

MIC of industrial materials, Brite Euram thematic network
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presented at the:

COST 520 - BIOFOULING and MATERIALS
meeting in Budapest, 31 May - 3 June 2000

Monitoring systems for MIC

by

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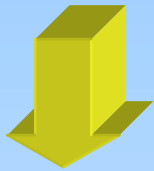
CESI

Via Reggio Emilia, 39

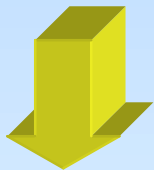
20090 SEGRATE (MI), Italy

THE BIOFOULING PROBLEM

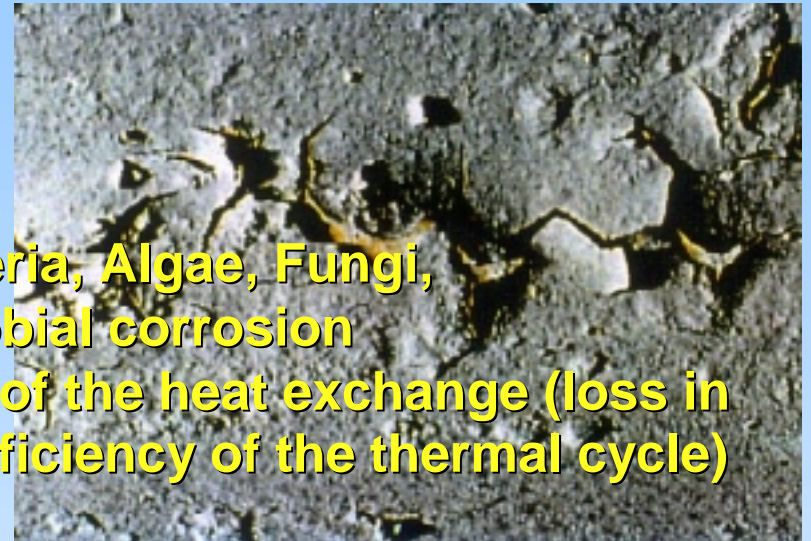
BIOFILM



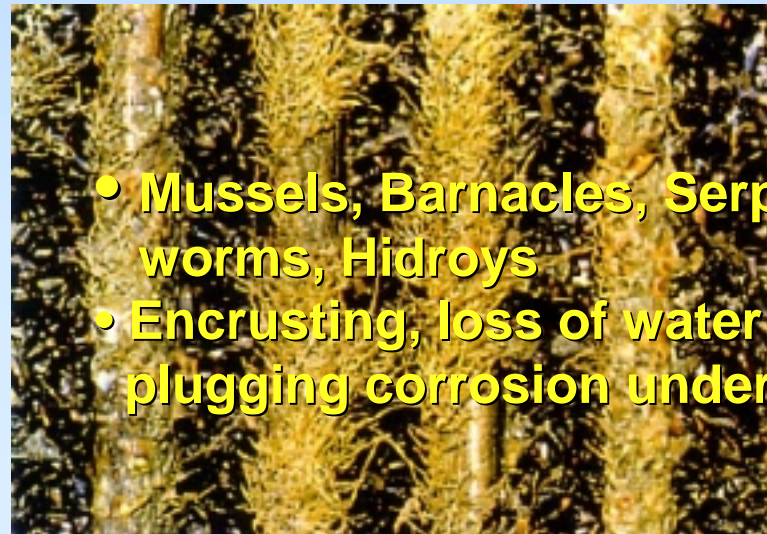
MICROFOULING



MACROFOULING



- Bacteria, Algae, Fungi,
- Microbial corrosion
- Loss of the heat exchange (loss in the efficiency of the thermal cycle)



- Mussels, Barnacles, Serpulid worms, Hidroys
- Encrusting, loss of water flow, tubes plugging corrosion under deposit.

Table 1 - Traditional techniques to document MIC off-line

Analyses	Technique
Deposit analysis:	Determination of dry weigh and wet chemical analysis of corrosion product, slime sludge
Microscopy observations:	SEM, ESEM (Non fixed slime), TEM, X-Ray Fluorescence spectroscopy, EDS, XPS.
Microbiological analysis:	Commercial Kit for MIC (available in USA), Kit for luminescent bacteria (TRA-CIDE ^{TR}), Total bacteria count (commercial, as Dipstik)
Respirometric assay for SRB:	ELISA immunologic tests (commercial as RapidcheckII ^{TR}), Lipid analysis, Gas Chromotography (GC), Gas Chromotography/Mass Spectroscopy (GC/MS)
Staining and biological analysis:	Acridine orange for reveal adenosine, Analysis with epifluorescence microscopy, H ₂ S revealing, Hydrogenase Test (for SRB), DNA, RNA tests (genetic probes), ATP analysis Analysis of APS (adenosine- 5' phosphosulphate reductase) enzyme reduce sulphate to H ₂ S, Available for field test for SRB (Rapidcheck ^{TR}).

