New water-borne products matching solvent-borne coatings in corrosion protection

1. Introduction

Water-borne coatings for industrial corrosion protection are still a novelty to the industry and in particular for offshore heavy-duty purposes. Certain generic types of water-borne coatings for steel protection have been around for many years i.e. inorganic zinc silicates introduced over 50 years ago, alkyd emulsions 40 years ago, acrylic emulsions 35 years ago and the first viable generation of epoxies was introduced in 1973. The reasons for the so far low usage of water-borne coatings for corrosion protection, in spite of a long track record, are multiple and complex. The customers are conservative and reluctant to try paints based on new technology, there is still little environmental legislation in place for industrial coatings, water-borne products are perceived to be more expensive, with inferior performance compared to solvent-borne coatings and to have several limitations for use. The first generation of water-borne epoxies and acrylics were, in many cases due to the customers' lack of knowledge, applied in an incorrect manner and used under inappropriate service conditions. This resulted in early failure for the coatings and the misconception was created that water-borne coatings are not at all suitable for use in corrosion protection.

We have however come far since then, environmental legislation on solvent emissions is about to be implemented in many parts of the industrial world, raw material suppliers have developed new resin technology which permits formulations of water-borne products that are closing in on the performance gap with its solvent-borne counterparts, new accelerated test methods introduced that better correlate with reality and puts water-borne product performance in a better light, an increasing number of case histories prove that water-borne coatings give long term corrosion protection and people in general have become more environmental conscious.

The newest generation of water-borne industrial coatings have been pre-qualified according to NORSOK M-501, rev.4 to protect offshore installation from corrosion. Only one paint company in the world have succeeded to get such an approval for a complete water-borne coating system and when combined with a solvent-borne primer the hybrid system surpasses a pure solvent-borne coating system in performance and at a lower cost/square meter.

2. A short historical review

2.1 Generic types of coatings

Already in the 1940'ties a water-borne inorganic zinc silicate paint for corrosion protection was developed. The product did not get a big breakthrough then due to the elaborate application process, however there are pipelines in Australia that are painted with this type of paint that, after over 40 years of exposure, are still in excellent condition with no rust. Water-borne alkyds are far from new since research was started on this area in the late 1940'ties however, it is only in the 1990'ties modified emulsified alkyds has been put in use for industrial purposes. In the early sixties they started to develop and use water-borne acrylics for protection of metal, particularly in the US. The acrylic technology was further improved at the beginning of the 70'ties and today there exist storage tanks that were painted back then with a pure acrylic paint system where the coating system is still in good shape. In 1973 Anchor Chemicals came with the first generation of water-borne epoxy. Paints based on that type of epoxy had serious limitations, performance was rather poor and they were only to used to a limited extent for corrosion protection. Twenty years later we got the first generation of high molecular weight solid epoxy dispersions, cured with polyamine adducts. These epoxies have shown to be equivalent with solvent-borne epoxies for most purposes and this new technology is conquering constantly new markets. In the mid eighties the first generation of water-borne 2-component polyurethane paint appeared and they have been greatly improved in performance during the 90'ties. During the last ten years a lot of new water-borne paint technologies have been launched such as zinc rich epoxies, fluoropolymer, polysiloxane, 2-K acrylic-acrylics, epoxy-esters, polyesters and many more. Common for most of these new technologies is increasing use within corrosion protection as focus is put on the health and environmental aspects of solvents.

