

BIOFOULING ISSUE, GLOBAL IMPLICATIONS AND SOLUTIONS LINKED TO OFFSHORE BUSINESS

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SUMMARY

Biofouling is a problem well known to industries, manufacturers and researchers in various fields (i.e. heat transfer, marine engineering and power generation). During the last years, biofouling is also affecting to the offshore industries and its partners. The undesirable attachment of organisms to different kind of surfaces leads to significant impacts, both economic and operational. Some of them could be the loss of equipment's design parameters, the loss of total equipment efficiency, the increasing of unscheduled maintenances (i.e. dry dock unscheduled routines), and the impact over day rates associated to offshore industry. Besides that, there are other factors to take into account, like the environmental impact and the local government regulations. DNV KEMA Energy & Sustainability has developed and applied dedicated techniques, offering customized monitoring and antifouling solutions for clients around the world. The present article intends to describe a selection of these techniques and their potential application into offshore energy business.

1. INTRODUCTION

The appearance of biofouling in industrial processes, in which sea water is involved, is an inherent part of the daily operation. Sea water is a readily available resource; the main drawback is that biological organisms present in the bulk seawater, under certain working conditions cause biological layers (biofilm) and macrofouling populations in different working areas of the facility. The consequences of this occurrence is mainly reflected in losses of thermal performance of facilities, economic losses, inability to carry out proper maintenance practices, etc.

Marine and offshore environments are quite susceptible to be affected by biofouling. So, it could play an important role on the development and operation of the new types of renewable energy linked to marine and offshore renewable energy's exploitation. Concerning this topic, new energy initiatives linked to marine go together with classical marine and offshore applications related to goods transport and oil-gas resources exploitation.

It is important to recognise that biofouling is an important issue, resulting in significant economical and technological impacts. It is an important topic to consider in the development of the new renewable technologies linked to marine and offshore fields. The proper consecution of this objective will revert into well prepared alternatives, able to face the future challenges this type of industries will need in a short term.

The present paper intends to show the background of biofouling development. Besides that the economical implications over the equipments and industries are covered as well. A review of the most common methods of biofouling mitigation will be reviewed. Last but not

least, the DNV KEMA Energy & Sustainability monitoring and antifouling solutions will be showed and explained.

2. FOULING

2.1 DEFINITION

Fouling is the formation of deposits on the equipment surfaces. This type of deposition originates significantly decreases on the equipment performance and/or the operational lifetime of the equipment.

2.2 TYPES OF FOULING

The main types of fouling are as follows (Epstein, 1981) [1]:

- Biological Fouling: the settlement and growth of microorganisms (biofilm) and macroorganisms such as mussels, oysters, barnacles, etc.
- Chemical reaction fouling: concerning the deposits formed by chemical reaction in which the substratum (e.g. condenser tube) is not a reactant. Polymerization of petroleum refinery feedstocks is an important example of this type of fouling.
- Corrosion fouling: occurs when the substratum itself reacts with compounds in the liquid phase to produce a deposit.
- Freezing fouling: due to the solidification of a liquid or some of its higher melting point constituents on a cooled surface.
- Particulate fouling: accumulation on the equipment surface of finely divided solids suspended in the process fluid. Sedimentation fouling is an appropriate term if gravity is the primary mechanism for deposition.

- Precipitation fouling: precipitation of dissolved substances on the equipment surface. This process is termed scaling if the dissolved substances have inverse temperature solubility characteristics (e.g. CaCO_3) and the precipitation occurs on a superheated surface

The fouling type of interest in the present article is the biological fouling. It is a type of fouling that appears in combination with other type of fouling like the physicochemical processes in the associated slime layer. So, the effects and interactions within the biofouling layer are of different natures (e.g. chemical changes on the equipment surface, chemical reactions within the bulk fluid, microbial activity, working parameters, etc.).

3. BIOFOULING

3.1 DEFINITION

Biofouling is defined as the undesirable accumulation of a biotic deposit on a surface. The deposit may contain micro and macro organisms (Characklis, 1990) [2].

