TYPICAL PROBLEMS WITH COATING FPU PROJECTS AND THEIR SOLUTIONS

1. INTRODUCTION

The building or rehabilitating of a floating production unit is a time consuming and costly undertaking. Projects faced with environments of high humidity and constant dew point and rains, which frequently causing delays and cost over-runs, primarily due to surface preparation problems and application restrictions of the coatings.

1.1 IN TODAYS MARKET

The ship and platform owners and their contractors are often faced with these adverse environment conditions, potentially and frequently causing delays for the completion of a project, due to surface preparation and application restrictions of the coatings. Delays are usually unacceptable and the applications are often carried out in conditions beyond the manufacturer's recommendations, which, causes potential pre-mature paint failures. Due to the expense of a dry-docking, the labour time and also the considerable revenue loss for down time, owners need to keep the downtime to a minimum. Therefore time is of the essence and time is money, usually big money.

2. THE MCU TECHNOLOGY

In the 1970's the offshore industry made a request to the coating industries to develop a coating that could be applied in high humidity conditions and in various temperatures if possible. This was due to the numerous pre-mature coatings failures for offshore marine maintenance. We will discuss here one of the most viable new technology developments; the moisture cure urethane, (more aptly called polyurea) and their developments over the past 30 years.

MCU – Moisture Cure Urethane or more appropriately called Urea. This unique technology coating invention is a single component pure urethane product that goes through a rather complicated production procedure where it is pre-reacted. The final cure is through the exposure to minimal amounts of moisture forming a polyurea. This is quite a different product to the widely known two component polyurethane coatings in many ways. The MCU is a much safer product for the applicator in primarily due to the lack of isocyanate (carcinogenic) free monomer. The polymer technology for this technology is used for production of many common products today including artificial heart valves, tennis shoes, automobile parts and caulking compounds for example.

This product is an extremely tough, pore free and has superior long-term adhesion, while remaining flexible during its long life. Independent third party testing has proven this to be more effective for corrosion resistance and long term monitoring of projects have demonstrated the MCU's to be more durable and have a longer lifespan, when compared to plural component technology.

3. EARLY MCU DEVELOPMENTS:

Like a lot of good ideas the concept was good, but the commercial aspects were poor. The initial products produced had inherent problems associated with them;

I. Over application of the then low recommended dft's produced gas entrapment or film blistering similar to plural component urethanes today.
II. The intercoat adhesion was not very good and it tended to easily peel from itself
III. They were unstable – often curing in the can prior to opening even after only storage for a few months.

Developments successful in laboratories often do not succeed in the real world. In the real world a coating must have as wide tolerances as possible as it is next to impossible to complete an application exactly as per manufacture's recommendations. Several coating manufacturers attempted the very lengthy and complicated production methods of MCU's in order to try and stabilize the material often involving "nitrogen blankets" over the product in the production tanks and in pails after canning. This process was time consuming, not cost effective and in the end offered no guarantee of stability.

All the major coating suppliers became discouraged and simply put this down as another good idea that does not work and could not justify the risks in continuing with the developments. Over the initial years a few smaller firms maintained a research into developments of these coatings. However the initial three key problems still exist with most commercially available products even today. Despite these inherent problems numerous projects were completed.

4. MCU COATINGS BACKGROUND

In 1980 William J. Brinton made significant discoveries and developed his own proprietary resins and formulations. Mr. Brinton's new formulations were the beginnings of a major turn-around for the MCU coatings. He was able to solve the three key problems and manufacture a product line with;

I. Products capable of being applied at up to 400% above their recommended DFT, without gas entrapment
II. Better than average intercoat adhesion, and substrate adhesion also
III. Long-term stability in the can.
IV. No maximum recoat time.

The new firm was established in with the sole intent to manufacture and market MCU's. In the early stages the focus was on the Bridge and Dam business. Within six years the Wasser MCU became the single largest supplier of bridge and dam maintenance coatings in the USA [1]. This was quite an achievement for a brand new, previously unknown firm, producing a technology product, which the industry's majority did not believe in.

