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**OVERFLATEDAGENE 2003**  
**The Surface Protection Conference & Exhibition**

***Protecting Offshore Investments against  
Corrosion with Innovative Epoxy  
Technology***

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# Protecting Offshore Investments against Corrosion with Innovative Epoxy Technology

## 1 Summary

The needs of anticorrosive protection are changing. New performance concerns, emergent environmental issues, careful cost analysis and increased safety concerns are creating new trends in the market for anticorrosive protective coatings. This article describes the new needs and points out the special relevance they have for the off-shore industry, and presents a novel tolerant epoxy technology incorporating the best trends to answer these new needs. This technology is based on a solvent-free epoxy coating which has both humidity and surface tolerance and can be extended with an edge-retentive version for increased protection. These features allow the offshore industry to reformulate its requirements regarding protective coatings, namely for maintenance jobs, both on the application side (increasing hydroblasting use, allowing damp surfaces and dispensing with dew-point restrictions) and performance (increased coating adhesion and service life for jobs performed under severe conditions). A number of results of the testing and application of this technology in recent years are mentioned.

## 2 Evaluating New Needs & New Trends

### 2.1 New Needs

Over the last two decades, the needs of anticorrosive protection systems have been changing. Table 1 presents the main needs concerning Performance, Environment, Cost and Safety issues:

<p><b>PERFORMANCE</b></p> <ul style="list-style-type: none"> <li>• Increased coating scheme service life demanded</li> <li>• Attention given to previous neglected failure causes:               <ul style="list-style-type: none"> <li>○ Poor coating coverage on angles, welds, etc</li> <li>○ Salt level at the steel surface</li> <li>○ Visual standard matching may not be enough</li> <li>○ Dew-point restricted coatings misused on wet environments.</li> </ul> </li> </ul>	<p style="text-align: right;"><b>ENVIRONMENT</b></p> <ul style="list-style-type: none"> <li>• New legal requirements concerning solvent and abrasive waste disposal</li> <li>• Media and social pressures in order to adopt cleaner technologies</li> <li>• Increasing costs for waste treatment</li> <li>• More demanding environmental control for certification purposes.</li> </ul>
<p><b>COST</b></p> <ul style="list-style-type: none"> <li>• Cost-benefit new look: service life vs. cost</li> <li>• Coating cost analysis including several components:               <ul style="list-style-type: none"> <li>○ Product cost</li> <li>○ Surface preparation cost</li> <li>○ Time of application cost</li> <li>○ Environmental costs: waste containment and disposal cost</li> <li>○ Safety procedures cost</li> </ul> </li> </ul>	<p style="text-align: right;"><b>SAFETY</b></p> <ul style="list-style-type: none"> <li>• Risk assessment procedures for anticorrosive treatments.</li> <li>• More attention on the health impact of surface preparation and coating procedures.</li> <li>• Increased constraints in the use of technologies that introduce additional risk (for equipment and people) within industrial environments.</li> </ul>

Table 1 – New Needs of Anticorrosive Protection

The off-shore industry, particularly for *in-situ* maintenance (blasting and coating while operating) is probably the most aware of the new needs regarding corrosion control, given the humid and salty environment, the aggressive corrosive media (the sea) and the safety and operational problems caused by traditional abrasive blasting. To cope with the new needs, some key new trends on both the coating and surface preparation activities have been observed: the increasing adoption of **hydroblasting** as surface treatment method, the increasing use of **solvent-free** coatings (e.g. solvent-free epoxies) and the attempts to increase the **edge-retentive properties** of the coatings.

