



UNSURPASSED SYNERGY
CEMENT MORTAR LINING'S PROVEN SUPERIOR
PROTECTION WITH SINTAKOTE[®] STEEL PIPELINES

FOR POTABLE WATER AND AGGRESSIVE FLUIDS APPLICATIONS

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CEMENT MORTAR LINING AND SINTAKOTE® STEEL PIPELINES

The facts behind cement mortar lining in today's steel water pipelines.

OUTLINE

Cement mortars are worldwide the most commonly used lining for potable water and sewage pipelines in the water industry today. Why?

Put simply, cement mortar linings systems:

- 1 provide active protection, superior to barrier coatings
- 2 satisfy both national and international Standards for contact with potable water
- 3 can be rapidly applied within strict tolerances
- 4 are robust and impact resistant
- 5 are suitable for a wide range of applications
- 6 are easily reinstated
- 7 have a service life in excess of 150 years

It's easy to make claims like this, couched in generality without specifics, and manufacturers promoting other linings often do just that. However, to demonstrate the veracity of the above claims, we have collated the facts, science and logic that stand behind each statement above. We have addressed each of the areas above AND the more specious claims made about alternative lining systems.

There is only one justified conclusion: cement mortar lining (CML) offers superior protection to ductile iron and steel pipelines.

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1 PROVIDE ACTIVE PROTECTION, SUPERIOR TO BARRIER COATINGS

Cement mortar linings provide active protection of ductile iron and steel pipelines by creating a stable hydroxide film at the metal/mortar interface. The corrosion protection is referred to as active because it provides protection even where there are discontinuities in the lining.

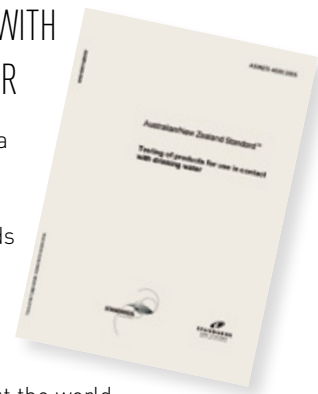
This is in stark contrast to polymeric linings such as epoxy, which are barrier linings, and require 100 per cent integrity to achieve corrosion protection. Any discontinuity will result in corrosion.

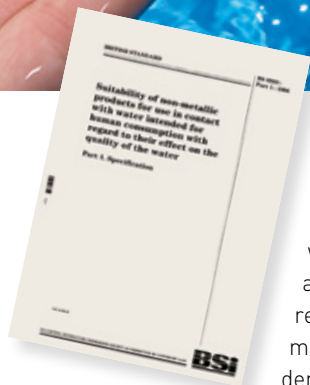


2 SATISFY BOTH NATIONAL AND INTERNATIONAL STANDARDS FOR CONTACT WITH POTABLE WATER

Cement mortar has a demonstrated track record in conveying water for long periods to required water quality standards, and currently meets all applicable standards throughout the world. Cement mortar does not support microbiological growth.

In situations where the conveyed water is aggressive, and the flow rate is low (resulting in a long residence time), a high pH can develop with cement mortar lined pipe. This is not a health issue and is simply prevented by the use of a seal coat. Seal coats provide an elegant engineering solution, by maintaining the best internal





protection for water pipelines, at a low cost, whilst ensuring all water quality requirements are met. They have a demonstrated track

record of over 70 years and meet the requirements of AS/NZS 4020¹¹.

It has to be noted that all pipeline materials, including epoxies, will leach some compounds into the water. Many epoxy linings are suitable for water contact; however it is critical that the mix ratios are carefully controlled, as any variation to the exact ratios can result in unacceptable organic compounds being leached into the water. This has occurred in the past.



3 CAN BE RAPIDLY APPLIED WITHIN STRICT TOLERANCES

A major benefit with cement mortar is the ease of application. The mixing and application of mortar is straight forward, leading to low risks in application. This is a significant advantage over epoxy linings that require careful control of ambient conditions, mix ratios, curing, etc.

