Old Keepers
Dulas
Hereford
UK HR2 0HL

Head Office
0333 405 4045
info@keelblack.com
www.keelblack.com

**MICROBIOLOGICAL CORROSION**

Boat owners and yards know all about rust. There is endless literature on electro-chemical and galvanic corrosion – all under the general heading of 'rust'. But there are other types of corrosion which closely resemble (but are not) rust in the conventional sense about which little is known by boat owners and by many yards. This is a corrosion caused by microbiological action which is can occur on boat hulls, particularly those lying in canals or rivers containing high levels of chemicals or decaying vegetable matter.

Microbially Induced Corrosion (MIC) is a highly unpredictable process but under the influence of micro-organisms, corrosion processes can be rapid, happening in a matter of months compared to the years it would take for ordinary abiotic corrosion to reach serious proportions. This phenomenon is well known in the oil, gas, water and mining industries but is little understood in the steel boating world.

MIC frequently occurs in areas with high nitrate content in the water – this particularly pertains to arable regions of the canal network and particularly to canals and rivers on the east side of the UK and where there is intensive crop farming using non organic chemical fertilizers with consequential phosphate, sulphate and nitrate run-off into the watercourses. Marinas fed by rivers are another risk area and, in salt water environments, it is well known that harbour muds are highly contaminated by sulphides produced by these creatures.

Sulphide films are, by their very nature, highly corrosive and the identification of such very obvious. It is usually found under muddy and slimy surfaces, sometimes even behind paint coatings and a very careful visual inspection is necessary to locate it. It is not discoverable by non-destructive testing such as ultrasonic thickness measurement, eddy current testing or the magnetic method familiar to most marine surveyors. The bacteria are often found inside oxidised welds or in areas which contain physical defects such as porosity, overlap or lack of penetration. The microbes leading to this condition can both cause corrosion from beneath existing coatings or seek out pinpricks in the steel coating and cause the reaction to occur from the outside.

MIC bacteria can be present under previous blackings and is not eradicated by simple pressure washing. Unless correctly treated, MIC can continue to thrive beneath the coating, emerging as major pitting.

**MICROBIAL CORROSION TYPES**

1. *GALLIONELLA FERRUGINEA*

   Characteristically leaves a fairly shallow pit of approximately oval shape and a 'rusticle' made of ferrous and ferric hydroxide. This is a brown non-toxic insoluble powder with black streaks. It is not rust though a marine surveyor has described it in one of his reports by the curiously contradictory name of 'living rust'. The name 'rusticle' was given to the detritus by Dr. Ballard when he found extensive amounts of the stuff on the wreck of the Titanic. It is commonly found on narrow boats and other canal barges in the form of an orange bloom or paste-like phenomenon, often in rings around deeper pits formed by the *thiobascillus ferro-oxidans* corrosion (see (2) below. Being easily washed off, the orange corrosion is frequently considered to have been eradicated. Not so.


2. *THIOBASCILLUS FERRO-OXIDANS*

   Often closely associated with the *gallionella* species, *thiobascillus ferro-oxidans* is a sulphur oxidizing bug (SOB). This leaves a similar pit to the *gallionella* species but with vertical stepped sides and the flat bottom covered with a hard silver-white substance. The latter is tetra hydrated ferrous sulphide and is non-toxic. It appears not to rust but will eventually start to discolour.


**DEALING WITH A MICROBIAL ATTACK**

If a hull is found with evidence of microbial attack, it is necessary to deal with it to try to prevent it recurring. A simple solution is for the whole area to be washed with copious amounts of high pressure fresh water. When dry the area affected should be coated with a strong bleaching agent (sodium hypochlorite) diluted 1:4 with water and left for twenty four hours. Afterwards a second high pressure fresh water wash is necessary followed by recoating. This will probably remove around 90% of the microbes but the only real solution is to blast back to bare steel and to treat any inaccessible areas such as tack-welded rubbing strakes as best one can with the bleach solution before applying the next stage of the coating process.

The main problem is that the microbes can continue to live beneath the existing paint coatings and once sealed in with a fresh blacking, the lack of oxygen and light is the perfect environment for them to thrive leading to a risk of corrosion from the inside out.

