Surface Preparation and Coating

A practical solution to the repair of ballast tank coatings

In this article by our contributor Brian Goldie, in conjunction with Bert Kok of Royal Coatings, the Netherlands, this topic of BT coatings is examined.

Over the past few years the importance of coatings on the structural integrity and hence safety of a vessel has been realised by the industry in general. Coatings also now comprise a significant proportion of the cost of a newbuilding, and the type and quality of the coating can affect the value of the asset. The reasons behind this stem from two major changes in shipbuilding practice, firstly the use of computer derived strength/design calculations which enabled more streamlined vessels to be designed coupled with the use of high tensile steels in ship construction which meant that the thickness of steel plate used could be reduced, resulting in cheaper vessels. However, with thinner steel plates, the corrosion margins were smaller and corrosion-initiated losses of vessels in the late 1980s, led to demands for better quality of coatings, particularly in the vulnerable sea water ballast tanks of large tankers and bulk carriers. The first IMO regulation covering this, Resolution A.798, mandated the use of light-coloured, hard coating of these tanks in vessels built in 1998 and subsequently.

Typical condition of Ballast Tank Coating after a number of years.

This was an important first step, however this early legislation laid down minimum requirements for the coating performance and did not address adequately the differences in performance of different hard coatings or the importance of proper surface treatment before coating. Various initiatives were then taken by industry bodies such as the Classification Societies and the Tanker Structure Cooperative Forum etc, which led to a joint IACS / Industry proposal on Guidelines for Ballast Tank coating Systems and Surface Preparation being presented to IMO in February 2005, with a suggestion that a standard should seek a target life of 15 years for the coating. This was accepted by IMO, who also decided that the scope of the standard should be extended to cover the coating of ballast tanks of all vessels over 500 grt.

These Performance Standards for Protective Coatings (PSPC) are due to come into effect on 1 July 2008, but because of the importance now placed on coatings, IACS decided to bring this date forward to 8 December 2006 for tankers and bulk carriers covered by the new IACS Common Structural Rules.

This article describes a practical method for maintaining and up-grading the coating system in sea water ballast tanks to ensure compliance with the new IMO requirements.

Since the introduction of the IMO Guidelines, all new tankers and bulk carriers and those having maintenance painting, need to have hard coatings applied to the sea water ballast tanks. The most common hard coatings used are 2K-epoxies, due to their good all round protection properties and long track record of performance. Originally these were solvent-based products, applied in several coats to achieve the desired dry film thickness, but due to increasing environmental pressures on reducing solvent emissions (VOCs), these are now generally 100 % solids (solvent-free) systems. These products have the advantage of being applied at high film thickness, such that only one or two coats are required to meet the PSPC regulations. The disadvantage of solvent-free epoxies in general is their need for special application techniques due to their high viscosity and short pot lives, as well as their poorer wetting characteristics.

What makes a good epoxy ballast tank coating ?

One ranking of suitability of hard ballast tank coatings, is to achieve a B1 classification in the Marintek, now DNV, Test (1), which rates performance in accelerated tests (in a wave tank, to simulate real service conditions in a ballast tank, and in a condensation chamber) in terms of blistering and corrosion. However there are other aspects which determine suitability of hard, particularly, epoxy coatings, namely, they need to be light coloured for ease of inspection, have good flexibility to reduce tendency to cracking and for maintenance use, to have good adhesion to less than perfect surfaces.

The requirement for light colour was introduced by IMO to aid subsequent examination of the condition of the ballast tank coatings, as normally these are very dark hard to access spaces.

Cracking can occur in an epoxy ballast tank coating for several reasons, the epoxy is intrinsically brittle or becomes brittle on ageing; it can be placed under stress, from shrinkage during curing, at critical points (eg welds) or from the flexing of the steel plates and it can be subject to thermal (cyclic) stresses, either due to being next to warm cargo tanks or cold against the outside hull. DNV and SP Swedish National Testing and Research Institute (2) carried out a joint research programme to study how the flexibility of coatings changes with time under simulated water ballast tank conditions. This study showed that traditional epoxy coatings had a flexibility of about 2.5 % relative elongation which did not change much on accelerated ageing. Attempts to improve flexibility had only limited success as relatively new epoxy coatings (when study was undertaken) designed to be more flexible had relative elongations around 6.5 %, which reduced slightly on ageing. However permanently improved flexibility can be obtained by formulating paints from other than the commonly used bisphenol A epoxy resins, and the study did determine two coating systems with very high relative elongations, one of which did not decrease on ageing.

