WHITEPAPER

# HOW TO SELECT THE MOST SUITABLE CONCRETE COATING SOLUTIONS IN THE WATER AND WASTEWATER INDUSTRY

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# ABSTRACT

When attempting to specify a protective coating for concrete services in water treatment systems, understanding the Key Performance Indicators (KPIs) required for a coating to perform well is a great starting point. To do this effectively, we need to understand the type of corrosion attack the concrete will be exposed to and then develop a robust understanding of the root cause of that corrosion mechanism. Once we understand the form and effects of the corrosion mechanisms, we can better select a coating technology that suits the exposure. Other factors, such as health and safety, cost, and technical support requirements, may impact a decision. However, from an engineering and operations perspective, selecting the right coating for the job based on identifying KPIs is the first step.

This paper will explore the various forms of corrosion affecting water infrastructure potable and wastewater systems, categorize the main types, provide examples and explanations for their root causes, and demonstrate their impact on surfaces, whether uncoated or coated with an incompatible technology. Additionally, compatible coating examples will be presented as potential solutions, with additional key performance indicators that may have been overlooked in the decision-making process.

# 1.0 INTRODUCTION

Concrete is one of the most economical and robust building materials. The material ensures our roads don't buckle, our homes don't crumble, and our dams don't burst. There are unlimited applications for where and how concrete can be used. Its incredible versatility to be sculpted and moulded into almost any shape or form and its weight and durability make it the ideal foundation for modern life. However, one drawback is that it is susceptible to erosion, corrosion, and abrasion damage.

This susceptibility to deterioration can have damaging and, in extreme cases, disastrous effects on water infrastructure and wastewater systems. Systemic infrastructure failure due to insufficient concrete coating or technology is avoidable. However, to solve a problem, it must first be understood. When equipped with the knowledge and best practices, operators of water and wastewater plants can ensure all concrete surfaces prevent corrosion from occurring in the first place.

# 2.0 DISCUSSION

The following observations and images are based on A.W. Chesterton Company's experiences in North America. However, they equally apply to water and wastewater operations throughout the Asia Pacific region.

The key focus area of this content is the corrosion mechanisms most commonly affecting concrete structures in water and wastewater systems, such as clarifier rake arms, effluent dosing pits, effluent pump sleeves, wet well tanks, and treatment plant flooring. The paper then provides the key performance indicators required of a protective coating to address the problem. Our aim is this paper will form a useful guide for businesses considering options for a protective coating strategy for their operations.

# 3.0 CORROSION OF CONCRETE

The cost and effort of maintaining concrete elements can be substantial when it comes to industries such as oil and gas, utilities, and infrastructure. Common issues include:

- Thermal expansion and contraction
- Cracking and delamination
- Damage from mechanical processes
- Destabilisation and damage from chemical exposure
- Atmospheric exposure
- Erosion and corrosion

Let's take a closer look at two common corrosion types regularly experienced in the wastewater industry.

## 3.1 Corrosion of concrete – Microbiologically Influenced Corrosion (MIC)

MIC is commonly found in wastewater treatment collections and treatment facilities in aerobic and anaerobic conditions.

The primary form of MIC in wastewater treatment plants is biogenic sulphide corrosion (Figure 1), which occurs when anaerobic Sulphate-Reducing Bacteria (SRB) metabolise the sulphate ($SO_4^{2-}$) ions that are rich in the untreated wastewater flows.

The SRB's metabolic process consumes oxygen; the resulting by-product is the sulphide ion (S2–). This ion is released into the water flows. The sulphide ions combine with hydrogen in the water flows to form hydrosulphide or bisulphite (HS–) ions. These ions react further to form hydrogen sulphide (H2S), which continues to build to saturation levels.
In turbulent flows, the H2S gas and carbon dioxide (CO2) are released into the humid enclosed head spaces commonly seen in wet wells and lift stations, collection pipes, grit chambers, and primary and secondary clarifiers.

