Electrocoating

A Special Focus on Electrocoating by Products Finishing Magazine

The Evolution of FrameCoat™ Electrocoat

Coatings are used to enhance appearance and make sure functional requirements are met. This new technology helped Ford achieve better corrosion performance with lighter components...

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Automotive original equipment manufacturers (OEMs) must adapt their processes to meet the demands of the evolving marketplace. Higher performance standards are required while, at the same time, meeting environmental and CAFE regulations economically. The Corporate Average Fuel Economy (CAFE) standards for light trucks in 2000 were set at 21.2 mpg. Congressional efforts are currently aimed at increasing the CAFE standard. One solution to these concerns is in vehicle weight reduction. This is accomplished through material selection (plastics, aluminum, composites, and gauge of steel), unit design, and manufacturing processes necessary to accomplish the design. Coatings are used to ensure that appearance and functional requirements are met. How to achieve better corrosion performance with lighter components was a challenge until FrameCoat Electrocoat was developed. This development allowed the industry to reduce component weight using the latest manufacturing innovation with environmental compliance in an economical manner.

Vehicle Construction

The separate frame and body type of vehicle construction is the industry standard for light trucks, as opposed to "unibody" construction used for most passenger sedans. In this type of construction, the frame and the vehicle body are made separately; each is a complete unit by itself (Figure I). The frame is designed to support the weight of the body and absorb all of the loads imposed by the terrain, suspension system, engine, drive train, and steering system. The body protects and contains passengers and cargo. The body generally is bolted to the frame at a few points to allow for flexure of the frame. Because much of the vehicle weight is from the frame, it has the most impact on CAFE regulations. The frame also is subjected to the worst corrosive environment. Therefore, the frame of the vehicle was targeted for weight reduction and performance improvement.

Conventional Coating For Frames - Hot Wax

Since the 1970's, underbody structural components have been coated with hot wax to provide a first line of defense against corrosion. Hot melt wax coatings are solvent or waterborne thermoplastic corrosion prevention compounds that are usually applied through a dipping process. The wax is preheated to a temperature between 125-195C (257-383F). Following an alkali cleaning and water rinsing operation, parts are immersed into the molten wax. The thickness of the wax deposited on the parts is controlled through preheating the parts and the actual time of immersion in the hot melt wax. Following the immersion process, the coated parts are allowed to return to ambient temperature through a process that controls the uniformity and finish of the hot melt wax. Hot melt wax thickness is commonly specified as 75-125 micrometers (3-5 mils). The limitations associated with hot wax were:

- Poor corrosion resistance, giving only 1-3 years surface rust protection (Figure II).

- Poor heat resistance. Wax melted off parts above 270F, requiring many heat shields on the exhaust system, leading to increased cost, weight, and noise.
- Poor resistance, as wax is easily scraped off a frame when touched or bumped.
- Does not allow rear cross member to become a trailer hitch.
- Does not allow bushings to be installed prior to coating.

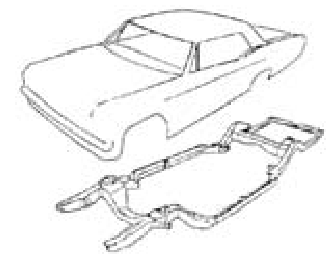

Figure I: Frame and body type vehicle construction

The need for a new coating originated in 1998 when Ford Motor Company expressed corrosion concerns on its light truck frames. The conclusion was that red rust was forming on the truck frames soon after exposure in corrosion tests. The red rust was found to develop in some of the most critical areas of the frames, around fastener holes and weld areas. The corrosion initially affected customer acceptance and, ultimately, resulted in customer durability issues.

Alternatives to Hot Wax

In order to reduce the vehicle weight and enhance corrosion protection, Ford investigated alternatives to hot wax: aluminum substrate, galvanized steel, or an improved coatings system. The use of aluminum substrate, while corrosion resistant, was determined to be too costly and not crash worthy. Galvanized steel was also too costly and had welding problems. Hot rolled steel with an improved coatings system was the best option. The application of an organic coating, is a cost-effective corrosion protection method. Organic coatings act as a barrier to a corrosive environment. They prevent or retard the transfer of electrochemical charge from the corrosive solution to the metal underneath the coating.

The Partnership

Ford Motor Company and PPG formed a team to find a solution to the corrosion issues. Ford Motor Company provided sample substrate to PPG for analysis and opened up its corrosion test facilities so that new coatings development in PPG laboratories could be subjected to their total vehicle accelerated corrosion tests.

Figure II: Hot wax: 60 cycle Ford APG

Defining the Requirements for Underbody Structural Components

In order to achieve the performance desired for the truck frame market, the following specifications had to be met. The new coating had to meet the 10-year durability specification and have less than 1% red rust during a two-year period. The coating had to show a significant improvement in edge coverage and weld protection. The new coating should cure at low bake temperatures, have low shrinkage, and have heat resistance capable of withstanding 400F so that some of the heat shields could be deleted near exhaust components. The coating should have protective throwpower greater than 300mm and be formulated without heavy metals (lead or chrome). Finally, the applied coating cost cannot exceed current technology.