For newbuilding, surface preparation and coating application can be controlled to a far greater extent than in maintenance. In block building, it is normal to use steel plates blasted to Sa2½ and primed with a modified zinc silicate shop primer. After assembly any damaged shop primer is repaired and then a full protection system of anticorrosive primer and epoxy mid and topcoats is applied. If coating intervals are followed correctly then adhesion of the epoxy to the substrate is not a problem and effective lifetimes of about 15 years can be achieved. Proper surface preparation in repair and maintenance, is both time consuming and costly. Often it is not possible to blast to Sa 2½ and other less perfect methods must be used. In this case the repair coating applied must have good adhesion to these types of surfaces.

Cost is an important criterion for deciding on when, where and which coating to be used for ballast tank repairs.

According to the new IMO regulation, a coating in good condition must have less than 3% general breakdown or area rusted (the percentage is of the area under consideration or in the critical structural areas). Thus tank coatings must have a "good" rating at the survey points or repairs must be carried out. According to Eliasson (3) the total ballast tank coated areas on a VLCC are approximately 300 000 m^2, and that the overall repair rate for on-board repair is 1 m^2/hour / operator, when all the steps in the procedure are taken into account (eg, fresh water wash, surface preparation, coating application). If we therefore consider a 10% overall

breakdown of the coating, then this would take 30 000 hours. If we can then assume that there are six extra men on-board, then the work would take 5000 hours or approximately 34 weeks. However, ballast tanks are only free roughly 50% of the time and there are other times when access is not possible, including poor weather. Thus in this extreme case, the total coating repair could take 1.5 years continuous work. The same job carried out in a normal repair yard with an output capacity of 1000 m^2 /day, (3) would require 30 days of work, the cost of which would run into millions of dollars when the off-hire costs were taken into account. Due to the conditions described above, the only course open to a shipowner is to have a good coating properly applied at newbuilding and maintain this regularly throughout the lifetime of the vessel.

A solution available

With these constraints in mind, one company has come up with a practical solution to the problem of using solvent-free epoxy coatings for the maintenance protection of sea water ballast tanks.

Royal Coatings Inc, Belle Chasse, Louisiana, USA, has developed a solvent-free epoxy system designed especially to address problems with other epoxy ballast tank coatings used in maintenance.

The system comprises, EasyPrime, a low viscosity, flexible epoxy with good wetting properties, and EasyFlex, a permanently flexible chemically resistant epoxy.

Whereas conventional epoxies have PVCs of at least 35% and the use of fillers / extenders makes them inflexible in service and which under stress, crack. In the EasyPrime/ EasyFlex system, the primer has a PVC of <2% and the topcoat <12%. This makes them intrinsically more flexible which was confirmed by the above mentioned DNV study.

EasyPrime

EasyPrime has been designed to have low viscosity and has a hydrophilic additive which can accommodate incidental amounts of water such that it easily wets out most surfaces and penetrates crevices formed from tightly adhering rust and old coatings. It has a low inert content and is semi-transparent and is applied until the surface has an even greenish colour indicating complete penetration and cover (the low PVC means that it is transparent until a dft of >15 µm is achieved). Its excellent flexibility and low shrinkage on curing allows it to resist impact damage common to conventional epoxies.

EasyFlex

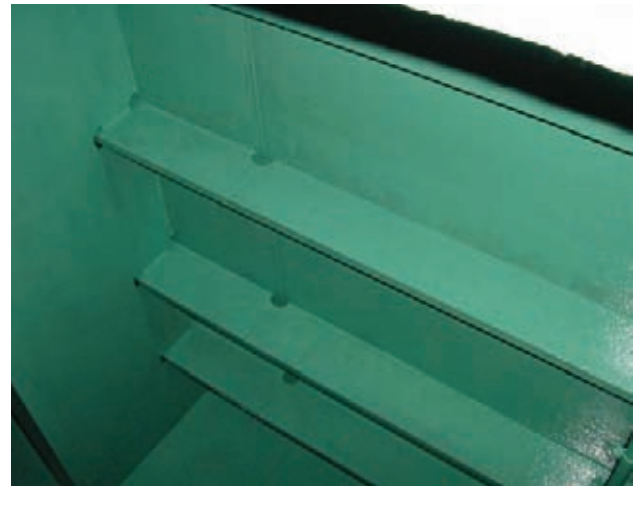
EasyFlex has been specifically formulated to be permanently flexible, chemical, heat and abrasion resistant 100% solids epoxy topcoat primarily for sea water ballast tanks and, potable water tanks on board ship. It can be used in new building, where it can be applied over most shop primers after sweep blasting and one coat of EasyPrime, but it is in maintenance situations where it really out performs other systems.