## 2.2 New Trends

While answering these new needs, as below detailed, the new trends often face new problems:

### 2.2.1 Hydroblasting

The use of hydroblasting has a number of advantages, namely a lower salt level content on the prepared surfaces, a lower environmental impact, decreased safety risks (compared with abrasive blasting) and less counter-effects on the original surface profile (see Figure 1) or on adjacent coated areas not to be refurbished. Due to safety concerns, hydroblasting is much more compatible with ongoing offshore industrial activities, when compared with abrasive blasting. Nevertheless, some drawbacks can be associated with this surface preparation, mainly the dry surface requirements vs. flash rust dilemma and the reduced performance of the protection compared with traditional coatings over Sa 2.5 abrasive blast standard. Typical available coatings are the main adversaries for a larger adoption of this preferable surface preparation technology. There are numerous reports of off-shore maintenance jobs using hydroblasting, under high humidity, where the absence of moisture tolerance of the coating can lead to increased waiting gaps and often to excess flash rust and dangerous salt levels when the surface finally dries. Reblast is then needed and the cycle may repeating forever... A possible outcome is giving up the job. Or carrying out the application anyway, therefore crossing the red line, delivering reduced coating performance.

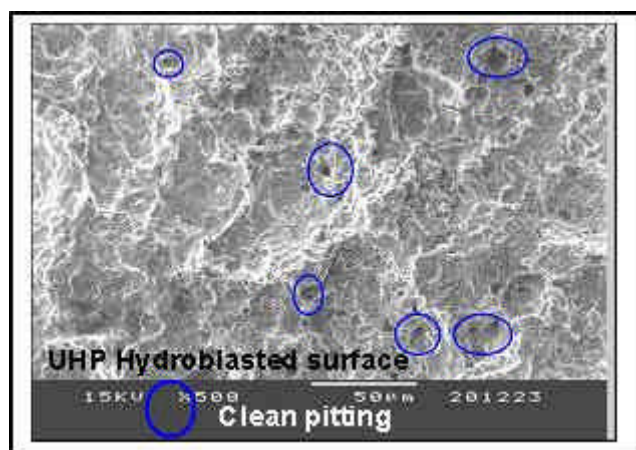


Figure 1 – Hydroblasted surface without salts and conserving the original profile.



Figure 2 – Edge-retentive coating from Euronavy

The salt level issue should be looked at carefully. In fact, immediately after hydroblasting, a SC-1 condition (surface free of detectable salts, as per SSPC SP12 regarding nonvisual contaminants) can be achieved. But under marine conditions, salt contamination of the surface will occur quickly, risking surpassing the SC2 condition (7 micrograms/cm<sup>2</sup> chlorides) after drying. A preferable chloride level below 3 or 4 micrograms/cm<sup>2</sup> is much easier to obtain if the coating application is possible just after blasting or washing, without need for drying.

### 2.2.2 Edge-retention

Coatings with increased edge retentive properties allow a better protection of critical areas, such as weld-seams, stiffener edges, etc [1]. The advantages of such coating's ability are especially important on ballast tanks and complex steel structures (e.g. bridges). A typical solvent-based coating, applied on a 90° edge by airless spray, will experience an after curing dry thickness reduction on the edge of 20 or 30%, compared with the adjacent flat surfaces. A good edge-retentive coating should present a ratio superior to 70% (see Figure 2), as per US Navy / NAVSEA requirements for long life ballast tank coatings (20 years). With such coatings, a trade-off is possible between extra performance and stripe coating needs (which can be reduced). On the new building side, edge rounding is normally mandatory on steel preparation specifications. This costly operation may also be reduced without critical impact on the performance, if an edge-retentive coating system is used. Normally, edge-retentive coatings have very high viscosities and give airless application problems. These drawbacks may imply the need for dual-airless equipment to apply the product.

### 2.2.3 Solvent-free

Solvent-free coatings are environmentally preferable and eliminate problems arising from solvent retention in applied coating films. Today's typical solvent-free epoxies on the market also have some drawbacks: reduced pot life and extremely high viscosities are the main ones, impairing a smooth application. Solvent-free epoxies tend to be applied with excess thickness, given the application difficulties, with negative impact on costs (paint consumption) and curing. A majority of solvent-free epoxies on the market are not surface tolerant and are dew-point restricted, thus making the option for hydroblasting problematic. Some solvent-free surface tolerant exceptions are tar-epoxies, thus not suitable given the present environmental & health safety restrictions.