3.2 TYPES OF BIOFOULING

3.2 (a) Microfouling

Under natural conditions, 90% of micro organisms in the biosphere live in biofilms; bacteria attach to conditioned surfaces and form a slime layer. The advantages of being attached to a surface include the continuous supply of nutrients, protection and the removal of metabolic waste products. The continuous movement of the aqueous environment over a surface also usually means that the water is aerated, which is an advantage for aerobic bacteria (Costerton et al., 1995) [3].

The creation of complex structures called extracellular polymeric substances (EPS) in which the microorganisms are embedded, facilitates the development of specific microbial communities (Characklis & Wilderer, 1989) [4].

By all these means, microfouling stimulates the settlement of macro-organisms like mussels, oysters and barnacles. The settlement of these macro-organisms leads to a substantial decrease in diameter of cooling water piping, thereby leading to even higher pumping costs and eventually leading to a forced outage for removal of macrofouling debris.

Another concern directly associated with biofilms is on the development of specific chemical environments on metallic surfaces that lead to an increase in the speed of corrosion of these metals. This type of corrosion is called microbial influenced corrosion (MIC). Accelerated corrosion may occur as the result of corrosive metabolic products such as sulphides, ammonia, organic acids, or mineral acids.

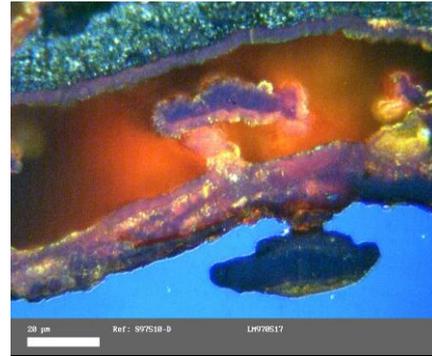


Figure 1. SEM biofilm scanning

3.2 (b) Macrofouling

Macrofouling may cause gross blockages of pipe work and seachests, and may cause so-called erosion corrosion, when shells pass through heat exchanger tubes. Biological growth in the cooling water system is therefore a constant threat to the operating efficiency. The fouling of heat transfer tubes is a never ending problem for almost all industries requiring heating or cooling by means of surface water. This requires adequate, reliable antifouling methods to prevent these problems. Macrofouling is very much location and water quality specific, both in terms of quantity and species variety.

Fouling by macro fouling organisms in intake (cooling) water systems like oysters, mussels, barnacles and hydroids can result in significant operational problems. This type of biofouling can result in:

- Increased flow resistance in intake channels
- Reduced cross section of effective flow intake channel
- Reduced pump capacity/head loss
- Insufficient water levels in pumping station
- Clogging sieves and condenser tubes
- Risk of corrosion erosion-corrosion resulting in leakages
- Risk of unplanned outages
- Risk of reduced performance of MW (Power) and/or potable water delivery (Desalination)
- Large time investment for manual cleaning.

All these effects have a large cost impact for an installation. It is therefore of crucial importance to apply an effective biofouling mitigation method.

4. BIOFOULING IMPACTS

Over many years, a wide range of biofouling impacts have been identified in many studies at a variety of

industries. On the 70's it was identified that the 20% of corrosion issues in the USA were caused by microorganisms (Thomson & Mathews, 1989) [5]. More recently, the total production losses identified in China due to biofouling were estimated in 4.68 billions of dollars. It represents the 0.169% of the total gross domestic product (GDP) (Xu et al., 2007) [6].

4.1 IMPACT OVER THE EQUIPMENTS

4.1 (a) Heat exchangers

Heat exchangers are very sensitive to biofilm formation and posterior microbial induced corrosion (MIC). The high cost of this kind of equipment and its importance in most of its industrial applications, makes the heat exchanger a special item to take care about. There are many different heat exchanger designs, types and layouts, but in the majority of cases when biofouling is present, their cleaning and repair routines turn into a very difficult operational and economical problem.

4.1 (b) Condensers

The primary function of condensers in power plants is to condense the steam flowing from the last stage of the steam turbine to liquid form again. From a thermodynamic point of view, the most desirable condition to be produced is when the cooling temperature is the lowest possible, in order to create the lowest possible vacuum on the steam side of the condenser. If the condensing temperature is low, then the backpressure on the turbine will be lowered as well, hence the turbine performance will be improved.