2.2 Changes in accelerated test methods

ASTM B 117 continuous salt spray testing has been considered the industrial norm for accelerated testing of coatings for corrosion protection for more than 50 years and it has for too long been a serious obstacle for a major breakthrough for the use of water-borne coatings. The test method has outlived it usefulness a along time ago. You only have to ask yourself the question how many coatings are continuously exposed to salt spray and humidity 24 hours a day, to realize that the method corresponds poorly with reality. In fact ASTM B 117 has a correlation factor around 0.5 compared to outdoor exposure for solvent-borne and even a lower factor for water-borne coatings. Coatings for corrosion protection are exposed to many different environments, such as sunlight, rain, heat, salts, pollutants etc. and it is important to underline that we do not have any accelerated test method today that can reproduce all these phenomena. We have however during the last few years got test methods that are great improvements, compared to ASTM B 117, the correlation factor is around 0.7 (9-10) and we are closing in on real life outdoor exposure conditions. The ASTM G 85 Prohesion test method, with the Timmin salt solution (0.4 wt% ammonium sulphate + 0.05 wt% sodium chloride), have cycles of wet salts pray and dry periods and was together with the Volvo Scab Test the first big improvements in accelerated test methods. When we started to use the Prohesion test method in our lab some years ago, it gave us the first indication that water-borne coatings performed far better than in the continuous salt spray test and that the bad results from ASTM B117 and BS 3900 were far from the truth.

The newest and best accelerated test method to assess the corrosion protection properties of water-borne coatings available today in our opinion is ASTM D 5894-96 and the cyclic test procedure in NORSOK M-501, revision no. 4 (5-9). Common for both these methods is the cyclic exposure to continuous salt spray, drying in air and UV/condensation chamber (ASTM G53), they differ in the number of hours exposed in each chamber and the total number of cycles/weeks for the whole test. The duration of the ASTM D 5894-96 is typically 12 weeks while NORSOK test procedure requires 25 weeks (4200 hours) of testing. Work done at SINTEF in Norway shows that the two test methods correlate well with each other, and the NORSOK cyclic test was found to have the best correlation with 2½ years North Sea field exposure (9), when compared to continuous salts pray, prohesion and the Volvo VICT Test. Many researchers have worked for years to find correlation coefficients for artificial accelerated testing for coatings compared to reality. Results compiled from data generated from many years of real life outdoor exposure in different environments in Holland gave the following correlation factors for different accelerated tests.

Correlation coefficients r (r = 1.0 means 100% correlation with reality):

Outdoor exposure testing	*r = 0.85*
Water Immersion testing, 500 hours	*r = 0.45*
Salt Fog testing, 1000 hours	*r = 0.50*
Cyclic TNO test, 1000 hours	*r = 0.65*

What can be concluded from this and similar tests is that cyclic testing has a higher correlation factor than running an accelerated test in just one mode i.e. exposing the paint to a single environment at a time. The first requirement we pose to a accelerated test is that is should give relevant information and when looking at the table above it tells you that a test with a correlation factor at 0.5 or below is not relevant at all. B. Appleman (1) stated that it is well recognized and documented that continuous salt spray testing is not suitable for replicating an exterior environment or predicting the performance of coatings. It is therefore a paradox that continuous salt spray testing like ASTM B 117 or BS 3900 is still used or asked for to such an extent. Perhaps it just confirms how conservative users of industrial paint are and how difficult it is to introduce changes. This is one of the reasons why it has been so tough to convince our customers to convert to water-borne coatings, since they ask for long term continuous salt spray test results, that we could not give them.

Picture 1. Marine paint test site south Norway.

In our company we have concluded that for accelerated testing of water-borne coatings for corrosion protection we only rely on cyclic salt spray in combination with UV/condensation + outdoor exposure in a marine environment. When it comes to outdoor exposure our test site is placed in Norway in a tough marine environment. The test panels are inclined at 45° facing south and exposed to rain, snow, ice, heat, sun-light, seawater fog etc. We rely a lot on our outdoor exposure testing since this is quite realistic, however it takes some time to test. We have however good correlation between 2 and 5 years outdoor exposure, so 2 years testing is in most cases enough to have reliable data. In June last year we decided to try to pre-qualify some of our water-borne coating systems according to NORSOK M-501, version no.4 and to our surprise we got all the complete water-borne systems approved and 50% of the hybrid systems (solvent-borne primer over-coated with water-borne intermediate and topcoat) approved. This we will elaborate on in the next chapter of this paper.

