NEW DIRECT-TO-METAL COATINGS

DEVELOPED FOR AEROSPACE AND MILITARY APPLICATIONS

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As with most coating end-users, customers in the aerospace and military sectors are always looking for ways to lower cost and increase the ease of applicability of coating technologies while maintaining the desired level of performance. Direct-to-metal (DTM), or self-priming, coatings are widely used in light- to medium-duty general applications, such as general metal finishing, automotive, appliances, lawn and garden, architectural metals, and metal furniture. DTM coatings are attractive for several reasons. First, by eliminating the need for the primer layer, they increase coating application efficiency and enable faster return to service. Second, they have the potential to reduce costs because they consume fewer raw materials, reduce labor demand, and lower energy use. Third, a reduced number of coats translates into reduced VOC emissions, lower odor, and a lower carbon footprint. Fourth, elimination of potential primer-topcoat intercoat adhesion issues is an advantage. Finally, even when two coats of a DTM coating are used to provide enhanced performance, efficiencies are still achieved in inventory maintenance and during application since only one coating formulation is used. Aerospace and military customers are hoping to realize these benefits as well. For aerospace applications, DTM coatings provide the additional benefit of weight reduction.

Exactly what is meant by direct-to-metal coatings? There are two main interpretations for DTM, according to Michela Fusco, market segment manager for Maintenance Repair and Operations (MRO)/Airlines with AkzoNobel Aerospace Coatings. One involves primer being directly applied to the metal surface (PDTM) without a pretreatment, while the other involves use of a pretreatment, but elimination of the primer and application of the topcoat direct-to-metal (TCDTM).

In April 2013, AkzoNobel introduced a PDTM system for aerospace applications consisting of a chromated primer (Aerodur LV 2114) with a single-stage or basecoat/clearcoat topcoat (Aerobase) approved to the SAE International Aerospace Material Specification (AMS) 3095A standard. The system has, according to Fusco, recently been selected for the repainting of commercial aircraft due to the time-saving benefits offered and the advantages of the basecoat/clearcoat finish. The system has been successfully applied with reported savings of half a day on a seven-day paint cycle.

The primer is based on an advanced, proprietary epoxy resin and the topcoat is based on urethane technology. "This DTM system eliminates the need to use any type of metal pretreatment, such as Alodine, Solgel, or Wash primer technologies; the primer is applied directly to the clean Scotch-Brited substrate and provides the necessary adhesion and corrosion resistance to meet the stringent specification requirements," notes Fusco. She adds that the new system is the first of its type to receive the AMS 3095A qualification, meeting the rigorous requirements for high gloss exterior paint systems for commercial fleet maintenance.

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"The elimination of the need for pretreatment enables our customers in the aerospace industry to improve the efficiency of aircraft maintenance. The AMS 3095A-approved DTM paint system can be applied on any type of commercial aircraft, whatever the climate, and anywhere in the world. In addition, it provides easy strippability within the typical MRO requirements," Fusco observes.

For DTM coatings that combine the primer and topcoat into one system, however, no commercial aerospace systems are currently available. Development work is being conducted for both commercial OEM and general aviation companies. "The work and the testing on TCDTM coatings for aerospace applications are still in the early stages," explains Fusco. "The requirements for a direct-to-metal application do not differ from the specification requirements already in place for conventional multilayer systems, so the technology must still meet the weatherability, chemical resistance, UV exposure, and all of the other requirements of an exterior decorative specification. As a result, the technology is largely limited to urethane chemistries," Fusco adds.

One area of research involves UV-cured coatings for aerospace applications. The French company Socomore is developing UV-cured hybrid sol-gel coatings for aeronautical and DTM applications. In fact, product manager Nadia Moreau was recognized by RadTech Europe, in November 2013, with the Paul Dufour award for her research paper on this topic. Moreau has shown that the novel UV-cured hybrid sol-gel coatings, which can be applied to a wide range of substrates including metals and composites, are effective at protecting aeronautical substrates against corrosion.