Cement mortars are typically mixed with a cement/sand ratio of 0.30 to 0.40. They are mixed with water to form a slurry that is delivered to the rotating pipe in closely controlled quantities. Once the slurry is delivered, the pipe's rotation is accelerated to rotational speeds of as much as 1200rpm and radial accelerations of as much as 200g. This rapidly consolidates the mortar driving off excess water and leaving a densely compacted lining. Tight dimensional control is achieved through accurate batching, controlled delivery, rotation and compaction. Minimum thicknesses can thus be achieved and fitness for purpose assured.



4 ARE ROBUST AND IMPACT RESISTANT

Exponents of epoxy linings point to their low weight as an advantage. The weight of pipe is rarely a limiting factor for truck loading. The only possible cost is with handling and installing the pipe at site. As machinery is always required there is rarely a cost advantage with lighter pipe.

The biggest issue in installation of pipes with epoxy linings is the internal reinstatement of welded field joints. Such reinstatement requires entry into pipes via the epoxy lining, blasting and application at the joints, all to the same specification that applies for the pipe body. The poor damage resistance of such thin linings makes this an horrendous chore, which is likely to result in many repairs, and reduced performance at joints.

Another significant issue is end damage where epoxy is used in the rubber ring joint region. The low impact resistance of epoxy means such areas are easily damaged.

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The controlling factor in determining the pipe wall thickness of water pipelines, especially for larger diameters, is pipe stiffness. One huge benefit of cement mortar is its high contribution to pipe stiffness. For example, in a 1 metre diameter pipe, the contribution of cement mortar to pipe stiffness is equivalent to more than 2mm of steel wall thickness. Conversely if one uses an epoxy lining in place of cement mortar, the pipe would need an additional steel wall thickness of more than 2mm to maintain the same stiffness. This adds a huge cost to the use of epoxy linings.



ARE SUITABLE FOR A WIDE RANGE OF APPLICATIONS

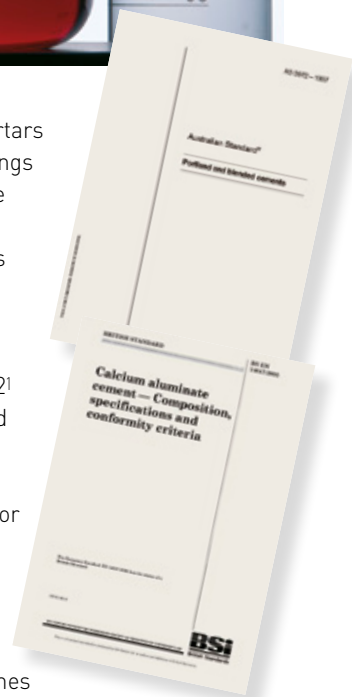
Cement mortar linings intended for potable water can be enhanced with a seal coat to protect them from aggressive waters such as those with low hardness and low alkalinity. Normally a bituminous seal coat is applied to a minimum dry film thickness of 100µm. Adhesion tests confirm proper application and fitness for purpose. Seal coats limit the diffusion of free lime from the cement to such an extent that a service life in excess of 150 years can be assured in the most aggressive waters.

In aggressive applications such as very low pH, high CO₂ or very high sulfates, calcium aluminate cement can be used to resist attack and protect the ductile iron or steel substrate. Applications include aggressive gravity sewage, bore water, sewage and effluents.

Cement mortars used for linings are available in various formulations and are specified to comply with AS 3972¹ Portland and blended cements or EN 14647² (for aggressive wastewater pipelines).

Potable water pipelines use cement supplied to AS 3972.

Wastewater pipelines use cement supplied to either AS 3972 or EN 14647 depending on the aggressiveness of the wastewater.

