“The elimination of the need for pretreatment enables our customers in the aerospace industry to improve the efficiency of aircraft maintenance.”

By Cynthia Chelmeke, CoatingTech Contributing Writer

As with most coating end-users, customers in the aerospace and military sectors are always looking for ways to lower costs and increase the ease of applicability of coating technologies while maintaining the desired level of performance. Direct-to-metal (DTM), or self-primer, 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 oxides, 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 pass carousol 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 benefits of weight reduction.

The concept behind direct-to-metal coatings is simple: since there is no primer, the topcoat is based on unprimer technology. This system eliminates the need to use any type of metal pretreatment, such as Alodine, Snigel, or Wash primer technologies; the primer is applied directly to the clean Scotch-Brite substrate and provides the necessary adhesion and conversion 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.

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 1DTCM 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 multi layer systems, so the technology must still meet the workability, 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.

The Army is researching UV-cured coatings for aerospace applications. The French company Sonocoatings is developing UV-cured hybrid sol-gel coatings for aeronautics and DTM applications. In fact, product manager Nadia Moreau was recognized by RadTech Europe in November 2013, with the Paul Dufoe 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 DTM. In December 2013, the company introduced a direct-to-metal, high-solid epoxy that meets the military MIL-PRF-22755G Type 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-solid epoxy can be used in applications that specify Grade A or Grade B, including Army or Navy equipment that requires weather resistant, 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 3,000 hours of salt spray and 40 cycles of cyclic corrosion. “This 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-22755G Type III specification. We are, as a result, thrilled to be able to offer one
NEW
DIRECT-TO-METAL
COATINGS
DEVELOPED FOR AEROSPACE AND MILITARY APPLICATIONS

by Cynthia Chinnery, CoatingTech Contributing Writer

As with most coating end-users, customers in the aerospace and military sectors are always looking for ways to lower costs 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 a 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 oxides, 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 pass an enhanced performance, efficiencies are still achieved in inventory management 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 benefits of weight reduction.

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

In April 2013, AkzoNobel introduced a PTFM system for aerospace applications consisting of a chromated primer (Aerdur LV 2114) with a single-bottle or two-pack/polyMERcoats (MERcoats) 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, Sinelco, or Wash primer technologies; the primer is applied directly to the clean Scotch-Brite 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 work and the testing on TDTM 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 multi-layer systems, so the technology must still meet the compatibility, 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 aeronautics and DTM applications. In fact, product manager Nadia Moreau was recognized by RedTech Europe in November 2013, for 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 cycles.

For military applications, meanwhile, The Sherwin-Williams Company has been successful in developing a TDTM. In December 2013, the company introduced a direct-to-metal, high-solid epoxy that meets the military MIL-PRF-22750G Type 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-solid 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, if it is to be awarded approval by the Army Research Lab (ARL) in Aberdeen, MD, which found that the coating meets ARL’s performance requirements for a minimum 3,000 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 or chromatin. The specification covers four types of coatings:

Type I—Standard formulation with a maximum volatile organic compound (VOC) content of 340 grams per liter (g/L) as packaged

Type II—Volatile organic compounds (VOC)-free formulations, that have a maximum VOC content of 340 g/L as packaged

Type III—Direct-to-metal, VOC-free formulations with a maximum VOC content of 340 g/L as packaged and offer enhanced corrosion performance, including 5,000 hr salt spray and 40 cycles on the cyclic corrosion test. This type is only available in semigloss and lustrous colors.

Type IV—Self-contained portable kits containing Type II or I ll VOC-free coatings, or not limited to brush, roller, and cartridge application.
"The use of the new system has reduced the installation costs of tank coatings while simultaneously quadrupling coating life expectancy."

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 coat-
ings with reduced application costs (two costs of the same coating rather than a three coat primer, basecoat, and topcoat system) that still provide the expected level of performance and are compli-
ent 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 effec-
tive 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 chemis-
try, and the coating is cured with a cyclicolamine amine. Even though two coats are actually ap-
pied, the Navy refers to the coating system as a single-coat system because the two coats can be ap-
pied in one day.

Use of the new coatings was fully imple-
mented 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 installa-
tion 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 $65 to $77.1 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 topsores.

NAVSEA has leveraged the 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 paint application processes to allow DTM ap-
plication of its new polysiloxane topcoat paint (i.e., a new, more durable, and color-stable hazel [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 ship-
builders to allow DTM application utilizing new con-
struction of some of its aiyed coatings in interior, dry spaces of ships, because these ponts perform in a similar manner to an alkyd primer/topcoat sys-
tem. NAVSEA has already updated ship and subma-
rine 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 envi-
ronment created by constant exposure to sea wa-
ter, according to Dr. Erick Lezzi, 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 another barrier layer that prevents water from penetrating to the substrate. Second, while polysiloxanes do adhere 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 environ-
ment, 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 Lezzi. 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 have 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. POTM work requires exceptional capability in the primer to address issues that are traditionally pretreat-
ment properties: adhesion promotion, metal cleaning, and corrosion resistance," he explains. Formulation of pigmented TCO1TM coatings is an additional challenge. According to Fusco, "It is necessary to develop a corrosion-inhibiting sys-
tem 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 main-
taining excellent corrosion performance. "The aerospace industry as a whole is very reluctant to move away from the old standards of highly chrom-
ium-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-
ings is a major cost consideration for airlines. "The advantages and reliable performance of our qualified DTM coatings will contribute to decrease airlines and MRO stations to adopt this technol-
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For Sherwin-Williams, in-depth knowledge of the resin and pigment chemistry in question was necessary to develop its new DTM epoxy coat-
ing. One of the biggest challenges, according to Pearson, was meeting the performance specifi-
cations 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, testing additional colors. If that formulation me-
ets 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 with-
out sacrificing quality or worker safety," Pearson remarks. She also notes that Sherwin-Williams continues to look for ways to make coatings work better and smarter.

Alkohol, 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 top-
cat and basecoat/clearcoat systems. "As a result," states Fusco, "the airline industry will have access to a totally chrome-free DTM solution for the repaint-
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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 envi- ronment created by constant exposure to sea wa- ter, according to Dr. Erick Lezzi, 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 to steel, they are very expensive versus epoxies, which provide excellent corrosion protection, and thus are very good primers. Polysiloxane can weather the performance that is required by the Navy. Finally, in such a highly aggressive environ- ment, 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 Lezzi. Webb adds that it is challenging to achieve top performance with a one-coat system because, typically, when one set of performance characteristics improves, 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 chrome pretreatments and primers has been a challenge. “In the aerospace industry, airframe 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. POTM work requires exceptional capability in the primer to address issues that are traditionally pretreat- ment properties: adhesion promotion, metal cleaning, and corrosion resistance,” she explains. Formulation of pigmented TCO/TDM coatings is an additional challenge. According to Fusco, “This is not only because it is necessary to develop a corrosion-inhibiting sys- tem that has the performance of a chromated coating, but that can be delivered in the desired paint color scheme of the airplane.”

Fusco notes that there is a significant need in the aerospace and military sectors, which rely heavily on corrosion protection coatings, to eliminate the chromate pigments while main- taining excellent corrosion performance. “The aerospace industry as a whole is very reluctant to move away from the old standards of highly chromated-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 MRD stations to adopt this technol- ogy,” asserts Fusco.

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