4.1 (c) Pumps

Biofouling has a huge influence on coolant pumps installed at all kind of facilities around the globe. Some pump parts like impellers, shafts or bearings could suffer misalignments and severe failures due to the continuous effort made by the equipment to compensate for the fouling impact over the pipes and the filters, and effort to maintain the design pressure within the circuit.

Coolant pumps associated to this kind of installations are of a considerable size, parts are expensive, manpower must be specialized, substitution units are not available in short notice period and work effort for corrective maintenances may take weeks or maybe months. All these facts significantly impact plant performance during its operational phases and decrease business profits. This equipment is usually categorized as vital, and instead of being robust, their influence on plant reliability is very critical in case of failure.

4.1 (d) Piping

The abnormal growth of macrofouling communities at the surfaces of the pipes will lead to diameter reduction

and friction increase. Pumps will have to do an extra effort to keep water demand according to the design range. It implies pump components will suffer and their life cycle time will decrease, incurring possibly into a non-proper contract fulfilment and increasing the operation costs (OPEX). Due to reduced flow, the overall efficiency of the plant will be affected.

4.1 (e) Filters and screens

The correct working conditions of the devices used to filter water for cooling purposes is of big importance in the plant operation. Once clogging of these components occurs, it creates the improper functioning of the entire system. Once the problem appears, mitigation of the fouling is required. In many cases mechanical cleanings is applied at regular intervals. This kind of strategy implies a huge amount of manpower hours (€/hr).

4.2 IMPACT ON INDUSTRIES

Many studies undertaken during the last decades have reflected on the effects of biofouling on a variety of industries. This chapter aims to cover some of the fields where biofouling has lead to the biggest losses for industries. The economic consequences of fouling are the essential reason for industrial interest in fouling of operation equipment. To assess the impact of a fouling situation, the economic and energy penalties arising from the operation of equipment subject to fouling must be considered.

4.2 (a) Naval industry

Biofouling is a well known problem in the naval industry. The hull of the ships is constantly colonized both by micro and macrofouling in several different locations. Some of them could be rudder or seachest. This fouling implies great losses linked to among others, the vessel's speed, fuel consumption increase, drag, less autonomy, the increase of the cleaning operations and maintenance of equipment and associated docking time.

US Navy carried out a study about hull fouling economic impact on a medium size combat ship Arleigh-Burke class destroyer (Schultz et al., 2010) [7]. Associated costs to the fouling of the hull included those related to extra fuel consumption and to the hull cleaning routines. The losses due to the hull cleaning and reapplication of coating are fewer than the ones due to extra fuel consumption. An estimation of all these expenses is 56 millions of \$ per year for all the destroyers in the Arleigh-Burke Class.

4.2 (b) Offshore industry

Offshore industries are typically more prone to biofouling phenomena due to their constant exposure to the marine environment.

Tropical and sub-tropical areas have been identified as the most sensitive to biofouling. Seawater conditions in these regions are more beneficial to biofouling proliferation than in other areas around the world. However, biofouling is not only linked to tropical areas, it is found in all marine environments. Even in the abyssal areas (from 3000 to 7000 feet), biofouling appears. Chemical reactions according to the specific environmental conditions enable the biofouling development in a different manner than in other environments (Parr et al., 1998) [8]. The research experience in this field of knowledge shows that biofouling development is characteristic of a specific sea depth, climate zone and season.

Economic losses in offshore industries are much higher than in other type of industries. One of the main reasons is that the equipments are working on a static manner during long periods of time. When a contract has finished, the equipment is moved from one location to another one around the globe. In most cases, the scenario is that the floating artifact is fully colonized and a deep cleaning and (sometimes) berthing is mandatory.



Figure 2. Fouling on the bar rack at a sea water suction bellmouth

Last but not least, it is also necessary to point out that in the majority of the cases, each country develops and states their own legal advices and regulations. In practice, this means that the free movement of artifacts between different exploitation areas is sometimes not easy at all. In 2007, the *Ocean Patriot* offshore installation was towed from New Zealand to Australia after finishing its duty. Another contract was waiting in Australia to be performed, but due to the high colonization suffered in the perforation units, it was not possible to proceed with the transfer. Australian legislation does not allow this kind of operation under risky situations. Divers were hired in order to clean the platform, the economic value of this operation was 5 million A\$ (Hsieh, 2008) [9].