3. Experiences with today's water-borne coating systems

3.1 Water-borne paint system for offshore conditions

Six years ago we launched a complete water-borne coating system for offshore corrosion protection on offshore installations. The paint system consisted of;

1 x 40 μm water-borne inorganic zinc silicate primer
2 x 80 μm water-borne liquid epoxy intermediate
1 x 50 μm water-borne acrylic topcoat

The paint system gives after more than 6 years exposure at our marine test site excellent corrosion protection and when compared to a solvent-borne high performance coating system consisting of;

2 x 200 μm solvent-borne epoxy mastic aluminium primer
1 x 50 μm solvent-borne 2-K polyurethane topcoat

We see that the water-borne coating system performs better than the solvent-borne and with much less creep at the artificial scribe. In a life cycle analysis of the two coating systems done in 1994 it was shown that using the water-borne coating system would lead to a 80-90% reduction in solvent emissions to the atmosphere, exposure to health hazardous compounds for the user would be reduced by 70% and the cost/ square meter for the paint system would be reduced by 20%. At that time we also proved, both in laboratory and offshore field trials, that the water-borne coating system could be applied and dried at temperatures down to 5°C and up to 85% relative humidity. In spite of these good results, the paint system was not used by the oil companies in the North Sea.

When we now look back we have to conclude that the main reason why the water-borne coating system was not put to use is simply that the corrosion protection business is extremely conservative, and demand many years of well documented relevant data (case histories etc.) on experiences with use of new technology before they dare to try/use the products. At that time there were no signs from environmental authorities that limitations on solvent emissions would be implemented and force users to substitute the solvent-borne products with more environmental friendly products. The users are in fact happy to continue to use the solvent-borne products they have used for years.

In 1995 they also switched over to water jetting as surface preparation method for coating maintenance offshore and in addition only paint systems that were pre-qualified according to NORSOK M-501 could be used. This meant that coating manufacturers again had to rethink and develop primers that could be used on waterjetted surfaces and run them through long, tough and costly test procedures to obtain pre-qualification approvals.

3.2 Hybrid paint systems

The area we have most practical experience with water-borne coatings in corrosion protection is with so called hybrid paint systems, where solvent-borne and water-borne coatings are combined to make a complete paint system, such as the ones mentioned below;

1. *WB epoxy primer + SB epoxy topcoat*
2. *WB epoxy primer + SB epoxy mastic + SB acrylic topcoat*
3. *WB epoxy primer + SB 1-K intermediate + SB 1-K topcoat*
4. *WB acrylic primer + SB 1-K intermediate + SB 1-K topcoat*
5. *WB acrylic primer + SB epoxy topcoat*
6. *SB epoxy primer + WB epoxy intermediate + WB acrylic topcoat*
7. *SB zinc-epoxy primer + SB epoxy intermediate + WB acrylic topcoat*
8. *SB zinc-epoxy primer + WB epoxy intermediate + WB acrylic topcoat*
9. *SB zinc silicate primer + WB epoxy intermediate + WB acrylic topcoat*
10. *SB epoxy primer + SB 1-K intermediate + WB acrylic topcoat*
11. *Solvent free epoxy primer + WB acrylic topcoat*

(WB = Water-borne, SB = Solvent-borne)

Good results are obtained with some of these hybrid systems for the protection of oil storage tanks, ship newbuildings, pipelines, steel constructions, bridges and in the car industry they have good experience with hybrid paint systems. We have in fact seen that some hybrid systems, like system no. 8-9, perform better than a complete solvent-borne system. We have also obtained NORSOK M-501, version no.4, approvals for hybrid systems no. 8 and 9, both on blast cleaned Sa 2½ and water jetted steel. This will be discussed further in chapter 3.4. System 9 would require an additional tie-coat to be completely solvent-borne and that leads to a higher cost/ square meter than the hybrid system. Below some case histories for hybrid systems are given;

Case history no. 1, Oil storage tank, west coast of Norway, painted in 1995 with hybrid paint system no. 8. The coating system is in excellent condition after more than 5 years service.

Case history no. 2, Gas pipeline, Algeria, painted in 1995 with hybrid paint system no. 7. The coating system is in excellent condition after 5 years service.

