CORROSION BY SULPHATE REDUCING BACTERIA

Presented at

ALBERTA Public Works, Supply & Services
Property Management Operations Division
Water Treatment Co-ordinators' Meeting #14
Edmonton, Alberta

October 16th 1991

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October 11th 1991

GENERAL DESCRIPTION

Sulphate reducing bacteria, known as Desulfuvibrio Desulfuricans in the scientific community, is also referred to as **SRB**. These bacteria are nonpathogenic (ie., they are **not** capable of causing disease) and they are anaerobic bacteria (ie., they require an oxygen free aqueous environment), but they are capable of causing severe corrosion of iron material in a water system because they produce enzymes which have the power to accelerate the reduction of sulphate compounds to the corrosive hydrogen sulphide, thus SRB act as a catalyst in the reduction reaction. However, in order for this reduction to occur, four components must be present. That is, SRB must be present, sulphates must be present, an external energy source in the form of free electrons must be present, and the temperature of the water must be less than approximately 65 C (150 F).

CORROSION MECHANISM

A water system naturally contains sulphate based compounds, but when sulphite is added to a closed water system as an oxygen scavenger and corrosion inhibitor, the sodium sulphite is oxidized to sodium sulphate as indicated in reaction 1 below.

$$2\ Na^{+1} + SO_3^{-1} + 0.5\ O_2^{-2} = 2\ Na^{+1} + SO_4^{-2} \qquad (1)$$

Excess electrons occur in a water system as a result of iron corrosion at the anode & cathode cells as indicated in reactions 2 & 3 below.

$4\ Fe = 4\ Fe^{+2} + 8\ e^{-1}$ (anode reaction) (2)

$8\ H^{+1} + 8\ e^{-1} = 8\ H$ (cathode reaction) (3)

The resultant accelerated corrosion mechanism of iron by the sulphate reducing bacteria is illustrated in equations 4, 5, 6, 7 & 8 below.

$SO_4^{-2} + 8\ H = S^{-2} + 4\ H_2O$ (4)
(cathodic depolarization by SRB)

$8\ H_2O = 8\ OH^{-1} + 8\ H^{+1}$ (dissociation of water) (5)

$2\ H^{+1} + S^{-2} = H_2S$ (reversible reaction) (6)

$Fe^{+2} + S^{-2} = FeS$ (anode corrosion product) (7)

$3\ Fe^{+2} + 6\ (OH)^{-1} = 3\ Fe(OH)_2$ (anode corrosion product) (8)

DETECTION

General

The presence of sulphate reducing bacteria in a water system may be determined by three methods. These include sensory perception, pH level determination, and biological analysis.

Sensory Perception

Since hydrogen sulphide is a by-product of their metabolism, the "rotten egg" odour associated with this sulphur compound is an indication that sulphate reducing bacteria may be present in the water system.

pH Level Determination

Since hydrogen sulphide is a by-product of their metabolism, SRB can also cause the pH level of the water system to fall to as low as pH 5.0. Therefore, if repeated caustic additions are required in order to maintain the pH level of a closed water system within its prescribed control limits, then sulphate reducing bacteria are most likely present in the system.

Biological Analysis

Biological analysis of a water or deposit sample collected from the system may be performed either by laboratory analysis or by field analysis. The basic procedure for both of these techniques involves the addition of the water or deposit sample into a container to which nutrients have been added, and incubation of the sample.

The laboratory procedure is costly (ie., approximately $40.00/sample), the sample must be collected in a sterilized bottle, and the sample should be delivered to the laboratory within 24 hours after collection.

The field analysis procedure, however, is substantially cheaper (ie., the field test kit is available from OSP Microcheck Inc., Calgary for approximately $4.50/sample), and it does not require a great deal of training or expertise. The field test kit consists of a graduated hypodermic needle & a sealed vial which contains a prepared medium. The water sample is simply injected into the vial (note: deposit samples may also be added to the vial), and incubated either at 32-37 C or at room temperature. If a quantitative analysis is required, an incubation temperature of 32-37 C must be maintained; however, if a qualitative analysis is required, the sample may be incubated at room temperature. If SRB's are present in the sample, they will reduce the sulphate in the medium to sulphide, which in turn reacts with the iron in the solution to produce a black ferrous sulphide film will on the sides of the vial within a 28 day period.

CONTROL and TREATMENT

In order to reduce the possibility of sulphate reducing bacteria proliferation in a water system, the following activities are recommended:

1. Maintain a water temperature greater than 65 C (150 F) for hot water heating systems and domestic hot water systems.
2. Reduce the corrosion of iron material in hot water heating & chilled water systems by eliminating air ingression into the system and by maintaining the prescribed inhibitor concentration in the system.
3. Drain & flush the expansion tank and cooling coils of chilled water systems at the beginning of the cooling season.
4. Circulate the contents of stagnant domestic hot water, chilled water, and hot water heating systems periodically during their shut down periods.
5. Chemically clean the piping of the water system if it contains appreciable amounts of corrosion deposits.

If sulphate reducing bacteria are detected in a chilled water or hot water heating system, a biocide such as Myacide (available from OSP Microcheck Inc., Calgary, Ph: 291-1658) must be added to the circulating system at a typical concentration of approximately 10 ppm. Subsequent biological analysis will determine when additional biocide treatment is required.