4.2 (c) OTEC industry

Ocean thermal energy conversion (OTEC) is one of the future options of energy supply from the seas. Its huge potential, supply stability and extremely low CO₂ emissions in its whole lifecycle are the main reasons to consider this type of energy as a promised one.

Several studies have reported the appearance of biofouling phenomena in the OTEC industry field. The

equipment identified as most sensitive are the heat exchangers. In this kind of industry, the plate heat exchangers are often applied because of the large area they provide for heat transfer. The dosing regimen optimization has been identified as the proper key to control this phenomenon, mitigating both microfouling and macrofouling (Sriyutha et al., 2005) [10].

More research is necessary to be done on this specific application.

4.2 (d) Desalination

Desalination industry requires huge volumes of sea water to carry out the process to produce potable water. Sea water contains a large amount of microbiology that form biofilms in the internal side of the pipes and on membranes. This leads into a reduction of the water flow. Chlorine has been the most applied disinfectant. Electrochlorination plants are the preferred to produce the hypochlorite (Thangappan & Sampathkumaran, 2008) [11].

Several studies have been performed in the Saudi Arabian coastal area. Due to its warm environmental conditions and geographic location, biofouling is highly proliferated. The water depths are typically shallow, so it is necessary to dredge continuously intake areas to maintain sufficient depth. This implies sediments and organisms are in the water column and these are abstracted with the water by the suction pumps of the facilities. All these substances create deposits which get solid and robust films in different plant parts. So it creates a combined effect of microfouling and macrofouling. The fouling implies huge economical losses and deep impact on operation and maintenance routines, shutdowns, etc.

5. MITIGATION METHODS AGAINST BIOFOULING

A wide range of mitigation strategies and methods have been developed along the years caused by biofouling.

5.1 PHYSICAL METHODS

Physical methods can be used to prevent settlement and/or to mitigate the individual's settles. In general, a number of techniques are available for reducing the effects of potential fouling in piping, structures, tube heat exchangers or other parts of the installations. Some of the methods are only applicable for certain type of equipments, while others are more universal in application.

Micro-filtration is one of the most popular one, it is a method to reduce the zoo- and phytoplankton load (including larvae) of the cooling circuit. It also reduces the organic load and the biocide demand. Microfilters sizes can be 50-100 µm, which claim to give effective

protection against macrofouling. The youngest stages of mussels and barnacles have lengths of above 150 µm, so a microfilter with 75 µm mesh width is likely to give effective protection against entrance of larvae of mussels and barnacles. However, such methods can only be applied for small water volumes.

Heat treatment or “thermoshock” is a well-known control method (Jenner & Janssen-Mommen, 1992) [12] and (Rajagopal et al., 2005) [13]). Thermal treatment consists of heating the cooling water to a temperature of 35–40 °C by means of (partial) recirculation, and maintaining this for 2 to ½ hours. Thermal treatment is accomplished by recirculating the heated condenser discharge back to the water intake. With each pass of the recirculated water through the condenser, additional heat is provided, thereby raising the temperature of the cooling water. The time needed to raise the temperature to ~40 °C depends on the starting temperature of the cooling water, the amount of thermal losses, and the volume of water to be heated. In general it takes 1 to 3 hours to reach the target temperature.

Sonic technology is based on the principle of vibration created by the energy associated with the transmission of the sound. It will remove deposits on surfaces, by “shaking” the deposit free. Cavitation produced by the propagation of sonic waves in the continuous phase near the deposit surface, can also assist the removal process. Claudi & Mackie (1994) [14] describe how acoustic energy in the range of 39 to 41 kHz fragments early stages of mussels within a few seconds. This technology has not been applied in large systems, as it only treats very locally.

There are other techniques included in the physical methods; such as ultra violet, electric shock, coatings and low frequency electric magnetic fields.

However, due to low efficacy of many of these physical technologies, especially for larger volumes, these are not regarded as feasible. Only thermoshock is a reliable method, however, it only allows mitigation after macrofouling organisms have already settled. Also, thermoshock is not able to remove biofilms.