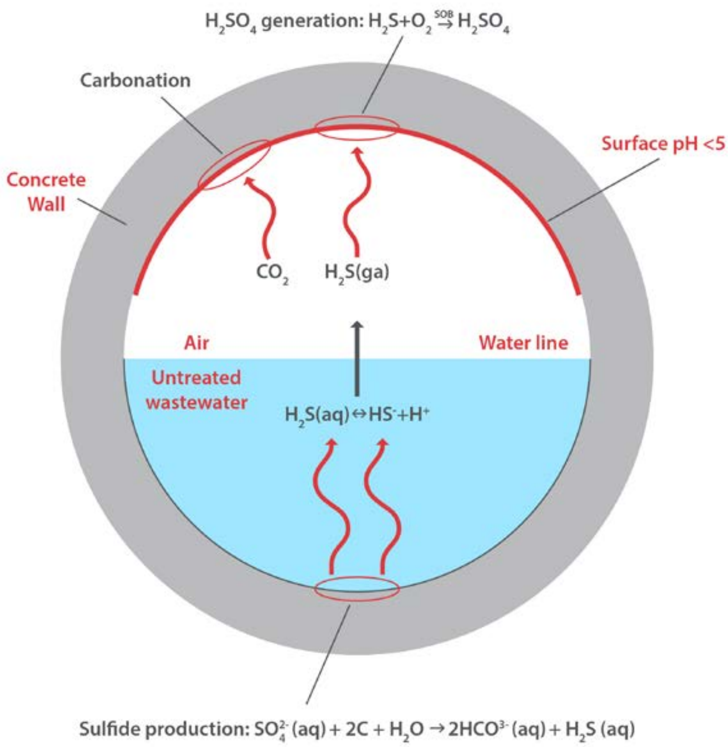


**Figure 1. Microbiologically Influenced Corrosion**

In the MIC processes the dilute sulfuric acid is present in enclosed head spaces of many wastewater-associated concrete structures such as manholes, wet well/lift stations, junction boxes, collection pipes (force and gravity flow), bar screen chambers, clarifiers and sludge tanks.

The corrosion reactions are significantly faster and more dramatic when concrete is the exposed substrate. This is primarily due to the alkaline nature of concrete (12.5 when freshly poured) reacting with the dilute sulfuric acid, which can easily assume pH levels of <2. The acid reacts with and converts the cement calcium hydroxide to calcium sulphate salts, easily dissolved in water. This leads to the loss of the cement paste and the release of the aggregate and sand constituents in concrete, eventually exposing any structural members embedded into the concrete. The resulting surface can be exceptionally rough and difficult to coat with thin (<1mm) coatings.

Figure 2. Biogenic corrosion in enclosed head space of concrete bar screen chamber

These gases combine with the humid atmosphere and form weak thiosulphuric and carbonic acid, which depresses the surface pH. Once the pH drops below 9.5, naturally occurring Sulphur Oxidizing Bacteria (SOB) can colonise on the surface and metabolise the H2S generating a weak sulfuric acid. This can result in surface pH <5 (Figure 1).

## CASE STUDY – Wet Well Microbiological Corrosion

**Issue:** H2S gas damaged the concrete in a wet well and sludge tanks, leading to coverage loss and aggregate dislodgement.
**Goal:** Protect against further aggregate loss and preserve the wet well structure.
**Root Cause:** Hydrogen sulphide gases from microbiological corrosion caused damage to concrete.
**Solution:** High-pressure water blast surface to pH between 7 and 10. Sweep sandblast surface to ICRI CSP3 finish (Figure 2.1). Apply a high-build, mineral-reinforced protective coating to a wet film thickness of >3 mm / 120 mils (Figure 2.2).