Naturally to gain approvals for these major government projects came only after third party testing required by each state and provincial approved third party testing laboratory. This involved numerous tests and the results were very positive. All testing showed this material to be either the top performer or of the top, depending on the test criteria.

The Army Corps of Engineers (ACE), a key American engineering group, dealing with marine structures, have completed a series of tests for steel structures in harsh corrosion environments. In total Wasser has been tested by ACE for over a 12-year period with various tests. This has included Panama Canal project, 3.5 years testing (Wasser became the exclusive supply for maintenance for 15 years), also testing for over-coating of existing coatings (Wasser rated best), and recent test comparisons of various MCU firms Wasser rated the best [2]. ACE uses more Wasser than any other coating.

Figure 1 The Astoria-Megler Bridge

The Astoria Bridge was the one of the first major projects where Wasser was entirely used. This structure, on the Pacific Oregon coast is subjected to constant salt fog and condensate. It was also part of a 6-year joint Federal Highways Agency and Oregon Department of Transportation coatings evaluation program [3].

This test report included 10 of the top-performing technologies available including; various zinc systems, various epoxies, waterborn's, Wasser MCU and even rust converters. It is interesting to note that in this test the ***zinc silicate*** as a stand-alone coating, performed better than zinc silicate over-coated with epoxy and a polyurethane finish coat. This test concluded that the Wasser system was the only coating that was rated SSPC SP10 (less than 0.01% corrosion) after 6 years exposure to marine salt fog environment. After the last full inspection 14 years after this Wasser coating project was completed, the structure had the same rating of, 0.01% corrosion. This was previously unheard of for bridge structures in or outside of a marine environment.

5. COATING OF STEEL IN ADVERSE CONDITIONS

The problem with coating vessels and platforms is always subject to climatic conditions, specifically, often unpredictable weather, such as heavy rain and high humidity in combination with warm or cold temperatures.

These conditions make it difficult to maintain the surface cleanliness after preparation and before the coating, and if the humidity is too high this will cause a coating application delay, which will require a re-blast and often 2 or 3 times.

Coatings that are applied and subjected to the dew point, rain or immersion prior to setting or curing, may not cure properly and will need to be removed. This is often missed and the vessel goes back in service with uncured paint! If it is removed this can be problematic as it can be soft and will need to be removed by hand, a very time consuming and costly job.

Many ship owners are adopting riding crews to have the work completed at sea during voyage. Riding crews reduce the loss of revenue associated with downtime at key-side or in dry-dock. However the time factor of completing a job is still a significant cost, with the labour costs, equipment required, mobilization, air travel, etc., are still over 90% of the project cost and the coatings are generally 5% - 10% of the cost.

Due to the problematic nature of coatings much of the recoat cost (90% is generally labour cost) is attributed to the difficulty in working with certain coatings. The MCU coatings' non-restrictions can save and reduce project time and associated costs by as much as approximately 15% - 30%. Think what that could do to the budget!

6.1 TYPICAL PROBLEMS ASSOCIATED WITH COATING PROJECTS

The problems start out simply in three parts, coatings choice, surface preparation and the application.

I. The choice of the correct coating is the first task. The coating generally must be as capable and flexible in its characteristics as possible. When deciding the specification suitability for the intended use considerations that have to be taken into account, including; (a) the long-term requirements of the system, such as; the adhesion and flexibility required, impact, abrasion and erosion resistance, chemical resistance and the life span expected, and (b) where the job will take place and at what time of year, so that climatic conditions can be taken into consideration. The extended considerations that should be taken into account for a timely and successful project are; surface tolerance, over-coat time, cure time and the general moisture tolerance of the system.

II. The tight time frame for vessel repairs, leave little time tolerance for proper surface preparation. It is often inadequate and often a good surface preparation will flash rusts, requiring a re-blast, however time or budgets may not allow for this and the coating then applied may be outside its surface tolerances and doomed for failure pre-maturely. Coating requirements for these situations need to be surface tolerant to flash rust, while still offering good corrosion protection properties.