5.2 CHEMICAL METHODS

Much work has been undertaken to develop suitable chemical treatments. The existing chemical methods for are clearly identified as oxidising and non-oxidising technologies. Oxidising biocides include chlorine, bromine, and iodine. These chemicals act by destroying cell membranes or their extra cellular enzymes, which leads to cell death. Historically, the application of chlorine has been the universal method to combat micro- and macrofouling. The dosing of sodium hypochlorite for the control of fouling species in the cooling water systems of power stations and (petro) chemical plants is well known. Other oxidising chemical biocides like

ozone, chlorine gas, peracetic acid, et cetera, have also been examined as potential biofouling control agents.

Non-oxidising biocides include numerous chemicals that act by interfering with a crucial life function such as metabolism or reproduction of the cells or by affecting metabolic processes. The most popular ones are the quaternary ammonium compounds (QAC), which are mostly focused on macrofouling mitigation. Some new research has been done on the assumption of apply this chemical compound against microfouling. While oxidizing biocides exert a non-specific biocidal action on the target organism, non-oxidizing biocides have more specific modes of action, on the cell surface. From the non-oxidizing biocides, isothiazolones and QAC's are the most frequently used. QACs for example are known to be partially neutralised by oxidative biocides and anionic dispersing agents. Isothiazolones on the other hand, are stabilised by sodium hypochlorite.

The choice of using a specific biocide to control micro- and macrofouling depends on several factors. These factors are:

- Legislation: in many cases regulatory limitations are a driving force to follow
- Effectiveness: a biocide has to be effective in the specific situation.
- System type: in the case of a cooling water system, the system type determines the residence time and thus the contact time between the biocide and the cooling water.
- Water quality: chemical and biological water quality affects the choice of a cooling water treatment program, and thus the choice of a biocide.
- Interactions with other water treatment chemicals.
- Economical aspects: facilities must be operated at the lowest possible costs. Since little attention is paid to design factors, treatments often have to make up for bad design, and therefore need to be chosen in such a way that they minimise risks of fouling. A change in the attitude is necessary to consider fouling since early stage design scenarios.

6. EXAMPLES OF DNV KEMA SOLUTIONS FOR MONITORING AND OPTIMIZING FOULING MITIGATION

6.1 BIOFILM MONITORING DEVICE; BioGeorge™

One of the most important facts on biofouling mitigation is the proper monitoring of the process. Online monitoring of biofilm formation provides critical information to automatic control equipment and to system operators so that mitigation activities can be initiated well before biofilm formation occurs. It provides feedback that is critical to the evaluation of the effectiveness of biocide additions and for optimizing the concentrations and addition schedules of biocides and other control chemicals.

The BioGeorge™ electrochemical on-line biofilm monitor, is successfully applied by DNV KEMA to detect activity of microbiological fouling on metallic surfaces in real time (Brujjs et al., 2001) [15]; (Venhuis & Brujjs, 2008) [16]. By creating conditions on the system's probe (Figure 3) that are conducive to biofilm settlement, biofilm activity on the probe occurs sooner than on piping or heat exchangers. Thus, continuously monitoring the probe offers an operator with real time information on the condition of microbiological fouling in his system, so that inspections or mitigation activities can be based upon measured biofilm activity.



Figure 3. Overview BioGeorge™ probe

The probe permits biofilm activity to be tracked continuously, online. It consists of a stack of nominally identical titanium discs that are configured as a right circular cylinder. The electrodes are electrically isolated from each other (epoxy resin) and from the body of the probe. One electrode (set of discs) is polarized relative to the other for a short period of time each day (Figure 4). This polarization cycle produces slightly modified environments on the discs that are conducive to biofilm formation.

