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ICE PIGGING - THE WAY AHEAD FOR WATER MAIN CLEANING

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ABSTRACT

Most water system operators, especially those tasked with maintaining an aging water system have at one time or another been required to carry out mains cleaning. For large diameter pipes, this generally involves use of a large sponge or plastic swab or pig, excavation of the pipeline at each end to install pig launchers and catchers, weeks of interruption to supply and a considerable burden on resources. Now, thanks to an important innovation by Professor Joe Quarini from Bristol University and Agbar Environment, a Bristol based company (the sole company licensed in the water industry to undertake ice pigging), the drawbacks of swabbing mains for both the water authority and its customers can be avoided with a new mains cleaning method called ice pigging. The method involves pumping an ice slurry into a water main usually through a hydrant or air valve. Once in place, the ice pig is moved along the pipe via normal water flows, controlled by a downstream valve and is removed via a hydrant or air valve upstream.

KEYWORDS

Ice Pigging, Water Main Cleaning, Pigging.

1.0 INTRODUCTION

Over the past decade water quality has become an increasing challenge for Gosford City Council (GCC). The most common complaint related to water quality comes in the form of discoloured water. With an ageing system and increasing responsibilities under the Australian Drinking Water Guidelines 2004, adopted by GCC as part of the water quality management program, GCC has been addressing water quality issues by implementing a program of works to improve system performance. This program has included mains cleaning activities such as flushing and air scouring the reticulation system and pigging the larger transfer system.

Whilst each of these water main cleaning processes can be effective under certain circumstances, each has a number of drawbacks and limitations. Flushing a water main, by initiating high velocities of water through the water main, removing loose particles and debris deposited along the pipe wall is only effective on water mains up to 150mm and must be repeated at regular intervals to maintain a positive result. The other drawback of flushing is the large amount of water wasted during the process.

Air scouring, which involves blowing high pressure air mixed with small amounts of water through the main to increase sheer stress on the walls, was once considered to be the technology to move water main cleaning into the future. It is now been shown to be an aggressive cleaning method causing pipe damage. The other issue that has arisen with this method is an associated health risk via the introduction of air into the main. As with flushing, air scouring is limited to smaller pipelines of size 375mm and below.

Pigging involves forcing several coated sponge objects (pigs) of various shapes, densities and roughness's through the pipe so as to wipe or scrape loose material and bio-films from the pipe walls.

Whilst this method has a high degree of success in cleaning water mains, it has a number of drawbacks. Pigs are unable to cope with large changes in pipe diameter and direction.

Further, pigging involves a high setup cost, needing a launcher and catcher to be installed at each end of the water main to be pigged. Issues can arise in tracking the pig's location where junctions exist along the pipeline and sondes introduced to solve this problem are not always successful. Pigs will not survive in tact on pipelines that have protruding service connections.

To better meet the challenges faced by GCC, numerous new technologies, such as high pressure water cleaners that crawl through the pipe line, sound waves and smart pigging that cleans and assesses pipeline condition, have been investigated. Each method was found to have drawbacks with respect to cost and length of pipeline able to be cleaned.

After further investigation, an innovative and environmentally friendly cleaning method, ice pigging, was identified. Ice pigging uses ice slurries as viable semi-solid pigs. This process in many ways mirrors conventional pigging without the need for installation of specialised launchers and catchers.

The advantages of ice pigging over other methods used by GCC appeared to be numerous; ice pigs never get stuck in the pipeline; if lost in the pipeline ice pigs will eventually melt; ice pigs are able to negotiate extreme changes in pipe size and direction; and ice pigs don’t require the installation of launchers or catchers thus reducing overall cost.

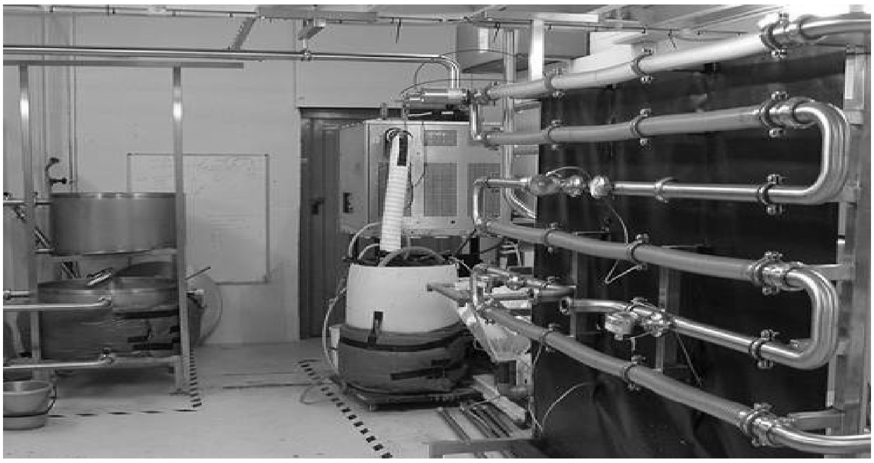
2.0 DISCUSSION

2.1 The Science Behind Ice Pigging

The science of ice pigging is based on harnessing the benefits of the extremely complex nature of semi-solid ice and particularly ice slurries.