Our and other paint companies experience tells us that it is usually much easier to persuade a paint customer to use a hybrid paint system than trying to get them to convert to a complete water-borne paint system straight away. Once the customer sees that these paint systems works, they will get more confident with water-borne coatings and maybe they will be willing to take the full step over to a complete water-borne coating system. It will probably take another 5 years or so, at least in Europe, before we will see large scale use of complete water-borne coating systems for heavy duty corrosion protection, when the impact of the VOC-directive will really start to influence the choice of coating system. The biggest challenge with these paint systems are to ensure correct surface treatment, correct paint application, film thicknesses, recoating intervals, climatic conditions and ventilation during application. We have seen many times that problems have occurred with correct recoating intervals for hybrids. If a fast drying water-borne thermoplastic topcoat is coated too early over a slow drying solvent-borne intermediate coating or primer the topcoat can seal off solvents from the underlying coat, leading to a serious loss of adhesion between the two coats. It is therefore very important not to take for granted that you can use the solvent-borne coatings over-coating interval with a solvent-borne coating, when you are converting to a water-borne coating. If the hybrid paint systems are correctly applied and are put to service where they are suited, excellent corrosion protection can be obtained.

3.3 Completely water-borne paint systems

Besides the water-borne paint system described in part 3.1 we have below listed some of the completely water-borne paint systems we have experience with;

1. *WB acrylic primer + WB acrylic topcoat*
2. *WB zinc silicate 1-coat thickfilm system*
3. *WB solid epoxy primer + WB hard acrylic topcoat*
4. *WB zinc epoxy primer + WB solid epoxy intermediate + WB hard acrylic topcoat*

Paint system no. 1 has been used for many years as a two coat system for light corrosion protection of indoor structural steel and machinery for corrosivity category C2-C3, according to ISO 12944. The two coat system has also with success been used for protection of galvanized steel and aluminium. Lately a new thickfilm acrylic primer (3) application has occurred for paint system no. 1. A coating system of 3 x 100 µm acrylic primer + 50 µm acrylic topcoat dries fast and can be applied in one working day and has been used in Denmark for corrosion protection of steel bridges in corrosivity category C4 – C5-I. Coating system no. 2 has been used for many years with great success in Australia for heavy duty corrosion protection of steel storage tanks, pipelines, oil platforms and road & railway bridges. When it comes to corrosion protection this one coat system is really the ultimate coating. Typically 125-200 µm is applied on grit blasted steel to minimum Sa 2½. Aesthetically the coating does not look nice after some time of exposure due to zinc salt formation on the surface however you are guaranteed long time corrosion protection. Coating system no. 3 has been approved to NORSOK M-501 standards both as a two and three coat system on blast cleaned steel Sa 2½ and water jetted steel. Coating system no. 4 has been approved to NORSOK M-501 standards on blast cleaned steel Sa 2½ and water jetted steel and has been used for corrosion protection of railway bridges and pipelines i corrosivity category C5-I according to ISO 12944. Below some case histories for completely water-borne coating systems are given;

Case history no. 1, 16 railway and road bridges in Melbourne, Australia, painted with coating system no. 2. Years in service 3-37. The oldest coating system is in excellent condition after 37 years service.

Case history no. 2, Railway bridge in Denmark, trial area painted in June 1999 with coating system no. 4. The coating system is in excellent condition after almost 1½ years exposure.

3.4 Water-borne coatings approved according to NORSOK M-501

The aim of the NORSOK standards is to reduce the overall cost level for the offshore field development by standardising a number of disciplines. In the area of corrosion protection, it has led to a simplified pre-treatment and painting specification that has been mutually agreed upon by the oil companies operating in the Norwegian sector of the North Sea. The main difference with previous routines was to change from demanding specifically described paint systems to functional demands supported by thorough documentation. To verify the durability of the various paint systems, the NORSOK M-501 specification describes a set of pre-qualification tests, which are carried out by an independent test laboratory with very specific and strict acceptance criteria.