**KPIs of coatings for concrete surfaces intended for MIC corrosion exposures**

- High tensile adhesion (>20 MPa) to resist under-film corrosion on steel
- Resistance to low pH (10% H2SO4)
- Resurfacing and barrier topcoats with edge retentive capability to prevent pinholes in applied films when applied on heavily pitted surfaces
- Low surface energy to reduce biofilm build-up

Figure 2.1 Wet well high-pressure cleaned and abrasive sweep sandblasted

Figure 2.2 Surface of wet well with final coat of protective coating for concrete

### 3.2 Corrosion of concrete – Acid / Chemical Attack

The same acid-base reaction occurs when process chemicals used in wastewater treatment plants encounter unprotected concrete. Chemical attack frequently occurs when sulfuric acid is present and used as a buffer and when ferric chloride and alum are used as flocculating agents. The areas more prone to attack tend to be containment and dose mixing stations, but the result is like a MIC attack. Initially, starting with the concrete's etching, then progresses as the cement paste is broken down to expose the aggregate, and eventually, rebar corrosion and spalling if left unaddressed.

Figure 3. Acid attack of concrete in sulfuric acid containment

### CASE STUDY – Chemical Attack on Concrete Inlet

**Issue:** Concrete surfaces at a dairy plant waste treatment inlet area were severely degraded due to chemical attack (Figure 3.1).
**Goal:** Repair damaged concrete and protect it from future chemical attacks.
**Root cause:** Hot (70°C/158°F) inlet waste ranging in pH from acidic to caustic was causing severe degradation of the concrete.
**Solution:** Decontaminate surface and mechanically grind to CSP3 finish. Apply quartz-reinforced concrete resurfacer at 6 mm (240 mils) to rebuild damaged concrete. Apply a mineral-reinforced severe chemical-resistant concrete coating at 0.8 mm (30 mils) to protect rebuilt concrete from further attack (Figure 3.2).

**KPIs of coatings for concrete surfaces intended for chemical exposures**

- Resistance to low pH from concentrated and dilute H2SO4. FeCl-, NaOH, NaOCl)
- Impact and abrasion resistance
- Low coefficient of thermal expansion for when thermal cycling exists
- Resurfacing and barrier topcoats with edge retentive capability to prevent pinholes in applied films when being applied on heavily pitted surfaces

Figure 3.1 Damaged coating

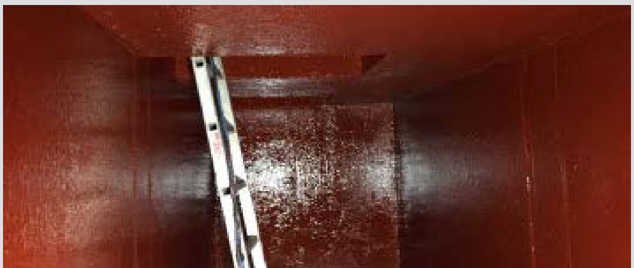

Figure 3.2 Concrete resurfacer and chemical resistant coating applied

# 4.0 CONCLUSION

Equipped with the knowledge of common corrosion types and the key performance indicators required of protective coatings, wastewater system operators can make more informed decisions about which products are necessary for concrete services in water treatment systems.

# 5.0 RECOMMENDED STEPS

An effective way to accurately identify which coating is suitable for a particular application is to consult with the product experts at Chesterton®.

Chesterton's ARC Industrial Coatings has a four-decade history of enhancing critical industrial equipment and structures. ARC Industrial Coatings are engineered to protect metal and concrete surfaces from the damaging effects of corrosion, erosion, and chemical attack.

One example is ARC S1HB, a single-coat, low VOC barrier coating that protects both metallic and cementitious surfaces from corrosive exposures. Its high-build, edge-retentive properties ensure maximum coating coverage over hard 90° edges and corners with minimal thinning at the sharp edges. ARC S1HB is resistant to a broad spectrum of corrosive agents, including H2S, hydrocarbons, wastewater flows, brackish and marine water exposures, as well as mild acid and caustic solutions.

Chesterton is a world leader in helping industrial companies improve the reliability and efficiency of their equipment. Chesterton has over 450 sales and service locations in 113 countries. Our 1,200 factory-trained local specialists and technicians work closely with customers in the field to help solve specific sealing and equipment reliability challenges.