It is compatible with hard and semi-hard coatings, surface tolerant and is UL/NSF Standard 61 certified for potable water use. Again the low PVC means that the topcoat is transparent until, in this case, a dft of 150 µm is achieved, thus ensuring proper application.

A typical application in a maintenance situation in a ballast tank would be high pressure water wash (typically 700 bar and maximum 1000 bar), to remove all corrosion and loose coatings, wash with clean water to aide removal of any remaining soluble salts and allow to dry for 24 hours.

The EasyPrime is then applied by brush, roller or airless spray until an even coloured coating is obtained giving a nominal dft of 50-75 µm. To ensure ease of application, the un-mixed epoxy coating is heated and maintained at approximately. 25° C to reduce the viscosity.

After curing for eight hours, a stripe coat is applied at edges and weld seams (or could be applied wet-on-wet), followed by one coat of EasyFlex,



EasyPrimed surface.

Stripe Coating.

again applied by brush, roller or airless spray at 250 – 300 µm. The tank can then be returned to service after18 hours at 20° C, without holiday testing. The completed coating system can then be optionally guaranteed for 5 years (or longer).

Working with applicators, in particular Van Zonderen of Rotterdam, a procedure was developed for use, either in drydock or using riding crews and this system has now been used successfully to protect sea water ballast tanks for more than 10 years.

Case studies

The following case studies demonstrate the advantages of the system, compared to conventional epoxy ballast tank coatings, in terms of application flexibility, performance and cost. If we consider the relationship between surface preparation and coating selection we can arrive at practical, cost effective ballast tank coating repairs. For example, if one accepts slightly inferior surface preparation, with a good wetting and adhering epoxy and a realistic lifetime, then a very cost effective solution is available.

EasyFlex finish coat.

PLV *Solitaire* (Allseas Group)

The Swiss-based Allseas Group S.A., founded in 1985, is one of the major offshore pipelay and subsea construction companies in the world, operating specialised vessels - which were designed in-house, including the largest pipelay vessel in the world, *Solitaire*. Based on the same principles as Allseas' *Lorelay*, her ship-shape provides excellent workability. She has a pipe carrying capacity of 22 000 t, making her less dependent on offshore pipe supply in hostile areas.

In 1999, the coating system in the sea water ballast tanks needed replacing. Before deciding on the replacement coating system, patch trials were carried out in one tank. The specialist contractor, Van Zonderen Offshore, Rotterdam, was commissioned to prepare the no 7 port double bottom tank for this trial, by hydroblasting whilst afloat. Using a pressure of

*PLV **Soltaire**.*

10 000 psi (700 bar) all the previous loose coating and corrosion were removed, leaving a rough steel surface of approx HB 2 quality (International Paints Standard, Thorough Hydroblast Cleaning) The tank was then cleaned with fresh water, all debris removed and then dried using dehumidifiers. Seven coating test patches were applied from various paint suppliers, including the Royal Coating system, applied by Van Zonderen Offshore. To aid the application by airless spray, a special electrically-heated portable water bath was designed by the contractor to keep the paint components at 25°C prior to application. One coat of EasyPrime was applied at 100 µm dft, followed by a stripe coat of Easyflex at critical areas, then the EasyFlex topcoat was applied at 200 µm dft. Control of the application thickness was based on the volume of paint applied.

The test patches were examined after about six months, and the condition of the Royal Coatings system was found to be very good. As a result, all water ballast tanks and void-spaces of *PLV Solitaire* were treated with the Royal Coatings system. This was carried out during voyages by a riding crew, supplied by Van Zonderen Offshore, whilst the vessel was in full production. Surface preparation and coating application were carried out exactly as in the trial. The coated tanks were again inspected in May 2002, after 40 months in service, and found to be in good condition, and as a result Lloyds Register decided to extend the yearly tank inspections to a two and half year cycle.

This vessel has just been inspected (September 2007) after some tanks had been coated for more than eight years and found to be in better than GOOD condition as defined in the PSPC standard. There was only minor coating repair in

Soltaire, Ballast water tank coating after eight years service.

some tanks. This is an excellent performance considering all the work was done with riding crews and is in part due to the professionalism of the contractor, van Zonderen Offshore BV. Allseas have confirmed they are happy with the use of the Royal Coatings system in the ballast tanks of the *Soltaire*.