III. Time is limited, the over-coat needs to be capable of being as short as possible, but at the same time having the longest possible re-coat window. Often the job requirements require all-out haste and allow traffic as soon as possible. Other times a long time between coats is required due to construction schedules or climate conditions resulting in subsequent coats being applied beyond the overcoat limitations, causing later adhesion failure.

Other problems to consider are; coating application is often too thick, causing gas entrapment, the climatic conditions are often beyond the manufacturer's recommendations, i.e. too humid, too cold or beyond the dew point limitations. This can cause curing problems. In the case of a finish coat being subjected to moisture by dew, condense or rain before curing will result in amine blushing – a phenomena causing loss of colour and gloss.

Coating's intolerance to flexing varies. Flexibility in coatings helps a great deal as vessels are subjected to flex, in their weld seams, corners and along the longitudinals. The external hull is subject to reverse impact and decks, cargo hatches and combings are subjected to impact and abrasion. If coatings do not have enough flexibility or become brittle over time, the coatings can crack. In turn these cracks open the film and allow moisture to penetrate under the coatings starting at the crack interphase and in many cases start the premature failing and corrosion process.

Figure 2 This paint cracking caused by hull flexing (likely a reverse impact) and a coating choice that was too rigid. The top coating adhesion was not good and when the membrane broke the result is intercoat adhesion failure causing the paint to peel. A contributing factor to this could be that the surface was either damp when coated or the surface may have reached the dew point before it had a chance to cure.

Figure 3 This coating cracked along an inside corner and as this coating system had no corrosion protection other than the film itself, corrosion started from

moisture creeping in through the interphase and undercutting the coating.

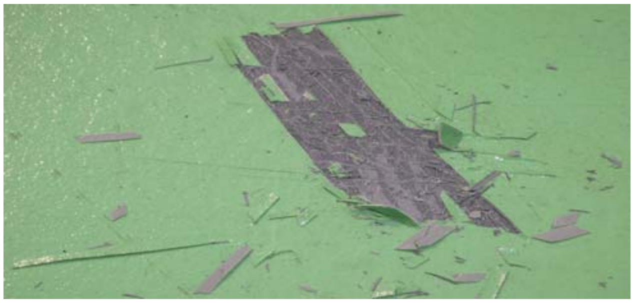

Figure 4 This was a new steel beam painted in a controlled environment shipyard shop in Singapore and delivered to an FPSO. The coating zinc, epoxy, urethane peeled as soon as a cross hatch was made – no tape was required.

Figure 5 Typical problems with aluminium at sea is an electrolytic reaction causing omega pittings. These pitting vary from steel as they have extremely sharp edges and can develop inwards at an angle.

Epoxy systems have problems adhering to aluminium and little penetrating properties necessary to coat these pittings. In one such case an epoxy re-coat discovered after several months that the system failed to solve the problems and the electrolysis in the pittings under the coating were still active. A test panel was prepared by UHP and the MCU-Aluprime was applied. After approx. 60 days in service an inspection was carried out and the system appeared to be performing well and the problem had been solved. The penetration was evident deep into the pittings and the adhesion value was between 7 – 9.2 Mpa. In all readings the failure was in the glue attachment of the dolly, not in the coating or the aluminium – coating interphase.

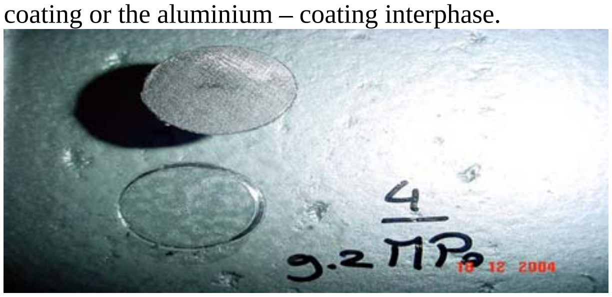

Figure 6 The photo of the affected areas after a test MCU-Aluprime. The project was completed in January 2005; a full detailed reporting of this project appeared in an article in Shiprepair and Conversion Technology Magazine March 2006. [8]

Figure 7 This is part of a destructive test for traffic decks on a RoRo subjected to extreme loads of 120 ton containers. The upper slide illustrates a ceramic pigmented epoxy coating and the lower in an MCU zinc and aluminium system.

