ADAPTING TECHNOLOGY TO SOLVE ONE OF INDUSTRIES MAJOR PROBLEMS

Paper Presented by:

Peter Marchant

Author:

Peter Marchant, *Product & Development Manager,*

ITS Pipetech Pty Ltd

10th Annual WIOA
NSW Water Industry Operations Conference and Exhibition
Newcastle Jockey Club,
6 to 7 April, 2016

ADAPTING TECHNOLOGY TO SOLVE ONE OF INDUSTRIES MAJOR PROBLEMS

Peter Marchant, *Product & Development Manager,* ITS Pipetech Pty Ltd

ABSTRACT

Between 1925 and 1980 Asbestos Cement pipe was seen as a cost effective product and was widely used across Australia in the construction and expansion of our domestic water networks for the distribution of drinking water. The life expectancy of this product has fallen short of what was intended and today most States are abandoning AC distribution networks with Australia having installed many thousands of kilometres during this period. Water authorities and regulatory bodies are searching for viable insitu lining solutions as open cut replacement are either too costly or too disruptive. In some circumstances, simply abandoning the pipeline is not an option. Proposals for relining existing assets must address the specific challenges of lining into asbestos cement fibre host pipe structures including structural integrity, ability to reinstate connections, operational functionality and above all water quality. This paper looks at how rehabilitation of existing AC water mains can de-risk the operation and provide a relined asset without the need to use excavation methods to construct on line or off line replacement thereby avoiding the environmental issues of dealing with Asbestos as well as the disruption and costs associated with replacing large sections of existing networks.

1.0 INTRODUCTION

Today, a large percentage our domestic potable water infrastructure, both transmission and distribution infrastructure has been in the ground for longer than or is approaching 100 years old and is showing signs of prolonged degradation and failure is common.

As most of our infrastructure was constructed around the turn of the last century the main source of material for the base grid was traditionally cast iron however as pipe technology advanced through the 20th century new materials were introduced to the networks, materials that were lighter, cheaper and claimed to be virtually indestructible to the rigours of network operation which through population expansion needed to grow and develop way beyond the remits for the original infrastructure design.

New materials such as Plastics, Pitch fibre, Asbestos cement and Ductile iron were introduced into the networks and more recently fibreglass and composite fibre pipes have been added to the source material.

All of these materials when used in an active water infrastructure react differently. The way in which the networks operate challenges the design of the pipework and questions the integrity of the material that it is constructed from as operational forces often exceed the design limitations of the Product. Pressure surges, hydraulic hammering (Fluid Hammer), negative vacuum and pressure main induced cavitation are all conditions that affect a modern day water infrastructure network.

Where these conditions are known to exist or can be predicted to happen in the network, the design can accommodate measures to protect against the risk, however it is the areas where these conditions happen at random, usually as a consequence of an unplanned event that manifest in unexpected pipe failure often in areas of a network that were never originally designed to accommodate such severe operational range of conditions.

Many different technologies have been invented and brought to market to address this issue, to reinforce and strengthen the integrity of the networks as well as to repair the asses as traditional open cut replacement becomes more disruptive and costlier as urbanisation grows.

A large number of products now exist that can successfully rehabilitate nearly all types of host water main however one base source in particular is proving to be a difficult issue to resolve to a satisfaction that can be both dependable and reliable to withstand all operational conditions that can be materialised in every day operation.

This source material is Asbestos Cement pipe.

2.0 ASBESTOS CEMENT PIPE (AC PIPE)

Originally seen as a popular and cost effective means to provide reliable water distribution infrastructure thousands of kilometres of water and sewer main have been laid throughout the World using AC Pipe. It is estimated that over 2 million kilometres of the product have been laid worldwide and of this over 60,000 Kilometre’s exist in our current day Australian drinking water systems.

Asbestos Cement (AC) pipe is made from a blend of Portland cement, water, silica or silica containing products and up to 12% asbestos fibre. The pipe is formed blending the mixture into a mould which is then subjected to pressure and heated and cured in an autoclave to form the finished product. Because the pipe contains asbestos fibre this provides the strength when mixed with the cement and acts in lieu of conventional steel reinforcement traditionally found in concrete pipes however its prime advantage is the reduction of weight and therefore handling which makes it a cost effective pipe to construct.

In addition to the weight advantage the properties for the pipe showed superior resistance to corrosion particularly to acid sulphate soils and in the case of sewer conditions provided excellent resistance to Hydrogen Sulphide. The pipe could be manufactured in a mould therefore the construction tolerance was superior to concrete providing the pipe with a very smooth inner surface with good flow and hydraulic properties.