### 2.2.4 Integrating New trends

The ideal solution to answer the new needs, in order to avoid the above drawbacks of the individual approaches, would be a coating system incorporating the new trends. This system should be solvent-free, tar-free, tolerant to humidity and to surface preparation / flash rust, user friendly (for the applicator) and have good performance (allowing long life protection over hydroblasted surfaces, on operating off-shore equipment, similar or superior to that achieved using traditional technologies over abrasive blasted Sa 2.5 surfaces). Euronavy have developed such a novel solvent-free epoxy technology that integrates all these aspects.

## 3 Solution

Euronavy created the first version of this novel epoxy system on the beginning of the 90's. The system was further optimised during a decade and as been approved by referential customers such as US Navy, SNCF or oil companies. Is now being increasingly used, namely on offshore equipments (maintenance, FPSO conversions and new building). Table 2 presents the main features of this product family and the typical respective system characteristics.

<b>PRODUCT FEATURES</b>	<b>SYSTEM CHARACTERISTICS</b>
<ul style="list-style-type: none"> <li>○ Modified epoxy, polyamine cured</li> <li>○ Solvent free</li> <li>○ Tolerant to damp surfaces</li> <li>○ No dew point restrictions</li> <li>○ Tolerance to adherent iron oxides</li> <li>○ High compatibility with old coatings</li> <li>○ Very high adhesion to steel (&gt; 170 Kg/cm<sup>2</sup>)</li> <li>○ Reacts with steel, oxides and moisture</li> <li>○ Steel roughness is not a critical factor</li> <li>○ Friendly pot-life (up to 3 hours at 25°C)</li> <li>○ Applicable by brush, roll or airless (60:1) with adequate viscosity.</li> <li>○ "edge retentive" version (ES301 S) available.</li> </ul>	<ul style="list-style-type: none"> <li>○ Surface preparation standard: hydroblasting to SSPC SP12 Wj2 (Wj2-M visual standard as per SSPC Vis4 – NACE N°7, MEDIUM flash rust)</li> <li>○ Typical DFT per coat: 100 – 150 microns</li> <li>○ Same product for priming / intermediate / finish</li> <li>○ If UV resistance is needed, the system may include a classic polyurethane topcoat</li> <li>○ 2 or 3 coat systems, ranging from 200 to 450 microns total DFT, depending on the areas to be protected, corrosiveness and service life target.</li> <li>○ Comfortable recoating window (16 h – 1 week at 25°C)</li> <li>○ No need for dehumidification in enclosed spaces such as tanks and voids.</li> </ul>

Table 2- Euronavy novel solvent-free epoxy technology: product features and system characteristics.

The use of the novel system itself, even without the use of hydroblasting, allows extended protection, as can be seen below (see 4. Results). The high adhesion values, the solvent-free feature without application drawbacks, and the edge-retention abilities are the basis of this superior performance. Example: US Navy / Navsea have a service life expectancy of 20 years for ballast tanks coated with this system, over SSPC SP10 / ISO 8501 Sa 2.5 abrasive blasting [6], with a total DFT of 10-14 mils (250-350 microns), with one stripe coat only.

The joint use of hydroblasting and this novel epoxy technology is (apart from the separate advantages of the product), the most interesting case for the offshore industry, namely for maintenance on site, during operation. Table 3 presents the impact of the combined use of hydroblasting and this novel epoxy from Euronavy, in each of the different needs listed before:

	HYDROBLASTING + ES301 SYSTEM
PERFORMANCE	<ul style="list-style-type: none"> <li>○ Coating immediately after hydroblasting or washing, without the need for drying, assures the lowest possible salt level.</li> <li>○ Edge retentive intermediate/finish is an additional factor of success</li> <li>○ Very high adhesion contributes to increased performance</li> <li>○ The absence of dew-point restrictions and the surface preparation tolerance makes it possible to achieve good performance under offshore environment.</li> <li>○ The solvent-free nature eliminates the risk of solvent retention. This issue is particularly important if heavy pitted steel is the case.</li> <li>○ The good rheology avoids potentially dangerous over-thickness.</li> </ul>
ENVIRONMENT	<ul style="list-style-type: none"> <li>○ No solvent release</li> <li>○ Because the use of hydroblasting is no longer detrimental to the quality of the protection if using this system, this environment-friendly surface preparation method is not only possible but also preferable.</li> </ul>
COST	<ul style="list-style-type: none"> <li>○ Lower overall cost of hydroblasting + coating is possible, depending on the situation, for the same protection quality level.</li> <li>○ Saves related costs: no abrasive removal and treatment cost, no need for dehumidification in enclosed spaces.</li> <li>○ Save time: no need to stop hydroblasting or coating application under humid conditions. The number of stripe coats can be reduced if using the edge retentive version.</li> </ul>
SAFETY	<ul style="list-style-type: none"> <li>○ Lower flammability risk, both during application and for the paint stock, due to the solvent-free nature of the system.</li> <li>○ Lower impact on human health: no abrasive dust, no solvents.</li> </ul>