RoRo vessels experience pre-mature coating failures often and typically within 6 – 12 months after application either new or after recoat. Wagenborg conducted a detailed test study on one of their vessels with various coating systems including ceramic filled epoxy, glass flake epoxy, high-build epoxy and MCU coatings. Several epoxy systems including glass flake and ceramic filled were applied. After several months all except the MCU exhibited cracking with coating loss and undercutting prior to destructive impact test by a consulting firm [8]. These vessels load containers weighing 60 to 120 tons each, requiring extreme impact and abrasion resistance. Many RoRo owners including Wagenborg, Swedish Orient, TransAtlantic, Stena, Spliethoff and Tor Lines have now chosen these products as the replacement coatings for decks.

7. THE MCU SOLUTION

Initially these moisture cure urea coatings were intended to be a solution for cold/hot and damp conditions. However during the past 25-years of the varied applications of these products and numerous third-party [3] testing have shown them to be a superior coating in many ways offering:

- Out-performance of most coatings in corrosion testing, passing, salt spray 20,000+ hrs. [4]

- Excellent adhesion requiring less blast profile (20-35µm), primers are surface tolerant to flash rust and magnetite.
- Better wetting out properties, necessary to penetrate into deep pittings.
- Excellent adhesion to and often rejuvenating old coatings.
- Better edge retention.
- They can be applied without dew point restrictions and in humidity's to 99%.
- Remain flexible, inert after full cure, no change chemically or physically.
- Better resistance over salt contamination.
- Better UV stability.
- Better abrasion resistance.
- 2 – 3 times longevity

These MCU coatings offer many applications as well as performance advantages. They are all single component and cure with traces of moisture. They can be applied in humidity's up to 99% and without dew point restriction and in temperatures from -15°C to +50°C.

THE BENEFITS OF MICACEOUS IRON OXIDE

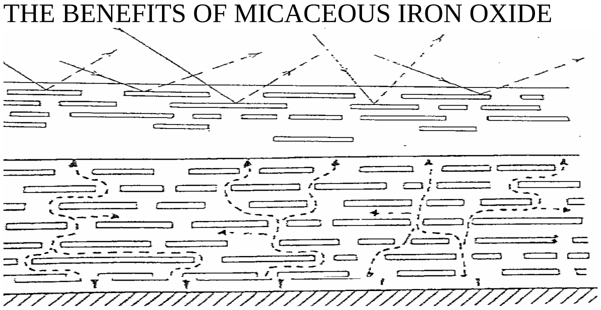

Figure 4 This illustration shows the two of the key workings properties of micaceous iron oxide (mio). The upper part of the diagram demonstrates the layers of mio flakes shielding the medium form the degrading effects of UV radiation. The lower diagram shows how the inter-leafing particles also reinforce and strengthen the coating film, by impeding the penetration of moisture and pollutants. This overall structure also avoids accumulation of moisture and gas entrapment by allowing micro permeable dissipation [5].

This phenomenon is similar to the workings of gortex material. It breathes allowing a one way micro-permeability. The key for a MIO pigmented coating is the quality of MIO used and the quantity used by weight in the volume of the coating. MIO is a mined material (later developments of synthetic types do not perform), and some mines may have more impurities than others, therefore it is critical to use a high quality.

Other key attributes of MIO is the resistance to erosion and longevity of the system and the edge retention of the film. The degree of MIO hardness is considerably more than any coating material and as the top layers of coatings erode the "MIO" becomes exposed and then retards this erosion further.