There are however, as with all man made pipes, flaws in the material, with Asbestos research into health concerns through the late 1960’s and into the 1970’s concluded that Asbestos was a serious concern to health and as such the manufacture of AC pipe fell into decline and installation of AC water mains ceased from the start of the 1980’s.

Whilst no new AC pipe was being laid the previous 60 years of installation was already in the ground and operating with some of the earlier network sections starting to mature and reach the end of the originally conceived operational life.

This in itself posed 2 different problems, the first being how can the existing AC networks be maintained including provision of new insertions and service, the second is how can they be refurbished and rehabilitated the main when it reached the end of its serviceable life.

As far back as the early 1990’s signs of failures in the AC pipe systems were evident although at that stage the causation was not fully understood.

Network operators who owned the infrastructure were demanding urgent repairs however the health concerns in dealing with AC pipe and the potential liabilities surrounding the material drove innovation to look at trenchless solutions – to repair the existing asset or replace the asset insitu without excavation and removal, the drive was to get service resumption rather than understand why the service had failed in the first place.

3.0 EARLY METHODOLOGY FOR AC REPLACEMENT

When industry first encountered AC pipe failure the tendency was to deploy a technique of on-line replacement using a system called pipe bursting or pipe cracking. Pipe bursting is a construction methodology that allows an existing pipe to be replaced with a new pipe of similar (or slightly larger) diameter without the need for extensive surface excavation.

The existing pipe is hydraulically burst open from the inside by a steel expansion wedge and the new product pipe is towed in behind. Lateral side and service connections have to be reinstated from the surface and tapped to the new main yet overall the degree of non-trenchless work is minimal.

Another methodology was to pipe ream, this adopted a modified directional drill approach by boring out the existing AC pipe and towing the replacement pipe behind the drill head however again this method still required excavation down from the surface to reinstate lateral connections and as such in both cases contact with disturbed and fractured asbestos pipe was an inevitable consequence of the operation which still exposed operatives to risk and contractors to liability.

Over time the view on Asbestos as a hazardous material has hardened and the need to avoid all possible contact with the material is now the prevailing course of action. This in turn has moved authorities away from the ideas of pipe bursting – pipe reaming as the main technology and more into alternative technologies that can be installed without damaging the host pipe structure and which are almost totally trenchless yet it is essential that before developing a solution the conditions affecting the host pipe are thoroughly considered and investigated.

4.0 COMMON CONDITIONS LEADING TO POTENTIAL HOST PIPE FAILURE

Before commencing any design, it is important to understand as much as possible about the existing service as well as why it has deteriorated.

The two most common conditions relating to potential host failure are physical conditions and operational parameters affecting the service: -

Physical Conditions

External corrosion and wall thickness deterioration

Tuberculation Corrosion, excessive internal detritus deposits, Loss of wall thickness, Weak or uncompacted fill material, Internal wall thickness delamination, Foundation and side support movement, Loss of Arch support, Infestation and root damage, Connection failure and ground water ingress into the joint.

Operational Parameters

Network Metrics, Regional pressure zones, Operational flow and direction tolerance.

Valve and PRV mapping, Located Pressure systems, Gravitational demands.

Any or all of these conditions can have a significance on why the host pipe is showing signs of compromise and analysis of these will determine the best available methodology to use in a rehabilitation program.

5.0 DETERIORATION OF AC PIPES

AC pipe whilst being revolutionary when first introduced has 2 major fundamental downsides. The first and obvious is the safety hazard of the Asbestos material, the second is its mode of degradation and ultimate failure when being used to convey water in a buried condition.

AC pipe was originally introduced as a source material that had excellent Sulphate resistance property but often the outer surface protection was damaged in the construction process allowing ground water to attack the pipes core and joint interface resulting in loss of thickness and the reduction to perform under operational pressure.

The internal surface of the pipe which is in contact with the water begins to soften and break down over time and due to the fibrous composition of the pipe material begins to delaminate. Whilst this delamination’s- tears in the structure are initially imperceptibly small and microscopic they allow water to progressively penetrate the pipe wall thickness softening the base material to the point where it begins to become structurally compromised.

The physical characteristics and functionality of the network operation can then adversely affect these minor flaws, in particular when hydraulic hammering, cavitation and or negative vacuum is present, as all of these will exacerbate and add further degradation to the weakened and damaged internal surface that is reliant on a perfect cohesive structurally bonded matrix to operate.

This phenomenon is unique to AC pipe such that traditional methodologies for trenchless rehabilitation used successfully on other base pipe materials are not always applicable to AC pipe and hence the issue that faces network operators across the world today.

The previously accepted approach to pipe burst or ream out the existing AC material is no longer an acceptable methodology.