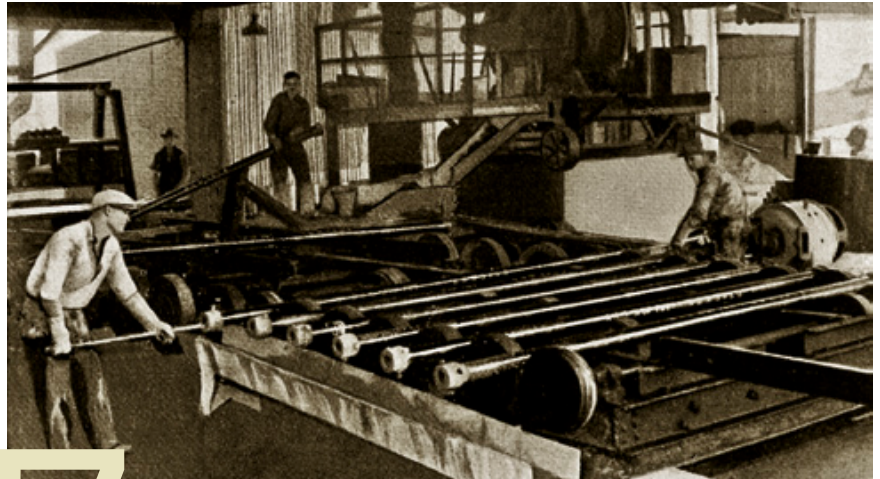




6 ARE EASILY REINSTATED

Cement mortar linings are easily reinstated if damaged.

Simple reinstatement kits are available ensuring the proper materials, mixing, surface preparation and application procedures are employed.



7 HAVE A SERVICE LIFE IN EXCESS OF 150 YEARS

Cement mortar has been used to line pipe since the 1840's. In the 1920's the process of centrifugal spinning was perfected. This process allowed the rapid application of linings to the entire pipe surface by placing a mixture of sand, cement and water into the pipe and rotating it at high speed. The centrifugal forces distribute the lining around the pipe circumference and compact it against the pipe wall. At the same time excess water is spun out, leaving a smooth surface mortar, with a very low water to cement ratio. Together with the low void content this results in a strong, low permeability cement mortar lining. Note these linings perform much better than cast concrete, due to the high cement content, low void content, and low water content of cement mortar.

The long history and performance of cement mortar contrasts with that of the newer liquid applied polymeric linings, such as epoxy. Whilst suppliers claim epoxy has been used for up to 40 years, continual changes to formulations mean very few, if any, have remained without a formulation change over a 10 - 20 year timeframe.

Cement mortar linings provide demonstrated long-term protection at a low cost, and consequently they remain the standard lining for potable water pipes.

Alternative linings, such as liquid applied epoxy, have not gained widespread acceptance because they do not provide the longevity generally required for water supply pipelines.

The long service history of cement mortar has allowed for continual assessment of performance. Recent tests have been undertaken on cement mortar taken from pipes that had been in service for 64 years (in NSW), for 40 years (in Tasmania), and for 34 years (in Victoria). Assessment of the samples

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verifies that a service life in excess of 150 years will be attained, even when conveying aggressive waters.

This performance is in contrast to that experienced and predicted for epoxy linings. The literature indicates a life of 30 - 50 years for 0.8 to 1mm minimum thickness epoxy. This information indicates a service life of 20+ years for epoxies that have a minimum thickness of 0.4mm. Such predictions are in line with the failures observed on a significant 24 year old epoxy lined pipeline in Australia.

ASSESSMENT OF THE WSAA APPRAISAL OF ORRCON EPOXY LININGS

The WSAA Appraisal³ discusses documents related to service life, but the only one referenced is an AwwaRF document⁴. That document reviews the service performance of epoxy linings applied at a thickness of 1mm to rehabilitate old mains. The pipelines range from 1 to 25 years old, with only five more than 10 years old. Three pipelines were found to be in poor condition, the two oldest at 20 and 25 years old, and the other at 1 year old. The 1 year old lining was Hycote 162 PWX, one of the epoxies promoted by Orrcon. This lining had an average thickness of 1.24mm, but exhibited many holidays, and blisters after 1 year in service.

The "Discussion" part of the WSAA appraisal states that whilst the thicknesses of the AwwaRF linings are 1mm it doesn't provide support that 0.5mm linings will also provide an equivalent life.