No coatings are entirely proof against a microbial attack from the exterior. Minute pinpricks, mechanical damage below the waterline are all opportunities for the microbes to penetrate the steel and commence the process from the outside in..

**WARNING**

SODIUM HYPERCHLORITE IS HIGHLY CAUSTIC AND TOXIC. IT MUST BE TREATED WITH GREAT CARE AND RUBBER GLOVES, WELLINGTON BOOTS AND EYE SHIELDS ARE **ESSENTIAL.**

**FINAL FINISHING**

If the pressure washing has exposed areas of bare steel, it is recommended that a zinc-phosphate rust prevention system such as Fertan be applied. This should be allowed to work over a 24 hour period and MUST be thoroughly washed off with water and a brush to ensure that only the bare steel retains the Fertan before a top coat of Keelblack is applied. This is essential to ensure that any subsequent coating is properly attached to the hull. Nevertheless, the microbes can still live underneath adjacent prior paint coatings so the only certain way to remove the risk of future attacks is by blasting back to bare steel – an expense many owners may not wish to contemplate.

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**SOME MORE DETAILED INFORMATION**

The bacteria themselves are invisible to the naked eye and fall mainly into four types: -

1. **Slime formers** which form slimy coverings over surfaces, reducing oxygen transport and trapping particles of debris.

2. **Sulphur oxidising bacteria (SOB)** which produce hydrogen sulphide from dissolved sulphates in anaerobic conditions. The bottom of the pit that results is black. Wet hydrogen sulphide is reported to corrode mild steel at rates that can exceed 2.5 mm/cm2/year but does not corrode aluminium to any significant extent.

3. **Sulphur reducing bacteria (SRB)** which produce tetra hydrated ferrous sulphate and the highly corrosive sulphuric acid. The bottom of the pit that results is silvery white*.

4. **Iron oxidising bacteria (IOB)** which oxidise soluble ferrous iron to insoluble ferric or ferrous hydroxide.

*The white deposits are the tetra-hydrated ferrous sulphate also known in its mineral form as rozenite [FeSO,4(HO)]. Note also the high surface area/depth ratio of the pitting. There can also be signs (small red-brown rusticles) of attack by microbes of the symbiotic species *Gallionella Ferruginea*. The presence of the sulphate prevents the steel underneath from rusting (oxidising) but NOT from corroding. (The vessel photographed above was constructed of Siemens-Martin mild steel).

**Some Information on the bacteria.**
Although it should be assumed that microbial corrosion could result in any environment in which the micro-organisms can survive, the extent of the activity of any specific species may be limited and conditions favourable to one type may be quite inimical to another. The bacteria associated with the corrosion of metals are unicellular, possessing a thick, rigid cell wall, dividing by binary fission and some have a flagellum to enable them to swim and thus be mobile. These organisms can be either *autotrophic* or *heterotrophic*, *aerobic* or *anaerobic*. Autotrophs obtain their energy from light or by the oxidation of inorganic materials and their carbon by assimilation. Heterotrophs are those bacteria that obtain both their energy and their carbon requirements from organic sources and assimilate carbon dioxide to only a limited extent. Anaerobic microbes do not require oxygen for their growth whereas aerobic bacteria do.
In summary, if the water contamination conditions are favourable, MIC can occur in almost any environment.

**OTHER MIC RISKS IN SALT WATER ENVIRONMENTS**
There are types of aerobic bacteria that can use up all the oxygen in **bilge water**. This results in an ideal environment for anaerobic sulphate-reducing bacteria (SRBs) such as *desulfovibrio desulfuricans*. These bugs **convert the sulphates** in seawater **into corrosive sulphides** that attack metal. Left untreated the microbes form a sludge that can eat through 10 millimetres of steel plate in a year.
**Accelerated low-water corrosion** (ALWC) is a particularly aggressive form of MIC that affects steel piles in seawater near the low water tide mark. It is characterized by an orange sludge, which smells of hydrogen sulphide when treated with acid. Corrosion rates can be very high and design corrosion allowances can soon be exceeded leading to premature failure of the steel pile.