

Research requirements in support of the renovation of pressure and non-pressure pipes

J.C. Boot ^{a,*}, J.E. Gumbel ^b

^a School of Engineering, Design and Technology, University of Bradford, Bradford BD7 1DP, UK

^b JG Pipeline Consultancy Ltd, Winchester, UK

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Abstract

In the UK a Trenchless Technology Network (NETWORK; www.ttn.bham.ac.uk) has been established with the prime objective of gaining a broad consensus between academia and industry on research needs so that collaborative research proposals can be developed to expedite the required information. This paper summarises the initial phase of this work in respect of the renovation of deteriorated pipe-work by lining. The paper considers pressure and non-pressure pipes in turn, as the factors limiting performance in the two situations are significantly different. In each case current practice and knowledge are first summarised, whence research needs are identified based on the experience of experts from all sides of the pipeline renovation industry. For both classifications of pipe research requirements are identified in the generalised areas of: host pipe condition assessment, lining design, lining installation, and system maintenance.

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1. Introduction

This paper summarises a report produced as part of the UK Engineering and Physical Sciences Research Council (EPSRC) Network in Trenchless Technology (NETWORK) under grant number GR/R14064/01. NETWORK (www.ttn.bham.ac.uk) aims to bring all relevant academics and industrialists together to synthesise knowledge in the broad field of trenchless technologies, agree the research needs in a priority order, disseminate this information as widely as possible and formulate research proposals to address these needs. As part of that brief, this paper on the use of pipe lining for the renovation of pressure and non-pressure (normally gravity flow) pipes, focuses on the needs of the water supply, gas supply, and waste water industries as these are the main users of this technology. However, similar techniques are used in the oil distribution, power generation, chemical process, and

other industries. Indeed much pipeline renovation is undertaken on an international basis by specialist contractors, a list of which is available through the national trenchless technology societies. These in turn can be contacted through the International Society for Trenchless Technology via its website at <http://www.istt.com>.

According to European standards (e.g. EN 13689, 2002), rehabilitation includes all methods of restoring or upgrading the performance of an existing pipeline system, whilst renovation is defined as ‘work incorporating all or part of the original fabric of the pipeline by means of which its current performance is improved’. In particular (ISTT, 1995) where the performance of the pipeline is unsatisfactory, but the fabric has a residual value, either structurally in its own right or as a lining support, renovation may be appropriate. In this paper the terms ‘renovation’ and ‘lining’ are taken to be synonymous. The paper first summarises current practice and thence develops the research requirements of pressure and non-pressure pipes in turn. The paper was prepared with the needs of the UK particularly in mind, but can readily be interpreted in the international context.

* Corresponding author. Fax: +44 1274 234124.

E-mail addresses: j.c.boot@bradford.ac.uk (J.C. Boot), jgconsultancy@dsl.pipex.com (J.E. Gumbel).

2. Pressure pipe

A pressure pipe can be classified as one which operates under an internal pressure in excess of atmospheric, and for which resistance to internal pressure is normally the dominant design requirement (Boot and Headford, 1996).

2.1. Current practice – water industry

2.1.1. Mains renovation

EN 13689 classifies pressure pipe liners as either *interactive* or *independent*, but a more complete classification now widely adopted in both engineering practice (Gumbel et al., 1995; Heavens and Gumbel, 1998; AWWA, 2001; Gumbel et al., 2004) and research (Boot and Toropova, 1999; Marshall, 2002a) defines the following three categories of lining:

- Non-structural
- Semi-structural
- Fully structural

A semi-structural lining forms a composite system with the deteriorated host pipe, relying on it for some measure of radial support, whilst the other two categories are applicable in the extreme cases of full and no (structural) deterioration. Fully structural linings are designed as stand-alone pipe using traditional pipe design methods, but as implied by the Class IV classification of AWWA Manual M28 (2001) should also in general be able to survive the possible dynamic event of future failure of the host. Semi-structural lining is appropriate if the pipe is currently structurally sound, and expected to remain so after lining, but might suffer local damage during the life of the renovated system. Local damage comprises small holes and gaps, which can occur for a number of reasons. Thus local damage is that which leaves the pipe with significant structural capacity over the anticipated life of the renovated system.