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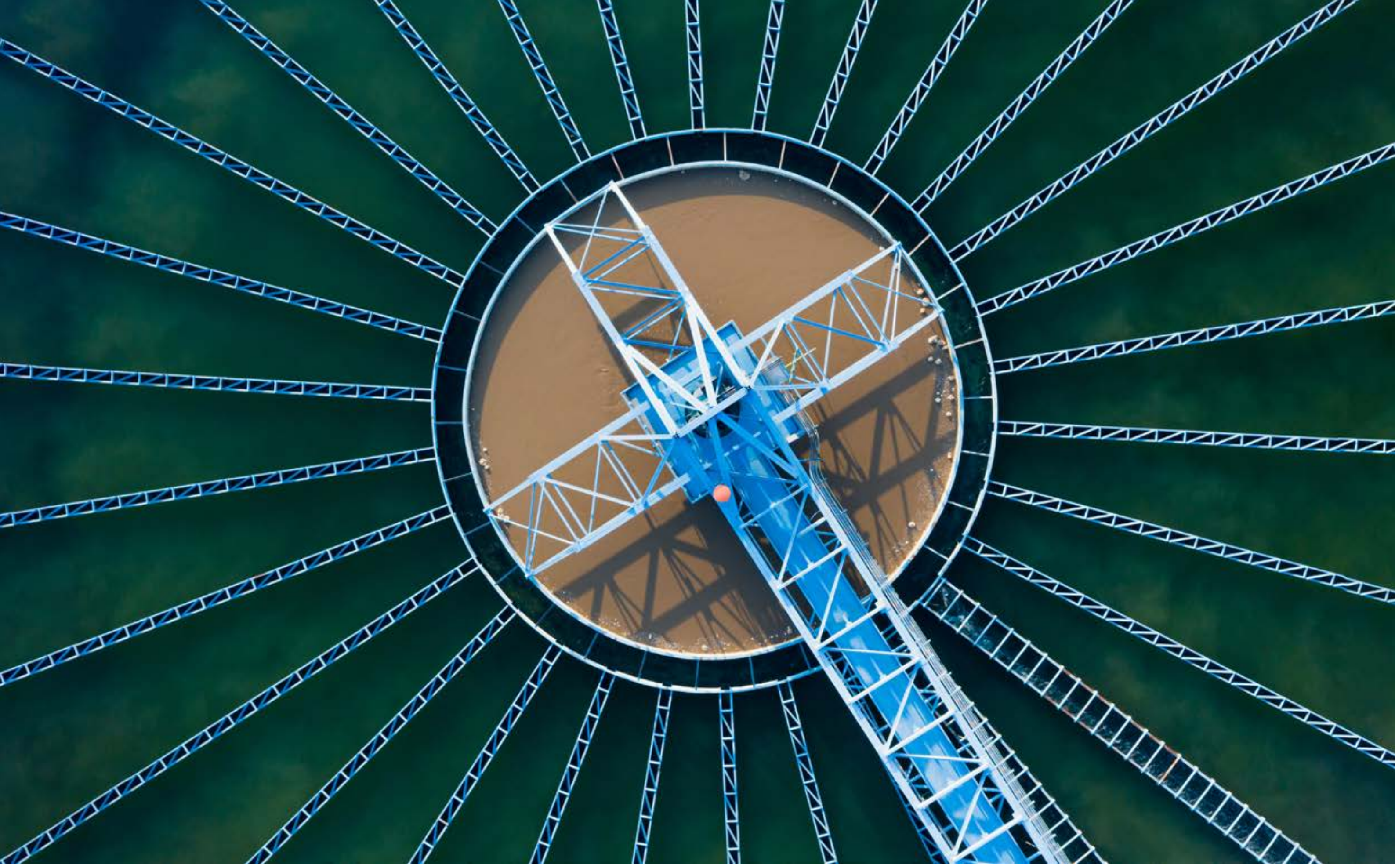

# ACKNOWLEDGEMENTS

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## Want to know more?

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## FOOTNOTES/REFERENCES


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