During the late 1990’s and early 2000, Professor Joe Quarini of Bristol University undertook a series of experiments to prove that when correctly controlled, ice slurries could:

- Be successfully pumped and have the ability to form a semi-solid pig.
- Produce a cleaning ability more efficient than high velocity water.
- Transport fine and heavy sediment at velocities lower than can be achieved by water.
- Maintain its cleaning ability whilst negotiating pipe bends and accommodating changes in pipe size.



<u>Figure 1:</u> ***Ice pigging test facility at Bristol University***

Put simply the major benefit seen in ice slurries are their ability to be pumpable, behaving like a liquid; and yet in pipelines, they behave as a solid thus increasing the sheer stress on the pipe wall to successfully clean the internal lining of water mains.

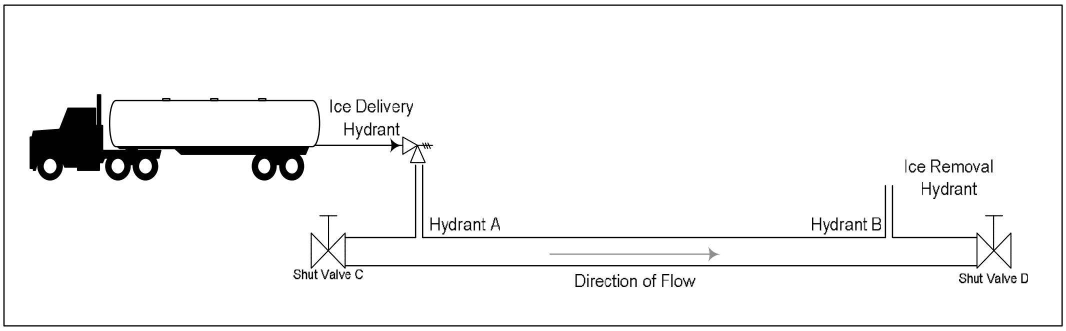
To maintain the qualities listed above, the ice slurry must maintain its consistency. This means that the ice must be maintained as a series of individual ice crystals. Over a period of time, ice crystals will be subject to Ostwald's ripening theory whereby ice crystals tend to stick together and form a solid mass as the ice ages. To maintain the ice in single crystals, a freezing point depressant and mechanical agitation is used. In ice slurries used to clean potable water mains, a uniquely designed brine solution is used.

2.2 Ice Pigging in Action

Once the theory of ice pigging was proven in the testing facility and a number of field-based trials were successfully carried out, a vehicle was constructed in Bristol to carry out ice pigging on a larger scale (see Figure 2). The vehicle itself consists of a large articulated truck used to carry a diesel generator, ice delivery pump and a geared stirrer. The stirrer is comprised of a stainless steel cylinder with a stirring device fitted to maintain the ice at the correct consistency as it is transported to site. The ice itself is produced by specialist ice making machines and pumped into the storage container for transport

<u>Figure 2:</u> ***The ice delivery truck onsite ready to begin pigging***

It is once onsite that ice pigging really changes the process of mains cleaning. Pigging a water main has always included the laborious process of removing a launcher to install the pig and removing a catcher to retrieve the pig. Ice pigging however, uses the fittings already available such as hydrants, air valves or even manual air bleeds. The process involves pumping an ice slurry into the pipeline via a chosen fitting. Once the ice pig is in place, water pressure is used to propel the ice through the pipe to be recovered at a pre-selected exit point (see Figure 3).



<u>Figure 3:</u> ***Schematic of ice pigging process***

With reference to Figure 3, the section to be cleaned is isolated by shutting valves “C” and “D”. At this point hydrant “A” and “B” are opened and the pump on the delivery truck is used to force a high ice fraction, ice slurry into the pipe, filling approximately one-third of the total length. Hydrant “A” is then closed and the ice delivery line is removed.