For military applications, meanwhile, The Sherwin-Williams Company has been successful in developing a TCDTM. In December 2013, the company introduced a direct to-metal, high-solids epoxy that meets the military MIL-PRF-22750G Typ III specification for epoxy coatings. This epoxy is designed for one-coat application directly over zinc phosphate steel or treated aluminum, eliminating the need for a primer coat. The two-component high solids epoxy can be used in applications that specify Grade A or Grade B finishes, including Army or Navy equipment that requires weather resistance, but is expected to find the greatest use on interior surfaces, according to Beth Ann Pearson, global product manager for Military Coatings with Sherwin Williams. She notes that the epoxy is designed for one-coat application directly over zinc phosphate steel or treated aluminum. It was awarded approval by the Army Research Lab (ARL) in Aberdeen, MD, which found that the coating meets ARL's performance requirements for a minimum 1,000 hours of salt spray and 40 cycles of cyclic corrosion. "The development of this DTM coating took several years, during which time careful selection and modification of the resin and pigment packages were achieved in order to provide a DTM coating that meets the performance expectations of the MIL-PRF-22750G Type III specification. We are, as a result, thrilled to be able to offer one

MIL-PRF-22750 Revision G Specifications for High-Solids Epoxy Coatings

The military specification MIL-PRF-22750 Revision G covers the performance requirements for two-component high solids epoxy coatings that are free of all inorganic hazardous air pollutants (HAPS), including any derivatives of lead and chromium.

The specification covers four types of coatings:

Type I–Standard formulation with a maximum volatile organic compound (VOC) content of 340 grams/liter as packaged.

Type II–Volatile organic hazardous air pollutant-free (VOHAP-free) formulations that have a maximum VOC content of 340 g/l as packaged.

Type III–Direct-to-metal, VOHAP-free formulations with a maximum VOC content of 340 g/l as packaged and offer enhanced corrosion performance, including 1,000 hr salt spray and 40 cycles on the cyclic corrosion test. This type is only available in semigloss and lusterless colors.

Type IV–Self-contained portable kits containing type II or III epoxy coatings for, but not limited to, brush, roller, and cartridge application.

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of the first direct-to-metal high-solids epoxies approved by ARL," Pearson comments.

The Navy is also interested in DTM coatings for certain applications. Notably, researchers at the Naval Research Laboratory (NRL) assisted industry in the development and evaluation of three fast-cure corrosion protection epoxy coatings with reduced application costs (two coats of the same coating rather than a three-coat primer, basecoat, and topcoat system) that still provide the expected level of performance and are compliant with anticipated environmental regulations, according to Arthur Webb, section head for Marine Coatings, Science, and Synthesis with the NRL. Because they are epoxies, the coatings are effective without a topcoat only for interior applications, but they can still be used on exterior structures if a topcoat is applied over them. The epoxy resin is based on diglycidyl ether and bisphenol F chemistry, and the coating is cured with a cycloaliphatic amine. Even though two coats are actually applied, the Navy refers to the coating system as a single-coat system because the two coats can be applied in one day.

Use of the new coatings was fully implemented by the Naval Sea Systems (NAVSEA) Command in September 2008, and, to date, nearly 1200 tanks have been protected on U.S. Navy surface ships, carriers, and submarines. The use of the new system has reduced the installation costs of tank coatings while simultaneously quadrupling coating life expectancy, according to Webb. As of 2012, NAVSEA has documented that these installations are providing a $6.5 to $7.1 million/year cost savings. The coating system is also being used in well decks, vent plenums, and bilges, and has even been tested as a high performance primer under advanced polysiloxane topcoats on ship topsides.

NAVSEA has leveraged United States Coast Guard (USCG) experience in its current update of "Standard Item 009-32: 'Cleaning and Painting Requirements,'" which is used by the Navy to define ship paint application processes to allow DTM application of its new polysiloxane topside paint (i.e., a new, more durable, and color-stable haze gray) on aluminum substrates. The polysiloxane DTM system, however, has not yet been proven for steel substrates because of the risk posed by pinhole rusting. In addition, NAVSEA has worked with shipbuilders to allow DTM application during new construction of some of its alkyd coatings in interior, dry spaces of ships, because these paints perform in a similar manner to an alkyd primer/topcoat system. NAVSEA has already updated ship and submarine specifications to allow these DTM applications, because the corrosion risk in these dry spaces is low and the alkyd paints provide an acceptable level of performance. Shipbuilders have reported to NAVSEA that eliminating the primer application step reduces overall coating system installation costs, according to a NAVSEA spokesperson.