The laminar aspects improve the edge retention, findings by improving the film strength, reduce polymer swelling, and form a tough laminar seal [6]. The pigment characteristics are much improved over glass flake epoxy and aluminium, without the negative aspects of cohesion problems. The MIO actually improves the inter-coat adhesion significantly. MCU coatings use MIO in most of their coating products and are used in all of their marine and structural steel coating systems.

7.1 MCU PRODUCT HIGHLIGHTS

The two key primers are both surface tolerant to dampness and flash rust. They exhibit excellent wetting our properties that allow the coating to penetrate into pittings and into poor weld seams and inside corners. They offer excellent adhesion to steel, iron, aluminium, alloys, stainless steel, galvanized steel, Metalized and corten steel. They will also both adhere to most all, existing coatings.

Most coatings in these systems, (including the surface tolerant zinc primer), have no maximum overcoat time and can be over-coated (on a clean surface) in many months later and have ideal intercoat adhesion. These coatings can be subjected to rain, condensate or even immersion within 30 minutes. There will not be any affect as to the cure and will not cause an amine blush.

There are 3 – 4 key coating products used in 3 systems that can be applied and used on the entire vessel. One of two primers, one of two intermediate coats and one of two finish coats. Two coat systems can also be used. The over-coat time is generally 3 – 4 hours and with the ***PURQuik***® additive a 3-coat system can be applied in as low as 3 hrs.

7.2 MCU ALUPRIME

- Surface tolerant penetrating primer/sealer
- Highly abrasion resistance
- Designed initially poor surface preparation
- All metal, GRP and concrete surfaces
- Will penetrate loose rust, recommend to remove scale & apply mechanically
- Overcoat within 3 – 5 days
- Passes 5,500 hrs. salt spray, NORSOK approved

7.3 MCU MIOZINC

- The industry's 1st surface tolerant zinc rich primer.
- Can be applied to both ferrous and non-ferrous substrates.
- Zinc and Mio filled, excellent edge retention.
- Compatible with zinc anodes.
- Recommended for immersion
- Surface preparation from ST 2 to SA 2.5.
- Excellent adhesion to existing coatings.
- Capable of high builds to 300 µm without bubbling or cracking.
- Infinitely re-coatable.
- Potable water approved [7]
- Passes 10,000 hrs. salt spray, NORSOK approved

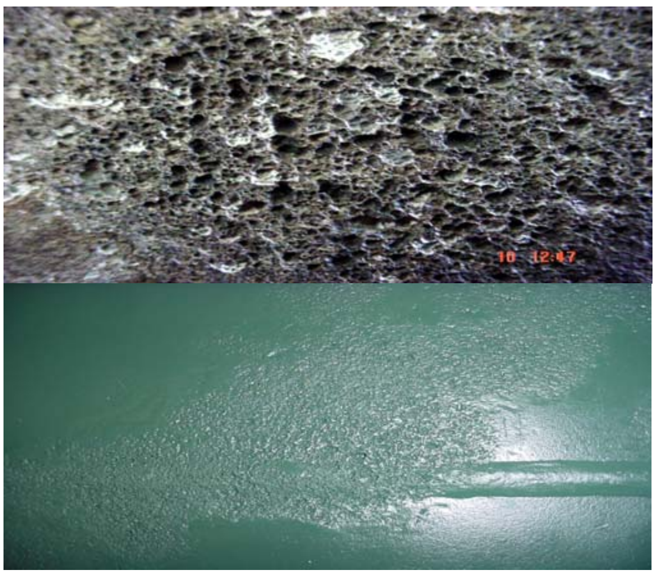

Figure 8 Upper - Macro photo of a proper blasted corrosion spot. Small omega pittings are visible. The pittings should be cleaned as much as possible. Lower - Good filling properties of the MCU MIOZINC into the fine cavities. [8]

7.4 MCU MASTIC

- Light coloured for ease of tank inspections
- Suitable for; ballast, drinking water, grey-water, black-water, drilling mud, cargo and fuel tanks; as well as engine and battery room
- Use as an intermediate coat for white finish
- Potable water approved [7]
- High abrasion resistance
- Applied in a one or two coat over primer

7.5 MCU TOPCOAT and MCU MIOTOPCOAT

- True aliphatic pure urea
- Excellent gloss and colour retention
- Capable of exposure to condensate, dew, rain fog or immersion within 30 minutes after application.
- Will not amine blush.
- High abrasion resistance.