Revision no.4 of NORSOK M-501 for system 1 (coatings for atmospheric Carbon Steel, above the splash zone) has the following test procedure and requirements, see table 1 below;

Test Procedure	Requirements
Cyclic test: Salt Spray (ISO 7253) - 72 hours Dry in Air - 16 hours UV-A (ASTM G53) - 80 hours Duration one cycle - 168 hours Total Duration, 25 cycles – 4200 hours	Corrosion creep from scribe: < 3 mm Blistering (ISO 4628-2): rating 0 Rusting (ISO 4628-3): rating Ri0 Chalking (ISO 4628-6): max. rating 2 Cracking (ISO 4628-4): rating 0
Adhesion before exposure (ISO 4624) Adhesion after exposure (ISO 4624)	Min. 5 MPa Max. 50% reduction from original value
Over-coatability (ISO 4624)	Over-coatable without mechanical treatment obtaining min. 5 MPa in adhesion value.

Table 1. Pre-qualification tests for coatings according to NORSOK M-501, rev. no. 4.

The requirements for pre-qualification to NORSOK M-501 place high demands on the quality of the paint systems. As already mentioned in chapter 2.2 we have obtained approvals of several complete water-borne coating systems and hybrid systems. We have listed them below;

1. *2x100 μm WB solid epoxy primer + 1x50 μm WB acrylic topcoat*
2. *1x120 μm WB solid epoxy primer + 1x80 μm WB acrylic topcoat*
3. *1x50 μm WB zinc epoxy primer + 1x120 μm WB epoxy intermediate + 1x80 μm WB acrylic topcoat*
4. *1x50 μm SB zinc epoxy primer + 1x120 μm WB epoxy intermediate + 1x80 μm WB acrylic topcoat*
5. *1x75 μm SB zinc silicate primer + 1x75 μm WB epoxy intermediate + 1x75 μm WB acrylic topcoat*

All the above paint systems have NORSOK M-501 approvals for both blast cleaned steel Sa 2½ and for water jetted steel (except paint system no.1 on water jetted steel). Creep from the artificial scribe for the paint systems were as follows;

Paint system no.	Creep at scribe, mm ***Water jetted steel***	Creep at scribe, mm ***Blast cleaned steel***
1	Not tested	2.6
2	2.5	2.3
3	0.5	0.5
4	0.6	0.3
5	1.4	0.7

Table 2. Average creep from scribe after 25 cycles in the cyclic test of NORSOK M-501 rev. 4 for the complete water-borne and hybrid paint systems given above.

Below are the results obtained at the same time for some very good solvent-borne coating systems;

6. *1x40μm SB zinc epoxy primer + 1x250μm SB epoxy mastic + 1x50μm SB 2K polyurethane topcoat*
7. *1x40μm SB zinc epoxy primer + 1x250μm SB epoxy mastic + 1x50μm SB 2K acrylic topcoat*
8. *1x75μm SB zinc silicate primer + 1x35μm SB epoxy tie-coat + 1x200μm SB epoxy mastic + 1x50μm SB 2K acrylic topcoat*
9. *1x250 μm SB glass flake epoxy mastic primer + 1x50μm SB 2K polyurethane topcoat*

Paint system no.	Creep at scribe, mm ***Water jetted steel***	Creep at scribe, mm ***Blast cleaned steel***
6	2.9	2.7
7	Not tested	2.8
8	Not tested	1.0
9	1.2	1.9

Table 3. Average creep from scribe after 25 cycles in the cyclic test of NORSOK M-501 rev. 4 for the complete solvent-borne systems given above.

When we then compare the results from table 2 and 3, we see the following. Hybrid system no. 5 performs far better than the comparable solvent-borne system no. 6 and 7. The complete water-borne system no. 3 performs even better than hybrid system no. 5. Hybrid system no. 6 performs better than the comparable four coat and thicker solvent-borne system no. 8. If we look at the results for two coat water-borne coating system no. 2, we are struck by the fact that such a system can pass the test, especially when we mention that much thicker solvent-borne glass-flake polyester and glass-flake reinforced epoxy coating systems did not pass the cyclic test requirements. If we compare water-borne system no. 2 with the 100 μm thicker solvent-borne system no. 9, we see that the solvent-borne system performs slightly better on blast cleaned steel and better on water jetted steel.