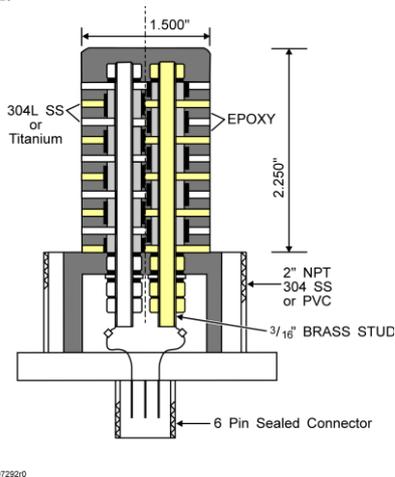


Figure 4. BioGeorge™ probe (section)

The externally applied potential creates different local conditions on the titanium electrodes that cause different microbiological colonies to become established on the

positive and negative electrodes (Nekoksa et al., 1991) [17] and (Guezennec, 1991) [18]. Tracking the daily applied current and noting significant changes in that current provides one method to detect the onset of biofilm formation. The difference in the magnitude of the applied current from the baseline provides a measure of the biofilm activity. The generated current (I_{gen}), the current that flows between the electrodes when no external potential is applied, provides an additional, and often more sensitive indicator of biofilm activity. In general, the onset of biofilm formation is signaled by an abrupt change in the generated current from the typical baseline value that is always very near zero.

6.2 MONITORING MACROFOULING; KEMA Biofouling Monitor

To have insight in the efficacy of the applied mitigation method, it is necessary to have a real time insight in the "cleanliness" of the system. For this DNV KEMA developed a monitor who can give a company real time insight, the KEMA Biofouling Monitor® (KBM).

The KBM is an ideal device for detecting and monitoring biofouling, determining both the settlement of larvae (mussel larvae) as the development of biofouling during the season (densities and growth). By means of the biofouling within the monitor, the efficacy of the applied mitigation treatment cannot only be determined, but also optimised. Next to this, the KBM can be used to test new anti-fouling chemicals or anti-fouling coatings on location.



Figure 5. Overview KEMA Biofouling Monitor®

The application of the KBM provides:

- Direct and continues insight in the development of biofouling in your cooling water system
- Direct insight in the efficacy of the mitigation method
- Cost-saving by optimisation of the mitigation procedure.

The KBM has been applied for the last 15 years at industrial sites all over the world. Over the years a further development of the KBM has taken place to make it even easier to operate, whereby the basic principle of

monitoring biofouling with the monitor did not change. This resulted in a new model in 2010 which only changed in the outside shape. Another improvement was the new and better valve in the KBM for cleaning the sedimentation space in the KBM. The monitor makes it also easy to measure for example chlorine concentrations (FO or TRO). This can be done by opening the lid and taken a sample from the water; this gives a good indication in the present chlorine values. In addition, it is possible to install a water temperature logger to monitor the water temperature..

The KBM is developed for sampling of fouling species in general. Water flow is up-welling through four PVC tubes, via a sedimentation chamber, and a central outlet. The settlement of fouling organisms occurs on four plates hanging in the four tubes, being representative for the fouling by mussels, oysters, barnacles and hydroids. No interruption of the water supply is necessary during sampling action and the KBM functions without sedimentation and flooding problems. The monitor is connected to the cooling water system as a by-pass loop and needs water flow of about 50 l/min. to ensure trouble free operation. The KBM enables fouling settlement registration during the seasons, which allows detection of bivalve settlement in an early stage, and forms an adequate check on the efficacy of the applied mitigation regime.

6.3 DOSING REGIME OPTIMIZATION; PULSE CHLORINATION®

To maintain a reliable and efficient operation of seawater cooling circuits, in the majority of the cases a biocide is added to prevent settlement and growth of marine fouling species, both macro and microfouling. Worldwide, the typical industry practice in coastal areas includes continuous chlorination of the seawater with periodic shock dosing. However this practice is not based on ecotoxicological data of targeted species, but is generally based on a post-hoc observation of antifouling efficiency of performed as an attempt to meet the discharge limits of residual biocide concentrations. Shock dosing is applied in the erroneous notion that it prevents fouling species from adapting to continuous chlorination. Such typical dosing procedures are practiced at a numerous locations elsewhere in the world

Pulse-Chlorination® (P-C) is based on the principle that in general bivalves (oysters, mussels and clams) have a recovery period before they open fully and restart filtration, for oxygen and food uptake after exposure to a chlorination period. Pulse-Chlorination takes advantage of this recovery time by using short successive periods of chlorination, alternating with periods without chlorine (Polman et al., 2012) [19]. During continuous chlorination bivalves close and switch from aerobic to anaerobic metabolism. When dosing intermittently, i.e. for several hours a day, bivalves will only close during the dosing period. During Pulse-Chlorination, bivalves

are forced to continuously switch their metabolic mode between aerobic and anaerobic, leading to a rather quick physiological exhaustion. This dosing procedure does not apply chlorine as biocide, but rather as a trigger to force mussels to switch between their metabolic modes, resulting in a rapid effect. To determine exactly the behavior of the mussel, i.e. recovery period, the valve movements are monitored in a special device, the MusselMonitor® (Figure 6).