ELECTROCHEMICAL TECHNIQUES AND MEASUREMENT FOR MIC

- *Open circuits potential measurement (OCP)*
- *Linear polarisation resistance (LPR)*
- *Electrochemical Impedance Spectroscopy (EIS)*
- *Electrochemical Noise (EN)*
- *Field signature method (FSM)*
- *Redox potential*
- *Hydrogen permeation measurement*
- *Dual-cell*

Table 2 - Non-destructive on-line devices to detect biofouling growth.

<p>Devices based on electrochemical effect:</p>	<p>BIOX^{TR} (High resistance coupling current sensor) BIOGUARD^{TR} (Coupling current sensor) BI°GIEORGE^{TR} (Differential generated current sensor)</p>
<p>Devices based on induced physical effects:</p>	<p>Optical sensors Differential turbidity devices FTIR spettroscopy in the transmission mode devices IR absorbence devices Differential heat exchange devices Differential pressure drop devices Differential mass transport sensors</p>
<p>Other techniques for fouling assessment:</p>	<p>Thickness measurement Tracers, radioactive or fluorescent radiography Laser techniques Ultrasonics ASTM system: combined corrosion and fouling monitoring system set-up with heat exchanger and corrosion element</p>

MIC IN POWER PLANTS

The most significant phenomena are present in :

- condenser tubes
- cooling water intake tunnels and culverts
- close loops
- cooling tower
- emergency (safety) service water systems
- service water systems with stagnant water flow (also for short periods)

CLORINATION TREATMENTS CONTROL

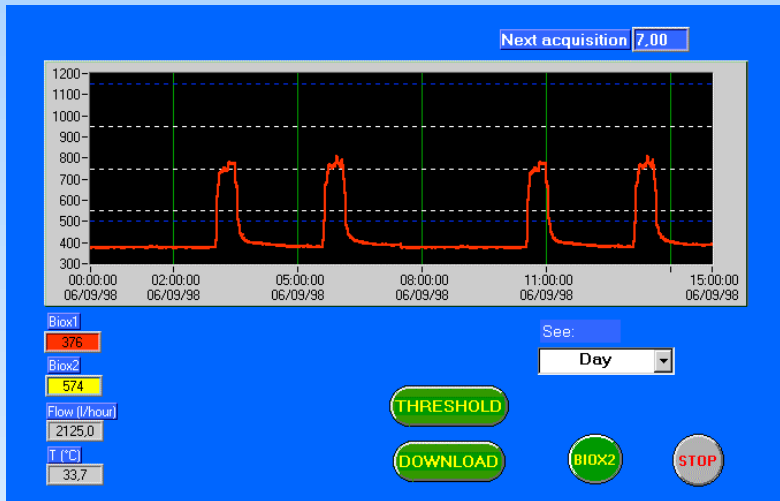
The Italian law allows **0.2 mg/l** as maximum value of chlorine concentration admitted at the discharge.

THE TRADITIONAL APPROACH (skilled personnel necessary)

- Periodical biological examination
- Periodical chemical analisys
(chlorine concentration and water chlorine demand as T.R.O)

BIOX probe

BIOX system employs a new simplified version of electrochemical biofilm sensor. Its response is correlated to the changes of electrochemical kinetic processes on metal surfaces induced by bacteria settlement or by oxidant agents.

