CAPROCO
INTERNAL CORROSION MONITORING SPECIALISTS

Bacterial Monitoring General Information

INTRODUCTION

A significant amount of research into bacterial corrosion has been undertaken in the last three decades. The underlying theme that has been established is that while the bacteria do not actually cause the corrosion to occur in the first place, it can act as a catalyst to accelerate the rate of corrosion.

Bacterial corrosion is rarely found in situations where there is not some other form of corrosion already present, but when bacterial corrosion is added into an already active corrosion cell, the effects and speed of the reaction are increased greatly.

BACTERIAL MONITORING THEORY

In more than 200 papers, research groups have established that the predominant bacterial population in natural, industrial and medical aquatic systems are adherent to submerged surfaces. These sessile populations adhere initially as single cells, but they soon proliferate and generate extracellular slime until they produce a thick adherent biofilm in which bacterial cells are embedded in an extensive polyanionic matrix of highly hydrated polysaccharide fibers. Within these adherent biofilms, bacterial that find themselves in a favorable microenvironment *(microniche)* respond by reproducing rapidly and these favorable sites are soon occupied by cooperative *"consortia"* of different species that favorably affect each other's growth and activity. One such cooperative and physiologically coordinated consortium is responsible for the corrosion of metals. These bacteria *(the sulfate reducing bacteria or "SRB's")* are strict anaerobes and they produce corrosive consortia when they are in the lower reaches of a biofilm, in contact with the metal substratum, and when they are associated with less strict anaerobes that screen out oxygen and with other bacteria that draw off and use their waste products *(excess hydrogen)*. Once established in a favorable microniche such as a flake or a scratch, these consortia of SRB's develop into extensive *"microcolonies"*. They produce H_2S, develop a local electrochemical *"cell"* and corrode pits in the metal surface. Thus, it is now unequivocally established that corrosion is caused by microcolonies of SRB's deep within adherent biofilms[1].

An important consequence of the growth of corrosion bacteria in consortia deep within adherent biofilms is that these destructive SRB's are protected from biocides added to the flowing phase, to a large extent, because these agents must saturate most of the anionic binding sites in the extensive biofilm matrix before they reach the target organisms. Extensive tests over six years have shown that concentrations of biocides, antiseptics, and antibiotics that will kill *"naked"* floating single bacteria must be increased 50 - 200 fold before they will kill bacteria deep within established adherent biofilms[2].

Conventional sampling for the presence of corrosion causing SRB's has depended on *"grab"* samples of the flowing water and data based on these samples have been misleading for three reasons:

1) The presence of SRB's in the flowing phase does not necessarily mean that corrosive consortia have developed on metal surfaces - many systems are treated unnecessarily.
2) SRB's in consortia within biofilms do not shed cells into the flowing phase with any regularity - serious corrosion problems may be missed.
3) Floating SRB's are very easy to kill with biocides and post-treatment samples often indicate effective control while actual corrosion continues unaffected deep in the biofilm - corroding systems are inadequately treated.

Therefore, we must first understand that corrosion is caused by SRB's in well organized communities deep within biofilms and not by floating SRB's in the flowing water phase. When we grasp this fact firmly we must realize that only direct sampling of the affected metal surface after biocide treatment will provide evidence that the corrosive population has been killed. Further corollaries are that corrosion is a function of highly organized microbial consortia and that line scraping at regular intervals may keep these structurally complex communities from developing, and that effective biocide killing of SRB's in biofilms may confer corrosion protection for weeks or even for months because of the time required for new corrosive communities to develop.

The original biofilm sampler was first developed for lab studies where it was particularly effective because it exposed one surface of an aseptically removable *"stud"* to the flowing water while keeping the sides and back of the stud dry and sterile. Within 2 - 3 weeks mature biofilms developed on the exposed stud surfaces and these biofilms are now used extensively by chemical manufacturers to test the efficacy of biocides, antiseptics, drain cleaners and antibiotics against biofilm bacteria. These laboratory devices have been *"side-streamed"* into oil gathering and injection water pipelines, and the studs have been mounted on *"spools"* set into these low pressure systems where they have yielded useful data on corrosion activity and biocide efficacy.

Now research groups have combined with Caproco's design team to produce an on-line biofilm sampling probe that allows the operator to assess bacterial corrosion in a high pressure pipeline system and to determine the efficacy of biocide treatments in controlling this corrosion.

APPLICATION

The Caproco biofilm probe is designed to be mounted in an access fitting flush with the pipe wall. The probe face consists of five studs for accumulating bacteria.

The probe stud is designed so that erroneous readings cannot be taken due to accumulation of dead bacteria on the stud. This is a common problem that can be found with other biofilm probes on the market.

Caproco offers three styles of biofilm sampling probes: retrievable (high pressure), retractable (low pressure) and fixed (high or low pressure). The retrievable and retractable systems both allow operators to: retrieve samples, and inspect and maintain equipment while the system is under full operating conditions. However, the operating system must be depressurized before the fixed probe (bull plug) style can be accessed. Sampling studs are replaceable, and come in: two, five or six stud systems.