Figure 6. MusselMonitor®

The on site tests to assess the optimal P-C regime at any given location, is carried out in the DNV KEMA mobile laboratory (Figure 7). This laboratory is a re-built 20ft sea container consisting in a “wet” laboratory part and a “dry” part for the electronic equipment. By performing the tests under the exact same cooling water system conditions, the results are directly applicable. Cooling water system conditions such as ambient water composition, residence time of the cooling water (pumps to condensers) and water velocity, are different at each site and are crucial for the desired regimes.



Figure 7. DNV KEMA mobile laboratory

The organisms used for the MusselMonitor®, are collected near the test location. For the chlorination experiments, sodium-hypochlorite is used from the plant site. The non-chlorinated water that is used for the tests is obtained from the vicinity cooling water intake. In the laboratory, the water is collected in a 1m³ buffer tank with a water flow of about 500 L/min. With submersible pumps, the water is directed from the buffer tank through

hard PVC tubing system to test tanks. In this system, the water flow is regulated and measured on-line with magnoflow meters. Continuous on-line measurement is made of the following water parameters: temperature, turbidity, dissolved oxygen, pH and salinity.

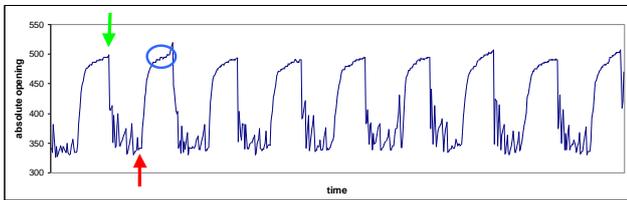


Figure 8. Movement behaviour (opening and closing of the valves) of fouling bivalves detected during P-C regime

6.4 POTENTIAL OF THE KEMA APPROACH TO OFFSHORE INDUSTRIES

Offshore industries are very prone to impacts by biofouling. The daily operation is affected and mitigation procedures are costly, especially when not carried out correctly. The approach as performed by DNV KEMA is to implement proper monitoring tools, in combination with optimised fouling control strategy dedicated to the specific system design and operating conditions. The main focus is to maintain prevention of fouling, i.e. maintain a clean system throughout the operating period of the facility. As such, OPEX and production are kept at optimal levels. Also, by proper monitoring, undesired situations are noticed at an early stage (early warning) hence required actions can be planned.

Such approach has been the best practice at many power plants, (petro) chemical industries, waste incinerators and LNG facilities around the world, where DNV KEMA has assisted its customers to optimise their monitoring and fouling mitigation procedures.

The offshore industry, applying large amounts of sea water in their systems, could equally benefit from this approach. Also, the monitoring tools are fit to be applied in the marine environment, at critical installations. Also, mitigation procedures can be optimized in a similar way, leading to increased mitigation efficacy and reduction of OPEX and an increase of operating profit.

7. CONCLUSIONS

Biofouling is a world wide phenomenon, arising in many different environments. Especially offshore installations and industrial activities are prone to be affected by biofouling, as they are located directly in the marine environment. Biofouling can occur in many forms, but in general leads to major impacts in terms of increased OPEX and loss in operating profit. Over the many years of operating equipment and facilities, a wide variety of mitigation methods has been developed, each of them

attuned to either system design and operating conditions, or to specific biofouling types and species. DNV KEMA has many years experience in monitoring and optimising antifouling procedures and their efficiency. Specific tools and methods have been developed, based on practical experience and sound science at a variety of industry types and environments. Their application at offshore facilities is regarded as equally applicable, serving the very same daily operating issues and leading to similar profit and cost reductions.

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