7.6 MCU FERROGUARD

- Environmental friendlier coal-tar epoxy replacement
- Manufactured with further refined pharmaceutical grade coal tar.
- Mio pigmented, uv stable, resists cracking
- Adheres well to existing coal tar without abrading
- VOC compliant
- Excellent moisture, and chemical resistance
- Passed 20,000 hrs salt fog test [4]

There are 13 coatings in the full range. All are VOC compliant worldwide.

8. CASE HISTORIES

Figure 9 MV Hual Trubador, Ballast Tank, Hoegh Fleet Services AS**.** System: MCU-Miozinc – MCU-Mastic Completed by riding crew in 2000, water jetting surface preparation. After 3.5 years, the coating was 100%, with no breakdown and no signs of corrosion, even on edges and scuppers.

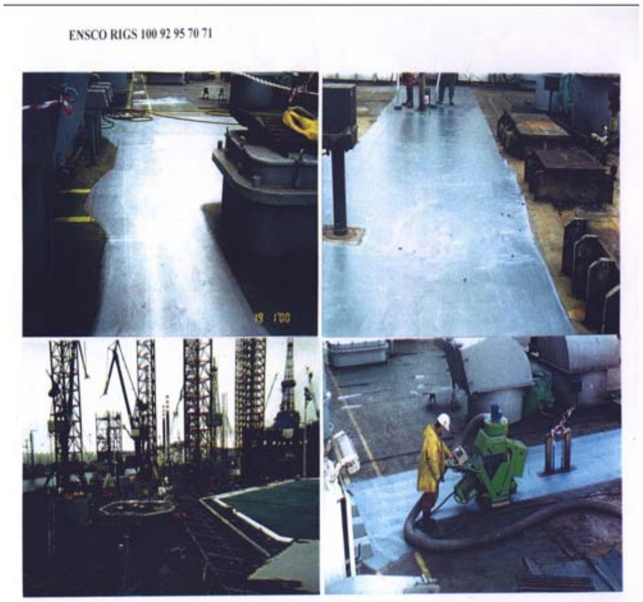

Figure10 Ensco 100, the world's biggest jack up rig was in for a full over 15 months in Rotterdam Verolme Botlek Shipyard using exclusively MCU coatings. When the deck was stripped it was blast tracked then had the MCU Miozinc applied. This was over-coated, by its own crew, 17 months later when the rehab was finished and the rig was towed to site. This unique zinc primer has not maximum recoat time and will not form zinc salts often associated with numerous marine failures. Even though zinc primers offer the best corrosion protection the entire industry except MCU paint suppliers have stopped using them!

Figure 11 (above) The surface preparation was mostly hydro-jetting and the corrosion and poorly adhered paint was removed. The old paint in with good adherence could remain. This technology offer excellent adhesion to old existing coatings including the MCU Miozinc primer. This entire rig was coated with 5 products.

Figure 12 FPSO Enterprise required tank coatings which could be applied over UHP surface prep and rust bloom chose MCU Miozinc and MCU Mastic. The Miozinc displayed no mid cracking or blistering even when applied over 400% above the recommended dft.

BW Offshore has chosen MCU-Coatings for all the tanks for their current FPSO Pioneer currently in rehabilitation in Keppel Shipyard, Singapore. This is already the third major FPSO project where BWO chooses MCU-Coatings.