ISTT (1995) and Heavens and Gumbel (2004) provide a reasonably comprehensive introduction to many of the techniques used to install structural and semi-structural linings, which include close-fit polyethylene and PVC, cured-in-place (resin-composite) pipes, adhesive-backed hoseliners and polyester-reinforced polyethylene (PRP) inserted hoses. The most commonly used and intensively researched lining materials are butt fusion welded pipe grade polyethylenes PE80 (IGN 4-32-03, 1987) or PE100 (WIS 4-32-13, 1993). Toropova (1999) summarises the beneficial qualities of these materials. For fully structural applications where the hydraulic requirements permit, loose-fitting slip-lined PE pipe is still widely used (Marshall, 2002a). However, close-fit PE semi-structural linings often offer a more effective solution on sustainability grounds, and because of their novelty in terms of installation and design have been the main focus of research interest; in the UK literature these are commonly referred to as polyethylene thin-walled linings or PETWLs.

Statistics show (Marshall, 2002b) that when small diameter cast iron pipes (i.e. <200 mm diameter) ‘fail’, it is nor-

mally due to a circumferential fracture caused by bending stresses established primarily by restrained soil movements. If this happens to a cast iron pipe lined with a PETWL the result is that the lining has only to span a very short gap. Thus this mode of host pipe ‘failure’ causes very little distress to the lining, and the lined pipe should continue to function normally (Crunkhorn et al., 2001, 2004) unless dynamic effects at host pipe fracture and subsequent potential soil movements are critical. A major constraint to the use of the PETWL principle has been that, until recently, structural design recommendations have only been available in research publications (Boot and Toropova, 1999) or individual suppliers’ product manuals (e.g. Subterra, 1998; Wavin, 2003). The recent report by Marshall (2002a) published by UKWIR now addresses this, although, unfortunately, the Water Industry is currently providing no drive to promote the use of this publication.

It is not clear whether the lack of specific semi-structural lining design guidance for the water industry has been a significant constraint to further application of the technique, since the bulk of renovations are specified and installed by a small number of specialist consultants and contractors who tend to be aware of the research recommendations in this respect. Certainly linings in the range SDR 30–50 are commonly installed in practice.

Assessing the properties of the existing pipe is a problem, especially in the absence of any detailed knowledge of the long-term (historical) behaviour of the pipeline under consideration. There is a WRC method (Williams et al., 1984) for assessing the residual life of cast iron pipe based on pit-depth measurement and assuming a continuing linear corrosion rate. This has been the standard corrosion assessment procedure in the UK for many years, but it is appreciated by all to be flawed in several respects. A major Canadian programme on pipe corrosion and assessment has been undertaken (Kleiner and Rajani, 2001; Rajani and Kleiner, 2001) which identifies a large number of available techniques for assessing probable future pipe performance, but comes to no clear decision on which is most appropriate in any given situation. The new report by Marshall (2002a) recommends a greatly improved (from the WRC method) and more rational procedure, which relates directly to the flexural failure most commonly encountered and is based on fracture mechanics. This procedure needs implementing; however, at the moment, there seems to be no drive to promote this methodology within the water industry. Olliff and Rolfe (2002) advocate a condition assessment approach to rehabilitation practice. These authors state that although much effort has gone into improving investigation and renovation techniques, this has not been matched in the area of condition data analysis.

The industry normally installs a non-structural lining in all pipes with more than 30 years residual life on the basis of the WRC pit-depth with the objective of improving water quality by avoiding staining as a result of pipe rusting and tuberculation. Historically these linings have been epoxy resin sprayed coatings less than 2 mm thick (WRC Engi-

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