To make it simple we have here only compared the corrosion creep from the scribe for the paint systems in table 2 and 3, since these are the critical results and all the paint systems mentioned have passed the other test requirements given in table 1. We can however conclude, as the title of this paper indicate, that there are water-borne and hybrid paint systems that are matching comparable solvent-borne coating systems in performance.

4. Environmental legislation and it's impact on the future

During the last 10 years more and stricter environmental legislation has been enforced on paint products, mainly for decorative paints but now also for industrial paints. The legislation is enforced both on the use of solvents in paint products as well as on substitution of health hazardous compounds in paint with less health hazardous compounds. Some countries like the USA, UK, Holland and Austria have introduced maximum limits for solvent content (VOC) in paint (see table 4 below), Switzerland has introduced a tax on the use of solvents and several European countries have introduced voluntary national plans to reduce emissions of solvents with up to 50% within few years. The European Union (EU) has ratified a VOC-directive that will be enforced in year 2003, that will "force" the users of solvent-borne paints to use paint products with significant lower solvent content i.e. powder, solvent free, high-solid or water-borne coatings. Within the EU-countries the full impact of the VOC-directive would mean a 67% reduction in solvent emissions compared to the 1999 figures. This means that the VOC-directive will have a major impact on companies who can not afford to reduce their solvent emissions through modernisation or installing costly filter or cleaning processes. In addition to this there are plan for national emission ceilings for amongst others solvents within year 2010. Several countries have EPA authorities that have put up observation lists for health hazardous compounds used in paints, were they either forbid its use or recommend substitution with less health hazardous compounds. There is reason to believe that national EPA authorities will enforce the substitution principle in a stricter manner in the coming years. There is no doubt that R&D done in paint companies around the world will become more and more driven by the environment.

	USA	**California**	**UK**	**EU (Car Industry)**	Japan
Year	1999	2002 (2006)	1998	1999 (2002)	-
Primer	350	200 (100)	250	540 (250)	-
Shopprimer	650	-	780	540	-
Topcoat	420	250 (50)	420 (510)	420 (400, Holland)	480

Table 4. VOC limits for industrial coatings in some countries

The latest years focus on solvents have lead to the development of powder, water-borne, solvent free and high-solid coatings and they all have their advantages and limitations. For industrial corrosion protection there has been a tendency the latest years to change from paints with a high solvent content to paints with higher solids or solvent free. This trend will however slow down and powder and water-borne coatings will grow in importance at the expense of solvent-borne coatings. High solid paints have limitations such as low flash point, might need extra solvent thinning to be applied, dries relatively slowly and high solid epoxies are mostly based on liquid epoxies that can give contact allergies. Solvent free paints have two big drawbacks, they dry very slowly at temperatures below 10°C and they give inferior corrosion protection compared to solvent- and water-borne coatings. Solvent free epoxies are also based on liquid epoxies and one can be faced with customers like oil companies who do not want to use paint products that can create allergies for the applicators. It is also possible to make 1-K solvent-borne paints with higher solids, however there is a limit, with today's available resin technology, to how high one can get in solids before the coating becomes impossible to spray apply. This means that this type of paint will even with somewhat higher solids, still have a quite high VOC. Powder coating is environmental friendly since no solvents are used. The technology has however a big limitation for industrial corrosion protection, since the object has to be "baked" in an oven. This excludes all larger constructions that need corrosion protection, which is the major part of the market. Powder coating will however become dominant in the OEM-market segment.

We are then left with water-borne coatings as the forth alternative for environmental friendly protection of steel. Their biggest limitation is the climate conditions during application, since one need to get rid of the water evaporating after application to get a good film formation. This demands good control of temperature, relative humidity and ventilation during application. Water-borne coatings also have limitations for use under sever conditions like under water, at high temperatures and in certain aggressive chemicals. This is mainly due to the binder's inherent properties. Flash rusting is a phenomenon that might occur with water-borne primers, with insufficient amount of inhibitor, is in direct contact with steel. Our experience is that this is a pure cosmetic defect with no influence what so ever on the long term corrosion protection of the coating. This has been confirmed by resent research done at the Swedish Corrosion Institute (4).

