

“Dollars & Cents - You Make the Choice: A Look at Elastomer Polyurethane Versus Epoxy Laminate Lining Systems for The Linings of Water or Wastewater Structures”

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ABSTRACT

The use of protective coatings is to enhance the durability of concrete structures by creating a barrier that will limit the penetration of water, acids, chemicals, solvents, and chlorides that will breakdown industrial or municipal infrastructure. Corrosion in concrete is not just caused by the constituents of wastewater, it can also be caused by the cleaning procedures of water treatment or membrane bioreactor (MBR) systems. Lining solution technologies presented included systems comprised of 100% solids epoxies, epoxy laminate alternatives and elastomer polyurethane applications.

The purpose of this paper is to provide an understanding of two lining solutions: elastomer polyurethane and epoxy laminate systems. The paper will provide insight into the effects of corrosion on concrete infrastructures, identify the various lining solutions, compare, and contrast the application techniques, cost structure, product performance in these environments and highlight project impacts of these solutions that should be considered by specifiers and clients when selecting the lining system for their projects.

Keywords: Coatings, Protective coatings, Concrete, Corrosion control, Corrosion management, Cost, Water and Wastewater, Water and Utilities, Materials Selection and Design, Coatings and Linings, Epoxy, Elastomer Polyurethane

INTRODUCTION

Asset owners spend significant monies each year on the construction of new and the maintenance of existing infrastructure. More than ever, these funds can be difficult to procure and budget. The owners include, both municipal and industrial entities and funds are limited in most cases, therefore, asset service life is very important to all parties.

The definition of Concrete Corrosion, “Concrete corrosion is the chemical, colloidal or physicochemical deterioration and disintegration of solid concrete components and structures, due to attack by reactive liquids and gases.”¹ Furthermore, the corrosion of the steel reinforcement, within the concrete, must also be considered.

Chemical causes of concrete corrosion include.

- Moisture Penetration
- Microbiological induced concrete corrosion from bacteria in wastewater (MIC)
- Sulfates
- Carbonation (CO_2)
- Chlorides
- Nitrates
- Fluorides
- Sulfide Attacks (H_2S)
- Industrial corrosive gases

Often, steel reinforcement (rebar) is corroded by electrochemical reaction. When the rebar corrodes, the resulting rust occupies a greater volume than the steel. This expansion creates tensile stresses in the concrete, which can eventually cause cracking, delamination, and spalling.

For the remainder of this paper, I will focus on the concrete corrosion in the wastewater industry. This includes the attack from moisture penetration, abrasive erosion, cavitation, freeze-thaw, cleaning chemicals, MIC, and H_2S . These structures include sewers, concrete tanks, channels, chambers, and manholes.

In the case of Microbiological induced corrosion (MIC), it is assumed that four events must happen to cause corrosion: (1) formation of liquid hydrogen sulfide (H_2S) that is dissolved in the water, (2) H_2S release from sewage/slime, (3) drop in concrete pH levels, and (4) sulfide oxidation.^{2,3,4,5,6}

Bacteria is part of the process because H_2S is formed as Sulfate-reducing bacteria (SRB) (See Figure 1). The bacteria colonize with the slime and sediments where they metabolize sulfur and sulfates from wastewater to H_2S . The dissolved H_2S is then released to the gas phase in the structure's headspace. As the H_2S gas penetrates the concrete surface and mixes with moisture and dissolves back to a liquid phase. The penetration into the concrete structure causes a lowering of the substrate pH. Simultaneously oxidation of H_2S to sulfur acid (H_2SO_4) takes place. Both will penetrate the concrete structure and react with the Portland cement. Corrosion could be caused by both the acid reaction and sulfate ions. The sulfate attacks the calcium hydroxide and the calcium carbonate in the concrete substrate. Either or both reactions compromise the cement matrix and result in concrete deterioration.

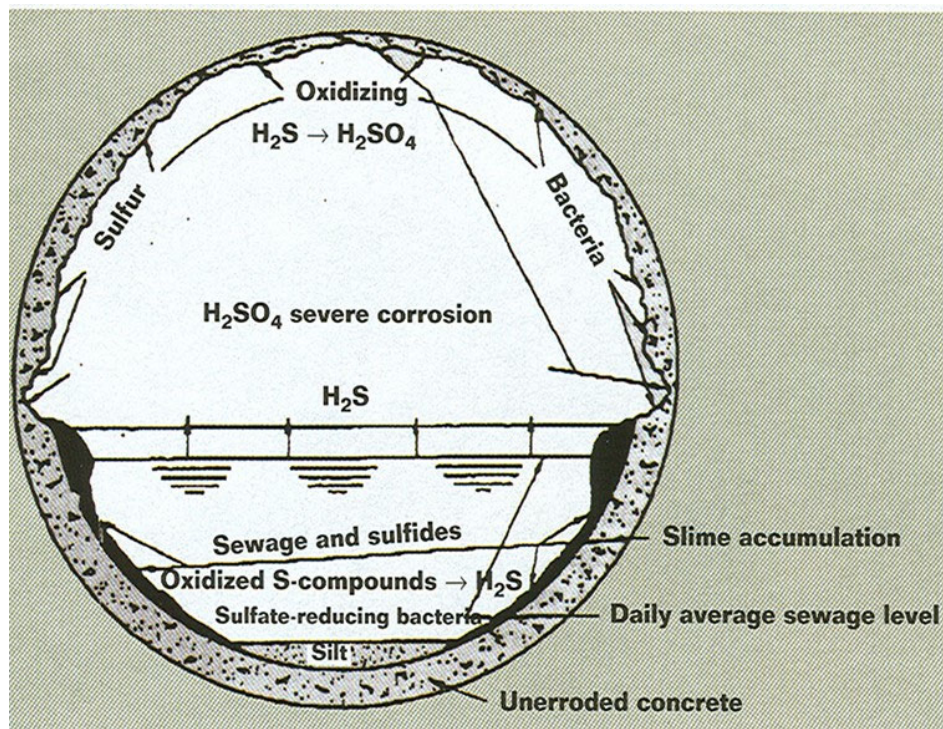


Figure 1.- MIC Mechanism

The corrosion rate in this case depends on various factors,

- Wastewater pH, biological oxygen demand, and amount of dissolved oxygen
- H_2S concentration
- Wastewater velocity and turbulence
- Air temperature and relative humidity inside the structures
- Concrete permeability and composition

Fluctuation of wastewater levels, suspended solids, cavitation, and freeze-thaw cycles can intensify the corrosion process. Therefore, the most severe concrete deterioration is commonly found at the scum line and the vapor space of the concrete structures. This area is the most at risk for freeze-thaw cycling and exhibits the highest concentrations of H_2S and CO_2 .

LINING SOLUTIONS TO STOP CONCRETE CORROSION

Qualified corrosion protection coatings manufacturers can present various concrete repair and lining solutions. Lining solution technologies included systems comprised of 100% solids epoxies, epoxy laminate alternatives and elastomer urethane applications. Because of the freeze-thaw cycling and inherent characteristic of concrete to crack, I will focus on epoxy laminate and elastomer urethane applications.

All successful lining applications start with proper surface preparation standards. To simplify this paper for the installation comparisons of either epoxy laminate or elastomer urethane, applications will utilize the same standard.