Once the correct amount of ice has been pumped into the pipe, Valve “C” is opened. This allows water to push the pig along through the pipeline. Once the pig reaches the ice removal hydrant, a tanker is connected to the hydrant and the ice including the collected sediment is removed from the pipeline and transferred into the tanker. The water following the ice pig becomes clean very quickly and can be flushed to a stormwater line. During this flush, turbidity readings are taken at hydrant “B”. Once the turbidity readings reach acceptable levels, hydrant “B” can be shut and valve “D” can be opened returning the system to normal operation.

To fine tune the ice pigging operation, monitoring equipment is placed at the inlet and outlet hydrants to test for temperature, flow rate and conductivity (salt content). Ultimately the results of these tests are used to monitor and control the ice pigging operation. Added to this, samples are taken from the outlet hydrant to study particulate removal rates.

To date the results recorded by ice pigging show significant improvements in iron and turbidity concentration and improvements in chlorine residual.

2.3 Ice Pigging: Where to From Here

So far, ice pigging has been used to clean over 100km of DN75mm to DN450mm pipes, most of which has been carried out in the United Kingdom. Figure 4 lists ice pigging achievements up to April 2010.

	Material	Diameter (mm)	Length (m)
Ferrous	Cast Iron	75	1475
		150	1600
		200	4412
		225	1906
		250	1666
		300	1380
		375	5050
	Spun iron	300	1550
	Ductile iron	300	516
		400	1330
		450	1100
	Steel	200	2400

	Material	Diameter (mm)	Length (m)
Non ferrous	Asbestos cement	150	5980
		200	23795
		250	4922
		300	25220
		450	900
	MDPE	300	4800
	HPPE	315	450
	PVC/UPVC	150	4800
		200	1389
		400	3750

Figure 4: *Ice pigging completed to April 2010*

It is believed that this is the start of what could soon become a worldwide phenomenon. Figure 5 indicates the international interest in ice pigging.

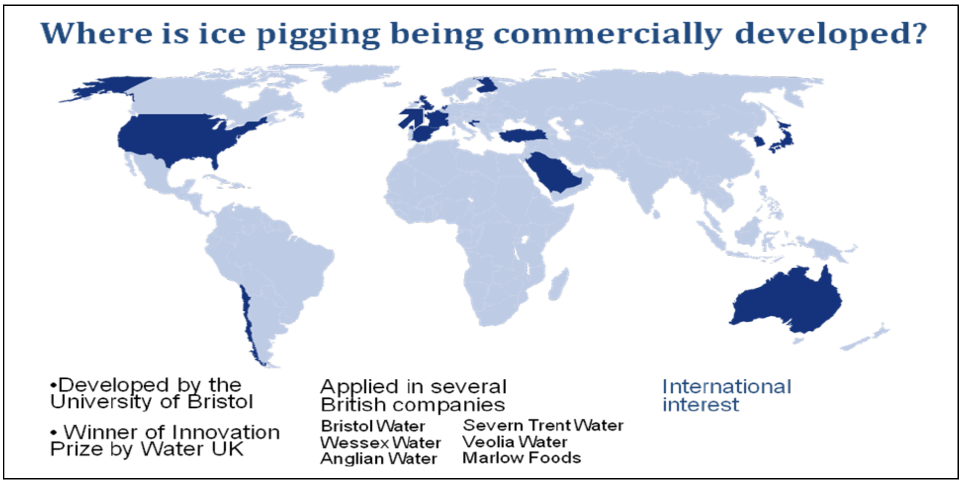


Figure 5: *Worldwide locations investigating ice pigging*

A visit to Australia by staff from Agbar Environment in September 2010 has led to arrangements being made for an ice pigging trial to be conducted in October 2011. To date, discussions are underway with three water companies from Queensland, three from Victoria and one from N.S.W.

3.0 CONCLUSIONS

Ice pigging, based on data obtained from overseas trials, is an innovative and successful technique for cleaning water mains, which uses pumpable ice slurries to replace the more traditional sponge-type pigs. Overall the benefits to the water industry come in the form of reduced costs, gentle but effective cleaning reducing the potential for pipe damage and reduction in down-time for water mains needing cleaning. It is also possible to add other products to the ice, in the form of sand to increase it cleaning ability and increased chlorine to assist in removal of biological contaminants

Further benefits of ice pigging are inherent in the process itself. Its ability to negotiate pipe size and directional changes with ease, to utilise existing fittings for the introduction and removal of the ice pig without the need for purpose-built launchers and catchers, and to achieve a reduction in iron and turbidity and an increase in chlorine residuals means that this technology appears to be a suitable and cost effective replacement for flushing, air scouring and swabbing.

Finally, given its cost effectiveness and overall ease of use it is the opinion of the author that ice pigging will soon be the standard method used for water main cleaning.

4.0 ACKNOWLEDGEMENTS

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