Table 3- The impact of the joint use of hydroblasting and Euronavy's novel epoxy technology.

## 4 Results

The technology presented in 3. *Solution* is now being used with excellent results on off-shore, from FPSO conversion projects to off-shore maintenance using hydroblasting. On the marine side, this system allows extended service life and cost reductions in US Navy fleet maintenance operations. Some examples and data:

- Adhesion tests carried way by a leading oil company reached 17,0 – 24,0 Mpa (pull-off, ASTM D-4541, A2), over hydroblasted (DW2 STG-2222 standard) and mechanical treated (St2/St3) steel, with dry and wet surfaces [2]
- Weathering tests passed (system 2 x 150 microns, hydroblasted damp surfaces): Salt spray 5000 hrs ASTM B117; 100% relative humidity 5000 hrs ASTM D2247 [2]
- The system is now approved by NAVSEA / US Navy to be used without dew-point restrictions over damp surfaces [5].
- NAVSEA/US Navy's Fleet Maintenance Reduction Program completed a Project related with Bilge Preservation Coatings [4]. This novel epoxy system was approved after careful on-service evaluation over several years by MTTTC and CES. With the novel system, the periodicity of bilge painting can now be extended from quarterly to 5 – 10 years, resulting in huge savings in fleet maintenance expenditure and sailors workload. The approval is valid for Surface Ships, Nuclear Subs and Aircraft Carriers and once adopted on the entire fleet is expected to lead to an annual cost avoidance of USD 6,000,000.
- This system was also approved by SNCF, the French Railway Company, as a suitable system to be used over hydroblasting [3] (3 coat system, including a polyurethane topcoat, total nominal DFT 240 microns). The adhesion values over dry and wet hydroblasted surfaces, as measured by (Eurailtest certified laboratory for SNCF) ranged from 9,4 to 10,0 Mpa (wet and dry surface, respectively, taken after 700 hrs

salt spray weathering). These are far superior to the SNCF required adhesion values under the test conditions (> 1,5 Mpa, EN 24624 pull-of test).

- The increasing adoption of this new system is driving development towards added capabilities, given the extension of its use on new building for off-shore equipments. One of these added capabilities is the certified compatibility of the system with welding operations. A primer coat of 75 microns of this product was certified as having no influence on the welding process (SGS Certificate 1201/10202).

## 5 Conclusion

The adoption of this novel epoxy technology is believed to give the best available solution to cope with the difficulties felt by the offshore industry, when drawing up suitable specifications for anticorrosive maintenance. In order to improve the traditional output of the maintenance jobs offshore, the coating system specification can now be upgraded. To simultaneously cope with lower costs (including the long term savings of extended service life), environmental friendliness, increased performance and safer applications, the offshore industry can now specify the following:

- Hydroblasting to Wj2-M (SSPC SP12 / SSPC Vis-4) as preferred surface preparation method.
- A minimum 12 Mpa of adhesion for the coating system, over both Sa 2.5 (abrasive) and Wj2 (hydroblasting) standards.
- Mandatory: solvent-free coatings should be used.
- Application-related coating features should be imposed (e.g. pot life at 25°C > 2 hours, easy application by air-less spray, 60:1, compatibility with welding).
- The system must be able to be applied over damp surfaces without dew-point restrictions, allowing the application, without this limitation, and saving a lot of time and problems under offshore conditions.

This type of specification change means a break with some traditional “rules-of-thumb” regarding blasting and coating activities. Sometimes is not easy to assume this, but a break is indeed needed when facing innovation.

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