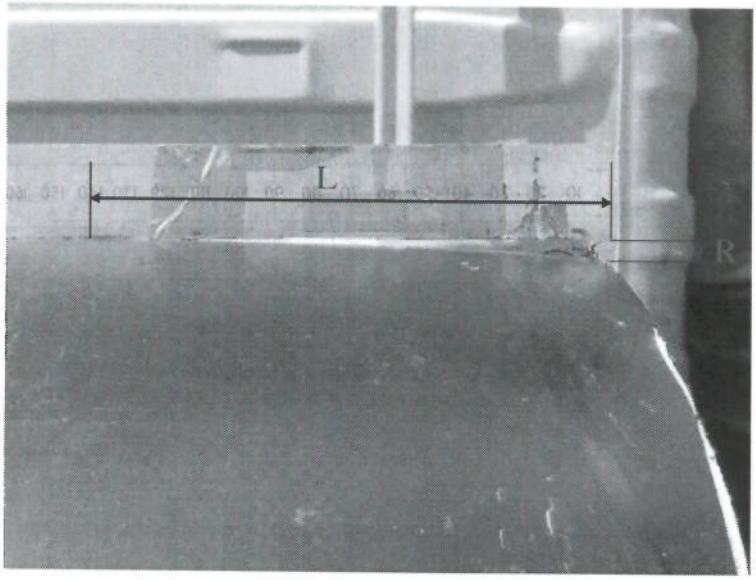


Figure 2: Measurement of End Reversion
(R= Reversion: L= Length of Reversion)