With pipe bursting the residual fractured asbestos pipe is left as a waste product in the ground and as such could be excavated and exposed by third parties undertaking other works. This is now deemed to be an unacceptable risk and is no longer an accepted practice by most infrastructure owners.

During pipe reaming the drill fluid is mixed with the fragmented asbestos pipe as it is broken up by the drill head and whilst this can be collected in a suspended solution condition at the exit pit it poses considerable issues with encapsulation and disposal such that the cost outweighs the commercial benefit, a secondary issue is that it is impossible to confirm that all latent contamination is removed from the drill hole post new main insertion, therefore there is always an inherent risk resident in the ground.

An alternative frequently adopted is to abandon the AC pipework and replace with new construction on a different alignment. Whilst this seems a logical approach there are fundamental issues with this. Firstly, the cost of replacement is significant and the disruption considerable as the works would involve top down excavation mainly in high population areas where traffic is using the infrastructure above.

Secondly, the new line replacement whilst solving one problem, leaves a greater environmental impact issue in that the redundant AC pipe is left in the ground. As this is no longer required as a water transmission / distribution asset by the network owner it is now falls under the classification of toxic waste which under most common day guidance has to be removed. Ownership of this product once decommissioned generally reverts to the Local Authority

6 .0 CONVENTIONAL APPROACH TO STANDARD PIPE REHABILITATION

Non AC water main can be successfully relined with many different products these include techniques for inflating or inverting resin impregnated tubes into the mains, application of sprayed material into the mains and slip lining pipes into mains. All of these have differing degrees of difficulty and installation issues however the degree of success relies on the time spent in assessing the condition the operation and the structural requirements of the new lining.

Some linings rely on adherence to the existing host whereas others are independent and are structurally stand alone.

Where adherence to the host is concerned several issues fundamental in the preparation of the host pipe need particular attention and rigorous control and if not undertaken with sufficient diligence the lining could be compromised.

Structural stand-alone linings do not need as much attention during the preparation.

Inverted or spray applied linings tend to rely on the lining adhering to the host to form a composite structure by chemically bonding to give support and strength to the new lining.

Stand-alone linings have sufficient in built ring stiffness to self-support under operational loading however under excessive pressure can be exposed particularly around connection points if not adequately sealed during installation.

The use of a proven technology, installed by trained and experienced operatives is fundamental to the success of any stand-alone lining system.

Whilst these technologies can be deployed successfully in conventional pipe the use in degraded AC pipe poses a different issue and it is here that the latest developments in rehabilitation technology are being focused.

7.0 AC PIPE REHABILITATION

The main issue with deteriorated AC pipe is the internal surface delamination and what effect this has on the sufficiency of a proposed trenchless lining installation.

Under normal operating conditions the water inside the pipe will maintain the lining shape as the water is generally under a relatively constant positive pressure however in a surge condition or under negative pressure – back current or vacuum the condition can be significantly different from anything that was envisaged or designed for when the lining option was conceived.

Fundamentally the unknown operational demands on a water network under emergency conditions, i.e. a network breach that requires an emergency reaction to maintain service such as instigating alternate flow management or back feeding at exceptional pressures to maintain supply are not fully understood therefore to design a lining that needs to act as a composite structure with a degrading host as a rehabilitation medium is a high risk strategy unless other factors are taken into account to mitigate this risk.

Reliance on adhesion alone is often flawed if the preparation of the host is not undertaken with strict application, diligence or control. Cleanliness is fundamental as is the dew point of the pipe prior to lining, cleanliness is further complicated by the potential erosion of asbestos fibre eroded in the cleaning process so suitable safety protection and filtration of the waste generated from the cleaning process is an additional complication and expense in the design and construction equation.

All of these factors need to be de-risked to provide a solution that is best for the situation.

8.0 SUMMARY

Effective lining systems already exist for non AC standard potable water mains and existing technologies have developed sufficiently structural lining systems that will self-support under any remit of network operational management.

Most AC pipe lining failures have generally arisen from the lack of lining ring stiffness, especially under extreme load conditions such as in a negative vacuum condition, as the bonding between the lining and the host pipe fails. This is caused by the delaminated inner surface fibrous layers of the host pipe pulling apart and separating from the original pipe construction regardless of the bonding achieved as the weakened inner face has no structural capacity and is incapable of withstanding the pull off forces from vacuum induced suction.

Combining the ability to bond to the host, whilst developing sufficient ring stiffness to withstand operational forces, facilitates a lining that will work in AC pipes and this has also been proven to withstand hydraulic hammer, cavitation as well as negative vacuum suction.

This methodology considerably de-risks the AC lining program and allows the structural lining of the existing asset to prolong the life span without exposure to the risks associated with other technologies. It is effective, it is risk free, and is less reliant on preparation and other external factors that influence the success of AC pipe lining.