It will be difficult for DTM coatings to find long-term use on the exterior steel surfaces of Navy ships, however, due to the extremely harsh environment created by constant exposure to sea water, according to Dr. Erick Iezzi, a researcher with NRL. "There are a number of reasons why DTM coatings haven't been utilized on the steel surfaces of Navy ships," he says. "First, as a coating dries, solvent evaporates, and in this process pinholes are often formed. In a DTM coating, those pinholes provide a route for moisture to reach the substrate. The primer, therefore, acts as an additional barrier layer that prevents water from penetrating to the substrate. Second, while polysiloxanes do adhere

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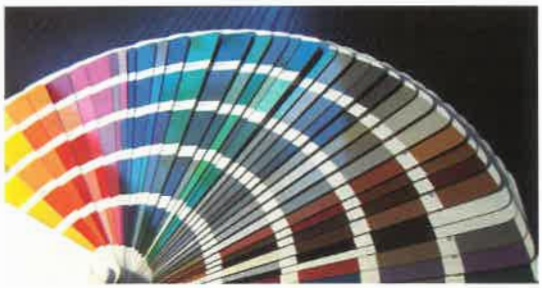
to steel, they are very expensive versus epoxies, which provide excellent corrosion protection, and thus are very good primers. Polysiloxanes provide the weathering performance that is required by the Navy. Finally, in such a highly aggressive environment, it will be difficult for a single coating system to provide the long-term performance -durability in terms of color and gloss retention, flexibility, and solvent and corrosion resistance—without adding excessive thickness," explains Iezzi. Webb adds that it is challenging to achieve top performance with a one-coat system because, typically, when one set of performance characteristics improve, another set of characteristics will decline. "There are always tradeoffs in coating performance, so it is very difficult to achieve very high performance in all of the necessary performance categories when using a DTM coating," adds Webb.

Fusco also notes that achieving the same level of performance in a DTM application as in standard multicoat systems that use chromate pretreatments and primers has been a challenge. "In the aerospace industry, air frame integrity is always the bottom line, so there is no room for replacing a corrosion-inhibiting system with another technology that does not meet the same criteria for protection of the aircraft. PDTM work requires exceptional capability in the primer to address issues that are traditionally pretreatment properties: adhesion promotion, metal cleaning, and corrosion resistance," she explains. Formulation of pigmented TCDTM coatings is an additional challenge. According to Fusco, "It is necessary to develop a corrosion-inhibiting system that has the performance of a chromated coating, but that can be delivered in the desired paint color scheme of the airline."

Fusco notes that there is a significant need in the aerospace and military sectors, which rely heavily on corrosion protection coatings, to eliminate the use of chrome pigments while maintaining excellent corrosion performance. "The aerospace industry as a whole is very reluctant to move away from the old standards of highly chromate-loaded primers and pretreatments to go to fully nonchrome systems; changing the stack-up of coatings at the same time is a very major step and one that will be addressed with extreme caution," asserts Fusco. However, she also notes that the opportunities created by both DTM processes are huge, because the cost of out-of-service time for repainting of an aircraft is very high, and thus time savings is a major cost consideration for airlines. "The advantages and reliable performance of our qualified DTM coatings will contribute to convince airlines and MRO stations to adopt this technology," asserts Fusco.



For Sherwin-Williams, in-depth knowledge of the resin and pigment chemistry in question was necessary to develop its new DTM epoxy coating. One of the biggest challenges, according to Pearson, was meeting the performance specifications on different types of metal surfaces. She notes in particular that proper surface preparation is absolutely critical as there are separate military specifications for surface preparation. To date, ARL has approved the Seafoam Green formulation, and is testing an additional color. If that formulation meets the specifications as well, then Sherwin-Williams will receive approval for all of the colors in its product line. "We are looking forward to being able to offer a full range of colors to meet the growing demand for direct-to-metal coatings that offer cost savings and increased productivity without sacrificing quality or soldier safety," Pearson remarks. She also notes that Sherwin-Williams continues to look for ways to make coatings work better and smarter.

AkzoNobel, meanwhile, has active programs for both types of DTM coatings. Most notably, in 2014 the company will launch a chrome-free DTM primer meeting the requirements of the AMS 3095A specification in combination with single-stage topcoat and basecoat/clearcoat systems. "As a result," states Fusco, "the airline industry will have access to a totally chrome-free DTM solution for the repainting of commercial fleets of any type of aircraft."