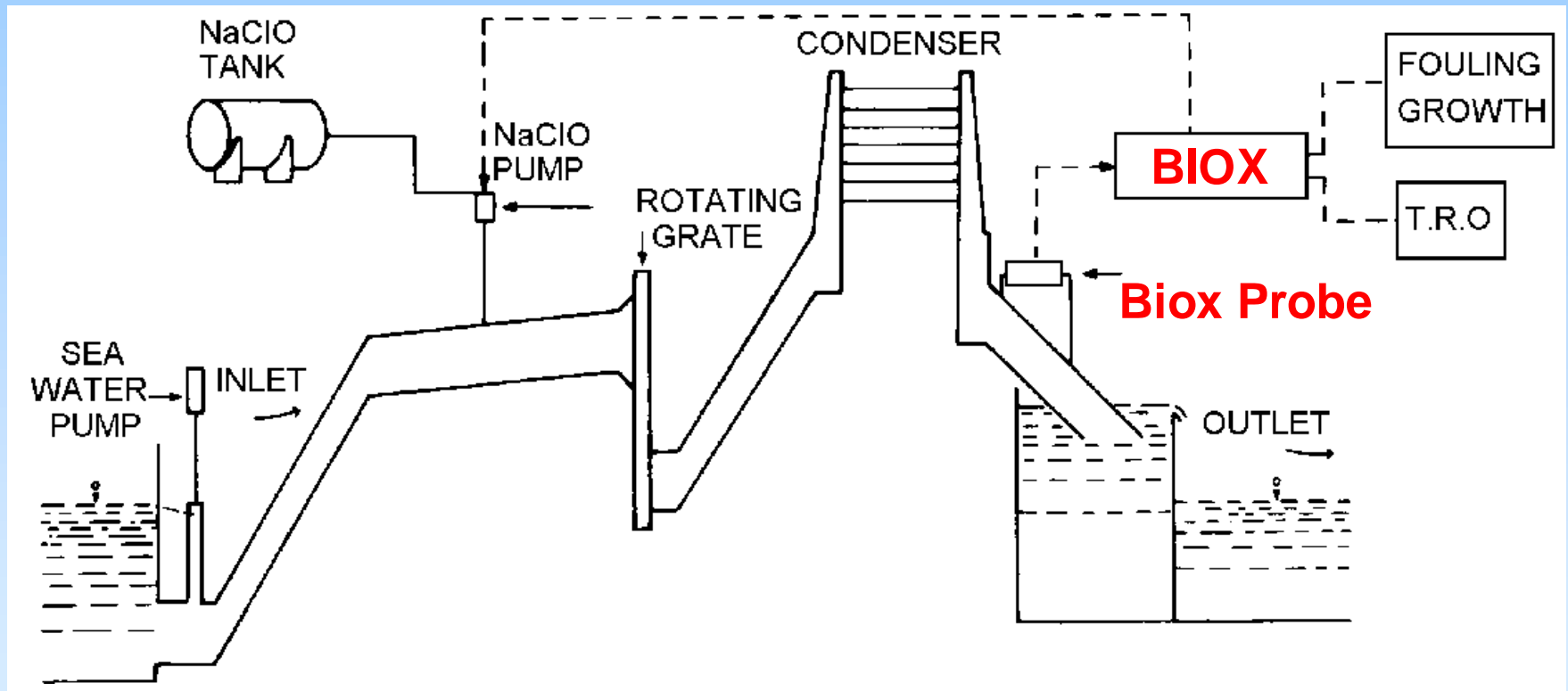


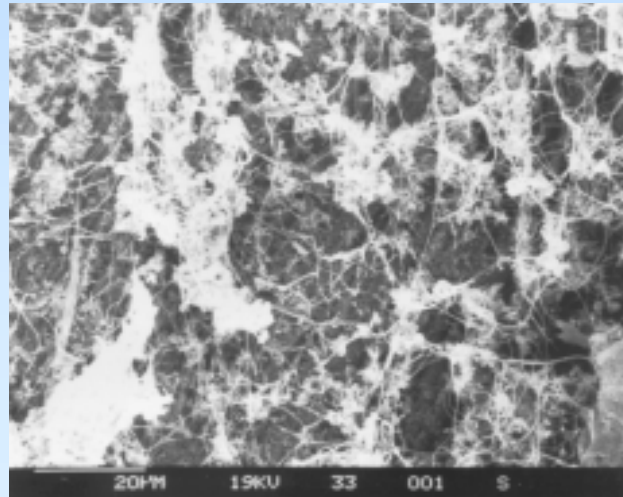
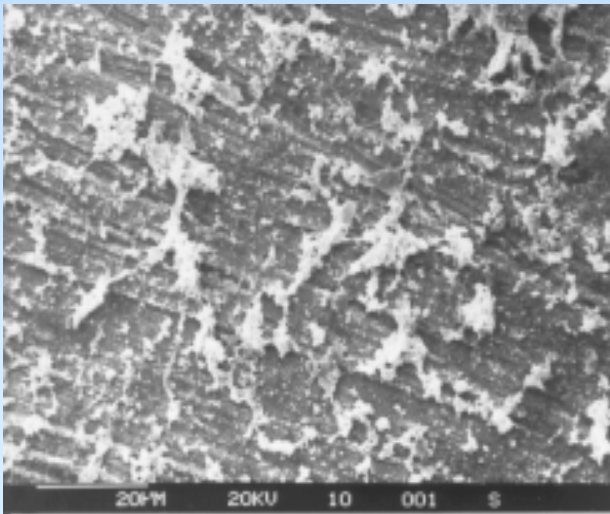
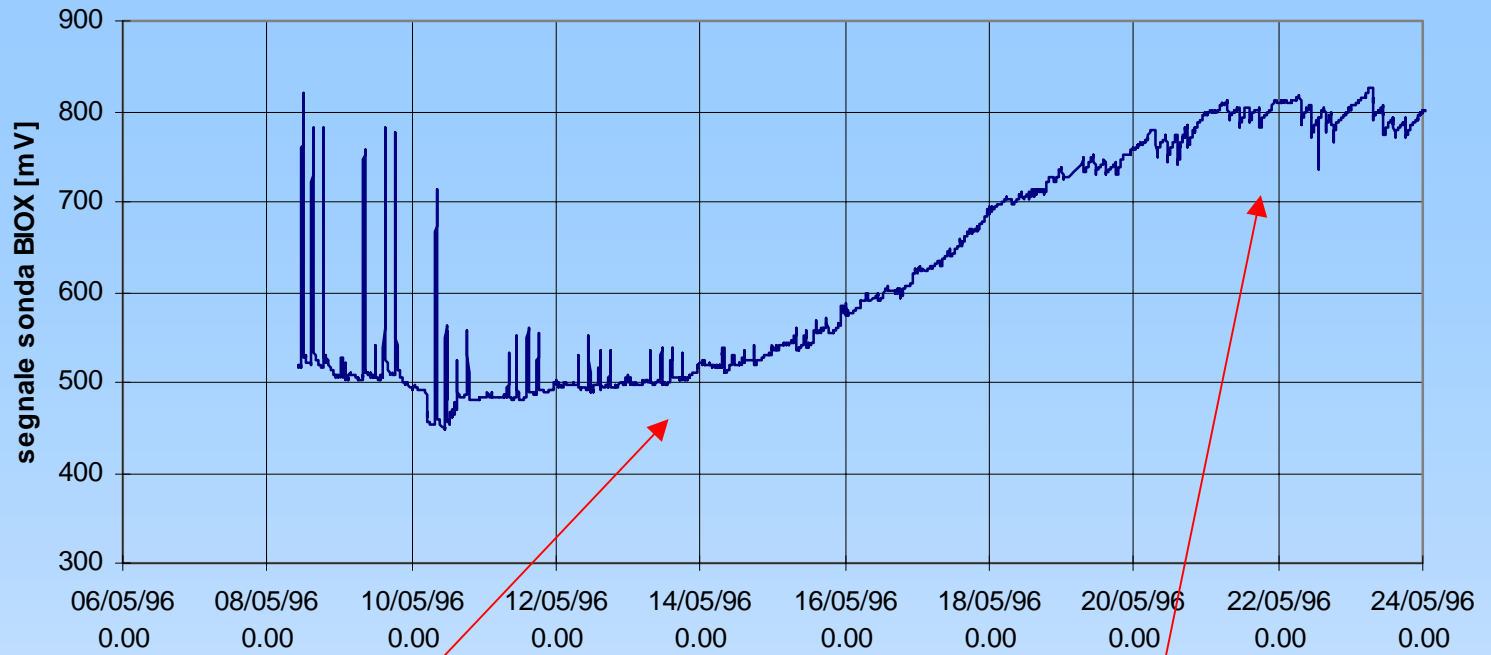
The probe sensitivity is close to

- 10^6 bacteria/cm²
- 0.1 - 1 mg/l as T.R.O.

The response of sensor permits to have, a direct index of biofilm growth and the effective biocide concentration on the sensor surface.

The BIOX probe installed at Vado Ligure power plant in the sea water cooling circuit





CONCLUSIONS

Lot of traditional electrochemical techniques for corrosion monitoring could be employed to detect MIC effects in laboratory and in-field

It does not exist a single technique able to document microbial nature of the corrosion and the right approach must be choose case by case.

New generation of on-line monitoring systems based on **electrochemical biofilm sensors** provides signal that can be used to rationalise the application of antifouling procedures in plants saving efficiency, decreasing corrosion and concurrently minimising biocide additions in cooling water systems.