Borgestad

Borgestad Shipmanagement is an international technology management company, currently with 13 vessels (11 bulk carriers and 2 FSOs). The 11 open hatch Boxshaped double hull bulk carriers are managed for Gearbulk

Shipowning Ltd on behalf of Kristian Gerhard Jebsen Skiprederi AS (KGJS). Gearbulk is owned 60 % by KGJS and 40 % by Mitsui O.S.K. Group

The vessels in the Borgestad fleet had previously had their ballast tanks protected by epoxy coal tar, but by 2000 these needed up-grading in view of the SOLAS and IMO recommendations. Borgestad needed a system which could be applied easily, over existing sound coatings and meet the "good" condition of the Class societies.

One of the current vessels in the Borgestad fleet was owned by Westwood Shipping Lines, and in 2001 a trial of the Royal Coatings system was carried out in the vessel, *Westwood Anette*. The vessel was sold in 2002 and the new ship manager (Borgestad) was impressed by the state of the test patches which had been carried out in the ballast water tank and which were about 12 months old.

The coating manufacturer confirmed that for these tests, the tank surface had been high pressure water washed (150 bar) and areas of coating failure/breakdown prepared by needle gun and then the surface cleaned with a proprietary alkaline cleaner (Easy Prep) to improve recoatability of the aged epoxy coal tar and after 20 minutes washed again with fresh water. After drying, two coats of Easy Prime followed by two coats Easy Flex were applied by brush / roller (four coats are required to give required dft with this method of application). After the 12 months test, the coating repairs were found to be in good condition and the adhesion of the repair system to the surrounding sound old epoxy coal tar coating was also good.

Due to this result, over the next five years, areas of coating breakdown in the ballast tanks of the 11 bulk carriers were repaired with this system by the crew, whilst the vessels were in operation, and at present the system is still performing well.

Westwood Anette.

The advantage to Borgestad in this protective system is that good performance can be achieved with minimum effort by the crew, who did not need any specialist training, whilst at sea. Due to vessel "in service application", drydock times are reduced which maximises the revenue earning capacity of the vessels.

The system lasts for 10+ years and any minor breakdown can easily be repaired, keeping the tanks in good condition, and not subject to special examinations by Class.

According to Michael Stephen Mc Rae (Senior Superintendent, Borgestad), use of the Royal Coating's system has allowed the owner to maintain 100% control of ballast tank coating condition by regular ship's crew without the need for any special equipment, such as breathing apparatus, dehumidifiers etc, and with zero VOC, there is no time limit to exposure which maximises crew working time (of course protective clothing must be used as is good practice). To date over 150 tanks have received

Queen Elizabeth 2.

upgrading using the Royal Coating system, and no failures have occurred where the manufacturers application instructions, which are very simple, have been followed.

Queen Elizabeth 2 (Cunard)

The world famous cruise liner, *Queen Elizabeth 2*, has had regular dockings at Lloyd Werft, Bremerhaven, Germany for refurbishment and maintenance and repair work over the past 10 years, including repainting of the sea water ballast and other tanks.

During April – July 2006, as well as general maintenance and repair, some of the ship's tanks were recoated. Previous to that, the water ballast tanks were painted in 2001 and 2004 by van Zonderen in the shipyard using the EasyPrime/EasyFlex system. In each case the ballast tanks were coated after water blasting to remove corrosion and old coatings as described previously. The Royal Coatings system was selected for its superior qualities and chemical resistance.

According to Peter Paisley, Technical Superintendent for Cunard, the recoating of the sea water ballast tanks with the Royal Chemical system has been very successful, subsequent tank inspections have shown only minor damage with minimum maintenance required.

Discussion

The above case histories demonstrate the versatility and cost effectiveness of the EasyFlex coating system for the protection of sea water ballast tanks during maintenance and repair. If we now look at the requirements of PSPC we see that there is a need for shipowners to only use coatings which have been pre-qualified by testing by, for example, DNV, or use coating systems that have proven and documented field performance with a final condition of "good" after five years in ballast tanks. Such a system is what is described above. The EasyPrime/EasyFlex system, has Class approval from ABS, DNV and Lloyds and proven and confirmed performance, with major owners such as Allseas, Bergesen, Cunard, etc.

Conclusion

The industry is now striving for perfection in ballast tank coating, but is this really necessary?

The Royal Coating's EasyFlex coating system has been shown to be a safe, versatile, cost effective, practical method for the repair and up-grading of seawater ballast tanks. It can easily be applied by the ship's crew or by specialist riding crews or in drydock to give five years or more protection to a "good" standard and should therefore meet the latest PSPC regulation.

The system can also be applied at newbuilding to

avoid delays and cost frustrations during the coating process and can also be used to replace soft ballast tank coatings.

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