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Industry Guidelines

EXPECTED SERVICE LIFE OF ELASTOMERIC PIPE SEALS

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EXPECTED SERVICE LIFE OF ELASTOMERIC PIPE SEALS

It is accepted that the expected service life of plastics pipes used in infrastructure work exceeds 100 years. This document considers whether it is reasonable to expect elastomeric seals used in both water and sewerage applications to match this performance. The analysis assumes that prior to installation, any seals made of polymers that are subject to ozone and UV attack are stored correctly and protected from ozone and weather. Before installation, seals should be stored in accordance with the appropriate Standards and manufacturer's instructions.

Considering the range of potential failure mechanisms for elastomeric seals and the unlikelihood of them occurring in an installed pipeline it is concluded that the seals are expected to provide a service life commensurate with that of the pipe. Coupled with experience to date, this suggests there is no reason to expect pipe seals to fail within 50 years and >100 years is not an unreasonable expectation.

Elastomeric seal jointed PVC pressure pipes installed at Millewa in northwest Victoria in about 1970 continue to function satisfactorily. Samples exhumed in 1996 for critical examination in the laboratory exhibited no signs of deterioration of the seals or the pipes. Similarly, some of the PVC sewer pipes with elastomeric seal joints installed in Ipswich, Queensland in 1975 were exhumed in 2000 and examined in the laboratory. Again no signs of deterioration of the seals or the pipes were evident and the pipes continue to perform.

The longevity of elastomeric pipe seals is further supported by the following statement that appeared in the preface of Australian Standard AS1646-1974, *Rubber Joint Rings for Water Supply, Sewerage And Drainage Purposes.*

> "Records are available which show that large numbers of rubber seals used in water supply installations have given excellent service for up to 100 years. However, some rubber rings in sewerage pipelines and to a lesser extent in water supply pipelines, have been reported to have deteriorated in a comparatively short time after being put into service, supposedly as a result of bacterial attack. It should be recognised therefore, that when rings are intended for use where a micro-organism attack hazard is high, special precautions may need to be taken to ensure that the rings are non-susceptible to such attack".

Subsequent research demonstrated biological attack was only observed in natural rubber seals and after the depletion of the antioxidant(s). From the 1970s, a minimum concentration of a particular combination of antioxidants was specified by water and sewerage utilities. Natural rubber seals manufactured subsequent to these requirements being imposed have not been observed as suffering micro-biological

attack. The evidence suggests that the expected service life referred to in the 1974 version of AS1646 (i.e. 100 years) is still valid.

This assessment of potential service life has been performed by considering all of the known, potential failure mechanisms and determining whether they will impact on installed pipe seals.

Potential failure mode - and likelihood of occurrence.

1. **Ozone attack.**
    a. Description
    Many elastomers are subject to ozone attack although some, for example EPDM show resistance. Additives can be added to susceptible elastomers to provide resistance to ozone. Ozone resistance testing of seals is required under AS1646.

    b. Potential Risk
    Installed pipe seals, especially those in buried applications will not be exposed to ozone and ozone attack is not a likely failure mechanism.

2. **Weathering, including UV degradation.**
    a. Description
    Long-term exposure to weather and UV radiation will cause many elastomers to undergo surface degradation and cracking.

    b. Potential risk.
    As with ozone attack, weathering and UV exposure will not occur with in situ pipe seals.

3. **Stress relaxation**
    a. Description
    When an elastomer is compressed between two surfaces, as in a pipe joint, it exerts a resistance force against the surfaces. The viscoelastic characteristics of the polymer results in this force diminishing with time.

    b. Potential risk.
    Stress relaxation of the elastomer should not cause a problem with captive seal joints in pressure pipes. The design of plastics pipes joints is such the water pressure inside the pipe tends to increase the interface pressure between the seal and pipe. The water pressure helps create the sealing effect.

    In the case of non-pressure pipe joints the joint design and material selection takes into account the stress relaxation characteristics of the elastomer. This is achieved by using an elastomeric compound with known and acceptable stress relaxation characteristics and requiring the joint to have a high initial interface pressure between the seal and the pipe. Although relaxation of the elastomer will occur, the residual interface pressure will still be high enough to effect a seal.

4. **Compression Set**
    a. Description
    Compression set is a characteristic of elastomers determined by assessing the loss of recovery of a specimen allowed to recover after being compressed between parallel plates for a prescribed period. It is a comparatively short-term test (3 day exposure) and can be performed under various environmental conditions. Compression set is not the same as stress relaxation but if all other characteristics are unchanged, a consistent compression set provides confidence in the consistency of the stress relaxation.
    b. Potential Risk.
    See Stress Relaxation.

5. **Microbiological attack**.
    a. Description
    According to the published technical literature natural rubber (NR) seals can be subjected to microbiological attack in situ and result in gross degradation of the seal. The evidence is that this only occurs after the antioxidant system is depleted. As a counter to this, the Australian Standard for elastomeric pipes seals introduced some 30 years ago, specific requirements for the antioxidant content of NR seals. No microbiological attack has been reported on seals made since the antioxidant was prescribed.

    b. Potential risk.
    This mode of failure is not considered relevant to pipe seals made of synthetic rubbers. For natural rubber seals made since the type and concentration of antioxidant was first prescribed, no failures have been reported

6. **Termite attack**.
    a. Description
    Termites eat cellulose based products such as timber. They are also known to attack materials that do not comprise a food source but which the termites happen upon. Elastomeric seals fall within the hardness range that termites can attack with their mandibles.

    b. Potential risk.
    There are no confirmed reports of termites attacking in situ pipe seals in plastics pipes. Given that captive seals are largely protected from exposure to termites and the seals are not a food source failure resulting from termite attack is unlikely.

7. **Chemical attack**
    a. Description
    Elastomers comprise polymers to which are added a variety of fillers, antidegradants, oils and curatives. Exposure to chemicals that can attack and break or alter the polymer chains, or penetrate into the polymer matrix, will degrade the mechanical properties of the seal.

    b. Potential risk

Elastomers generally exhibit good resistance to a wide range of chemicals but some elastomers might be susceptible to attack by some chemicals used in reticulated water systems or illegally dumped in sewers. However, the surface area of the seal that is exposed to the contents of a pipe is small and the effect is minimal. There have not been any reports of seals failing due to chemical attack in normally operated systems.

In the case of water pipes installed in contaminated ground it might be necessary to consider protecting the joints, perhaps by sleeving the pipe inside an impervious barrier. This applies, whatever the pipe material.

8. Oil absorption.

a. Description
Elastomers of different types exhibit a wide range of responses to oils. The magnitude of the response depends upon the type of polymer used in the elastomeric compound and the type of oil. For example, different responses occur with aromatic oils compared to aliphatic. In those instances where there is a response, the oil is absorbed by the polymer. The polymer swells and the mechanical properties degrade.

b. Potential risk.
Water pipe seals are not to be exposed to oils failure by this mechanism is not expected. Sewer pipe seals are not normally exposed to oils for long periods. If there is contact with oil through accidental or illegal spills, only a small part of the seal surface is exposed and the effect should be minimal. Seals made of general purpose elastomers have performed satisfactorily for many years, even in locations where they are subjected to trade discharges. For an installation where oil resistance is very important consideration should be given to using nitrile rubber seals.

9. Environmental stress cracking (ESC).

a. Description
A combination of environment and tensile stress can lead to stress cracking in plastics and rubbers.

b. Potential risk.
The environmental conditions leading to ESC are unlikely to occur with an in situ pipe seal. Moreover, the seals are mainly in compression rather than tension and therefore stress cracking is not a risk