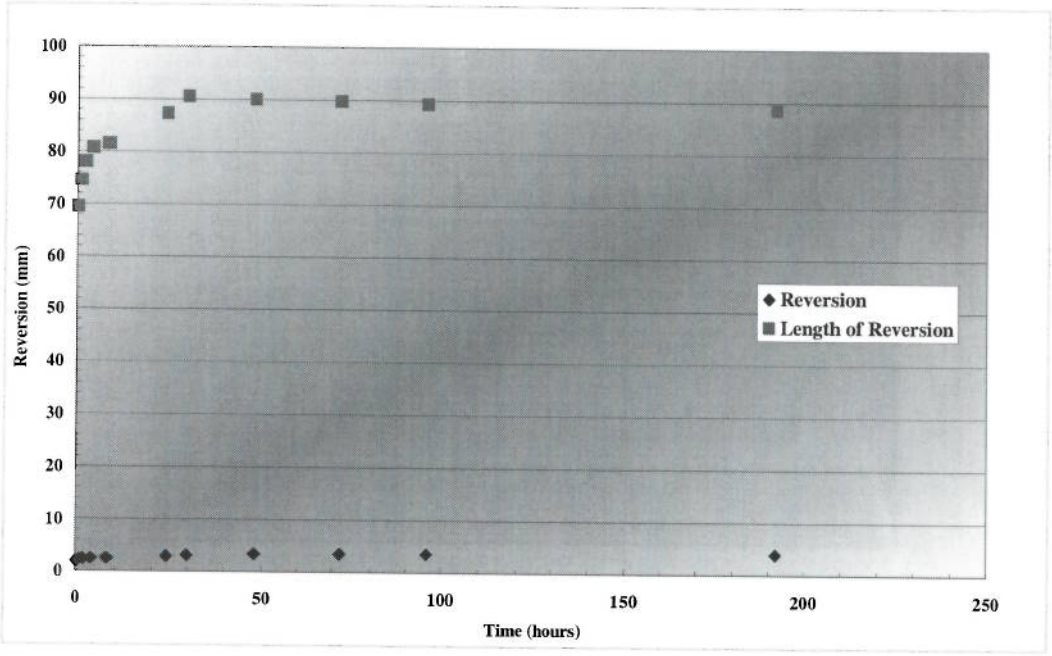


Figure 3: Change in End Reversion with Time for 500mm SDR 17 Pipe at 23°C

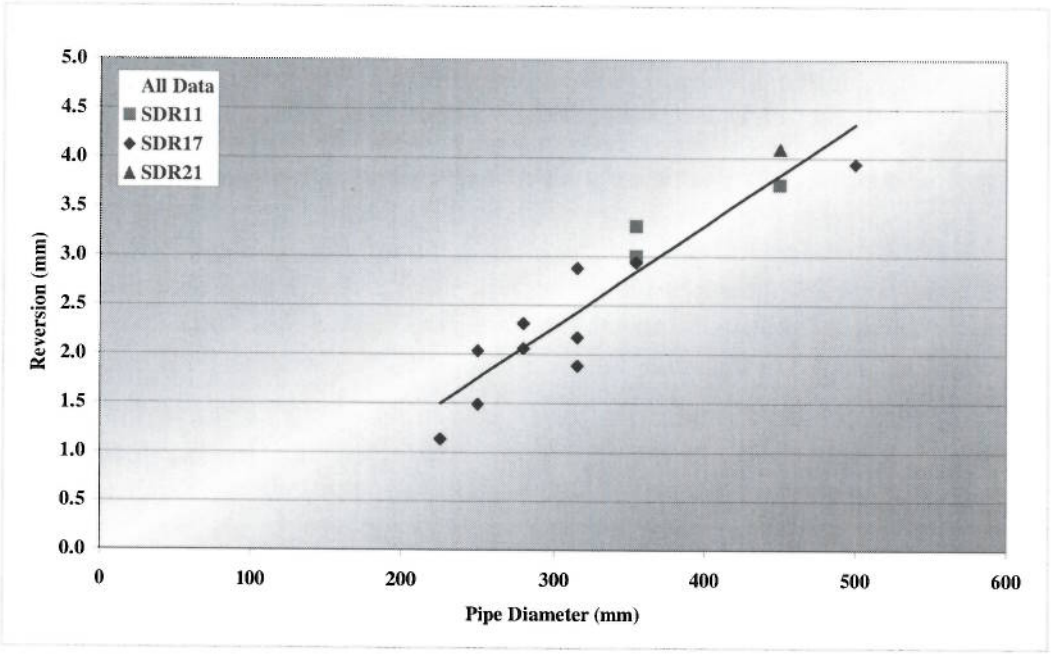


Figure 4: Reversion on Various Diameter PE100 Pipes

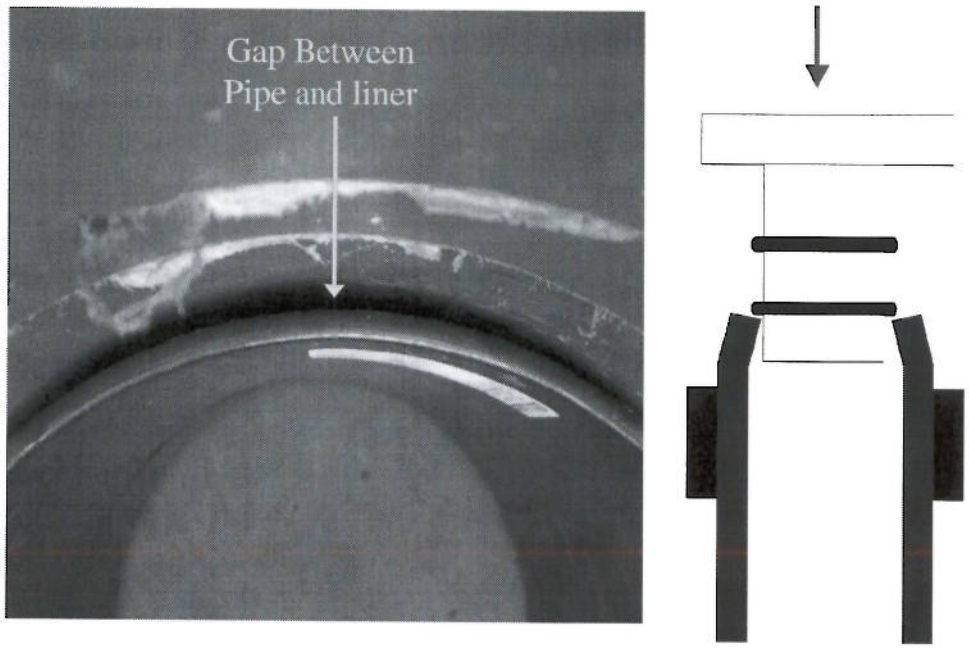


Figure 5: Problems with Mechanical Fittings (now resolved)
Left: gap between pipe and liner, Right: displacement of elastomer seals

Figure 6: Liners with Wedge Shaped Actuators from Viking Johnson