Such a conclusion is contrary to what's stated in the AwwaRF report. On page 52 of the report it states that barrier properties are governed by factors such as film thickness. On page 68 it states that film thickness is an important effect, where rusting was considerably worse under a 0.5mm lining compared to a 1mm lining. In addition the assessment of life is based on impedance, which is dependent on lining thickness. On page 74, it states that theoretically the impedance increases linearly with thickness, and that higher impedance was found as a result of higher thickness.

The 40 to 60 year life predicted uses electrochemical impedance spectroscopy, a method still in its infancy for life prediction, and evaluating only a very small lining area—8cm². The life is for a 1mm thick lining and needs to be reduced for the 0.4mm minimum thickness lining used by Orrcon. Using the theoretical linear relationship gives a life of 16 to 24 years.



We have reviewed some other documents from the literature as follows:

The WRC Code of Practice⁵ states that epoxy lining has a 75 year life and refers to Warren et al's paper⁶ as the source. However reference ⁶ states that for a 0.8mm minimum thickness epoxy the expected life is 40 to 50 years. It does not say epoxy has a 75 year life. As the service life relates to permeation, defects in the lining, and deterioration, it is reasonable to scale down the life expectancy according to lining thickness. For a 0.4mm minimum thickness epoxy (Orrcon lining) the 40 to 50 year life translates to a 20 to 25 year life.

UK water utilities expect a useful life of 30 to 35 years for a 1mm thick epoxy liner⁴.

A later paper from Warren et al⁷ states that epoxy linings (at 1mm minimum thickness) will provide corrosion protection for a period of 30 to 50 years. This is a much lower estimation than provided by the author in 1990, and again indicates a much lower life would result for 0.4mm thickness linings.

One major experience Steel Mains has had with the use of epoxy linings is a 54km long, 610mm OD steel RRJ wastewater pipeline supplied in 1980. It had a 0.4mm minimum thickness solventless epoxy lining and end coating, so the system was very similar to that now offered by Orrcon. The lining was specified by the State Rivers & Water Supply Commission (SR & WSC) after extensive investigation and represented 'state of the art' epoxy technology. It combined a Bisphenol A resin with an amine curing agent, and 100% solids content. SR & WSC also undertook strict testing and inspection of the lining at the place of application.

Surface preparation was a Class 3 finish using steel grit. Testing included full high voltage continuity testing at several thousand volts. Despite the high level of inspection we are informed that the lining is in a poor state, having blistered in parts, and with some loss of lining. Additionally, there have been pipe perforations due to internal corrosion.

The information provided indicates the inspection of Orrcon lined pipe is inadequate with regard to holiday testing, because it may not normally cover 100% of the surface, and the applied voltages are too low. The use of NACE RP 0188⁸ is not appropriate, as the Foreword of that standard specifically excludes liquid applied coatings on pipelines. The required voltage for 0.4mm thick lining to NACE RP 0188 is half the requirement specified in AS 3894.1⁹ and AS 3862¹⁰, and will not locate weak areas in the lining.

In summary all the information we have leads us to the view that a reasonable expectation for the Orrcon 0.4mm minimum thickness liquid applied epoxy is a 20 to 25 year life, not the 50 year life estimated in the appraisal.



CONCLUSION

The water industry in Australia generally requires a 100 year life for pipelines. For pipe lining this is achieved with cement mortar lining, a proven technology that meets all the customer requirements, and provides the best lining for the water industry by every measure. There is only one justified conclusion: cement mortar lining offers superior protection to ductile iron and steel pipelines.

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8. NACE RP 0188, Discontinuity (Holiday) Testing of new protective coatings on conductive substrates
9. AS 3894.1-2002 Site testing of protective coatings - Non-conductive coatings - Continuity testing - High voltage ('brush') method
10. AS/NZS 3862:2002 External fusion-bonded epoxy coating for steel pipes
11. AS/NZS 4020 Testing of products for use in contact with drinking water



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