5. Conclusions

As described in this paper, water-borne coatings can give corrosion protection at level with solvent-borne coatings. It requires however that one has to follow the rules for correct application and use of the coating. During the last 5 years there has been a quiet revolution in resin technology for water-borne coatings. Water-borne alkyd, 2K-polyurethane and 2K-isocyanate free systems perform just as good as their solvent-borne equivalents. Water-borne acrylics have many advantages compared to solvent-borne acrylics, water-borne epoxies can be made based on high molecular epoxy without fire- or health hazardous labelling and with much shorter recoating intervals than a solvent-borne epoxy. Raw material suppliers put tremendous amount of efforts in R&D to make better and better resins for water-borne coatings and this is reflected in the large number of patents filed in this area over the last 10 – 15 years. Not all new resins for water-borne coatings launched by raw material suppliers over the years have reached the sale volumes expected, and most paint companies working with water-borne coatings have experienced severe setbacks in their R&D work due to the discontinuation of selected resins. Another battle is the high price for the raw materials for water-borne coatings, but they will probably drop as the volume increases.

One thing is for certain we can not continue to pollute the earth atmosphere with solvents the way we have done for years. Organic solvents increase the ozone in our troposphere to health- and environmental hazardous levels. There are however solvents that do not have a large Photochemical Ozone Creation Potential (POCP), and this is the reason why the US VOC legislation allows for VOC except solvents. Very few solvents with a low POCP can be used in industrial coating formulations, so the use of solvents in paint products will decrease. This leads to an increasing usage of environmental friendly industrial coatings like water-borne and powder, at the expense of solvent-borne coatings.

Today there are two many different accelerated test for assessing corrosion protection and as already discussed some of the tests have very low correlation factors. Different customers require different accelerated tests so paint companies spend a lot of time and money on testing to satisfy all the customers' needs. All the different tests make it difficult to compare, so as one author puts it “there is a need for a universal standard for testing protective coatings" (2). The accelerated test requirements for corrosivity category C4, C5-I and C5-M given in ISO 12944 are not tough enough for Marine offshore environments. The best universal standard would be to join ASTM 5894-96 and NORSOK M-501, rev. 4 together to one standard, with 12-15 cycles for onshore applications and 25 cycles for offshore applications. The salt spray used in the cyclic test should be based on ASTM G85 – Prohesion test, rather than ISO 7253 as specified in ISO 12944 and NORSOK M-501, rev. 4.

Both test results from tough accelerated tests and an increasing number of case histories confirms that water-borne coatings are able to deliver excellent corrosion protection. By changing to water-borne coatings one will contribute in reducing pollution of our atmosphere and humans will be less exposed to health hazardous solvents.

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ABSTRACT

Water-borne coatings for industrial corrosion protection are still a novelty to the industry and in particular for offshore heavy-duty purposes. Certain generic types of water-borne coatings for steel protection have been around for many years i.e. inorganic zinc silicates, alkyd emulsions, acrylic emulsions, emulsified epoxy. The reasons for the low usage of water-borne coatings for corrosion protection, in spite of a long track record, are many. The customers are conservative and suspicious towards new technology, little environmental legislation is in place for industrial coatings, water-borne products are perceived to be more expensive, to have inferior performance and have limitations for use. In the early days' lack of knowledge about water-borne coatings led to incorrect application and using the coating under inappropriate service conditions. This led to early failure of the coatings, creating the misconception that water-borne coatings are not suitable for use in corrosion protection.

The world is changing, environmental legislation on solvent emissions is about to be implemented in many parts of the industrial world, new resin technology permits us to formulate high performance water-borne products, new accelerated test methods are introduced that confirms water-borne coatings performance, case histories prove that water-borne coatings gives long term corrosion protection and people have become concerned about pollution and environment. The new generation of water-borne industrial coatings have been pre-qualified to protect offshore installation from corrosion and when combined with a solvent-borne coating it surpasses a pure solvent-borne coating system in performance and at a lower cost/square meter. An as an extra benefit we also reduce solvent emissions in the environment.

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