8. NEW MCU BREAKTHROUGH – HIGH SOLIDS MOISTURE CURE

Another factor, which scared away most coatings manufacturers, is the cost factor. The common mcu technology is capable of producing a 53% volume solids (VS) product. Mr. Brinton was able with new technology to develop a 62% volume solids product. However the raw materials to produce these technology materials are significantly higher than many coatings on the market.

8.1 INCREASED TOLERANCES

The latest new development improves the MCU through minor modifications MCU HS coatings improves the film integrity. These coatings can be manufactured at high volume solids of 75% to 85%. These new developments allow for film thickness of 400 – 500 microns without gas entrapment or bubbling. The typical system for tank internals such as ballast, drinking water, grey and back water and fuel tanks, can now be applied in two coats instead of three, with fewer errors still and at a considerable further application cost savings. The square meter material cost of the new high solids will be reduced by an approximate 20% to 30% in comparison to the present material.

PRODUCTS	SV	DFT	TC	PC 30%	AREA	Est. Qty
	%	µm	M2/Ltr	M2/Ltr	M2	Ltrs
MCU-Mastic	62	75	8,27	5,79	10000	1728
MCU-Mastic	62	75	8,27	5,79	10000	1728
2 coat application				total	ltrs	3456
MCU-Mastic	80	150	5,67	3,97	10000	2521

Figure 10 Illustrates the comparison of a 1 coat from a two-coat application of MCU-Mastic. The first two rows are calculated at 62% VS, applied in two applications. The last row is calculated at 80% VS applied in one coat.

The new HS material does not sacrifice any of its well know characteristics such as surface tolerance, wet out penetration, flexibility, shore hardness or moisture impedance.

The volatile organic components (VOC) or solvents are reduced from 320 grams per liter to approximately 150, thereby also making the products more environmentally friendly. This is primarily a concern for shipyards in Europe and the United States where certain maximum allowances may be enforced or may become enforced in the future.

9. CONCLUSION

The Belgium – Norwegian group of MCU-Coatings acquired the Wasser technology a few short years ago, purchasing it from Mr. Brinton, who remains on their board as the technical director. During this brief period the group has become known as a quality producer of this unique coating. The coating has gained acceptance from some key ship owners and management firms. The coatings have proven themselves in tough marine environments such as ballast tanks, cargo tanks, RoRo vessels, FPSO's and offshore platform work, world-wide.

This technology has become successful due to the fact that the time and labour savings is considerably more than the cost of the coatings in most cases. Also in most cases 3 – 4 coatings in can be used for the entire vessel save anti-fouling. Projects could be completed with savings of 15% - 30% of the project cost as a whole and savings will exceed the coating costs in many instances. In addition the potential longevity is perhaps triple of what of typical current 2 component technology products.

The products are now being specified on rehabilitation work as well as new build projects.

10. REFERENCES

[1] Pittsburgh – 1986 Pittsburgh Engineering Review-Nace Conf.
[2] Army Corps of Engineers – 12 year test program
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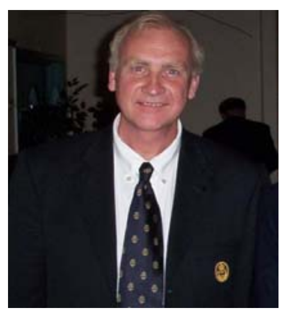
[4] BP Labs Ltd., Independent laboratory testing
[5] JPCL February 1981, by D.M. Bishop
- The Mystery of the Magic of MIO, by Malcolm Hendry
- ASTM Designation D 5532 –94 mio

[6] JPCL November 1995, Comparison of natural and Synthetic MIO, by S. Wiktorek
[7] Complies with ANSI/NSF Standard 61 potable water.
[8]Wink Inspections BV

11. AUTHORS BIOGRAPHY



Morten Sørensen holds the current position of Managing Director, at MCU-Coatings group of companies. He has been with Wasser High-Tech Coatings for 15 years as technical sales director and also marine manager, prior to establishing MCU-Coatings to develop the European / Middle East and marine markets.