Cationic Epoxy Electrocoat – The Logical Choice

Because of the need to coat both the inside and outside of the truck frame, cationic epoxy electrocoat was identified as a viable coating candidate. Electrocoat is a widely used coating technology that has provided excellent levels of performance on industrial metal objects for more than 40 years. Electrocoat technology has evolved dramatically since the early 1960s, when it was first commercialized as an anodic automobile body primer at Ford Motor Company. In 1971, cathodic technology was introduced, and in 1976 cathodic primers for automobiles were introduced. By the 1980's, high-build, super-smooth primers and high-performance acrylic systems were developed, expanding the use of electrocoat. Today, cationic epoxy electrocoat is the coating of choice for automobile bodies and parts due to its excellent corrosion resistance, good throwpower, reduced solvent levels, and lead-free formulations. Consider the low incidence of rust in cars today vs 20 years ago. Electrocoat technology is one of the primary reasons for rust reduction and the associated extended rust-through warranties that are now available to consumers.

The Electrocoat Process

During electrocoating, electrically charged particles are deposited out of a water suspension to coat a conductive part. The electrocoat paint is applied to a part at a certain film thickness, which is regulated by the amount of voltage applied (Figure III). The deposition is self-limiting and slows down as the applied coating electrically insulates the part. Electrocoat solids deposit initially in the areas closest to the counter electrode and, as these areas become insulated to current, solids are forced into more recessed, bare metal areas to provide complete coverage. This phenomenon is known as throwpower and is a critical aspect of the electrocoat process.

Conventional Lead-Free Cationic Epoxy Electrocoat

In late 1998, conventional lead-free cationic epoxy electrocoat was initially tested on frames, but did not meet all of the frame specifications. When total vehicle accelerated corrosion testing was performed, it was concluded that electrocoated frames were inferior to electrocoated sheet metal components. Frames are welded from hot-rolled heavy-gauge steel and stamped with many tooling and access holes subject to edge rust. Through its research, PPG Industries discovered the root causes for these premature corrosion failures on hot rolled steel chassis and on sharp edges. The root causes include surface contaminants (oxides, silica, carbon) and increased surface roughness compared to body panels or cold rolled steel. For these reasons, the use of traditionally formulated coatings systems was eliminated from the search and a new coating system was needed.

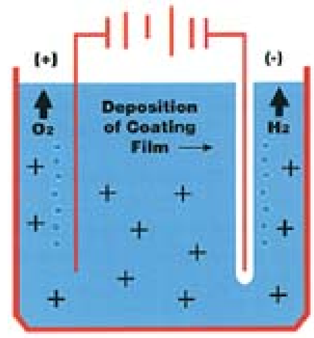

Figure III: Cationic epoxy electrodeposition

The Development of FrameCoat Electrocoat

More than 30 variations of coatings were tested at PPG and Ford Proving Ground until a formulation with the best attributes could be selected. This development work led to FrameCoat Electrocoat. The system is a cationic epoxy electrocoat developed specifically for chassis components on cars and light trucks. This coating was designed to meet the OEM manufacturers' 10-year corrosion protection requirements on hot rolled steel and cast iron chassis components. It is a unique resin system designed to provide maximum corrosion protection on marginal substrates subjected to the harsh conditions of automotive chassis parts. FrameCoat electrocoat provides:

- Superior corrosion resistance, especially on sharp edges, on hot rolled steel parts compared to previous automotive frame coatings
- Improved appearance versus wax
- Lower weight than wax
- High temperature resistance (> 400F) from exhaust components
- An environmentally friendly coating with a VOC content of less than 0.1 lb/gal. In addition, FrameCoat Electrocoat is free of heavy metals and Hazardous Air Pollutant (HAPs) materials.

FrameCoat Electrocoat was developed for use where high performance is demanded: truck and trailer frames, engine cradles, trailer hitches and tow hooks, suspension components, and underbody components.

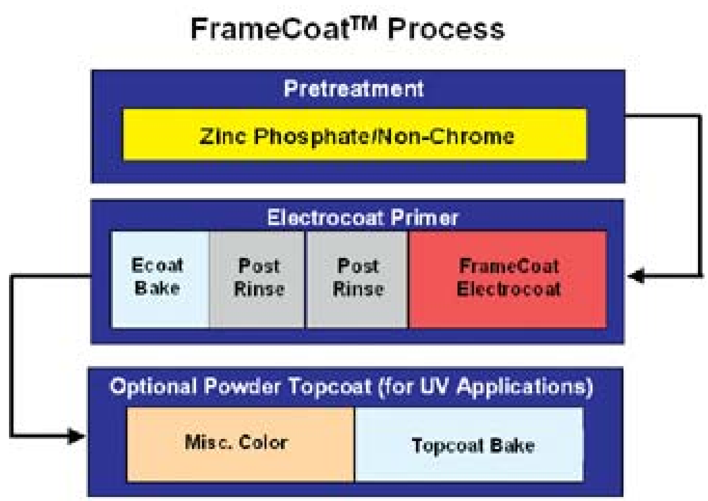

Figure IV: FrameCoat Process

The FrameCoat Process

In addition to the development of the enhanced cathodic epoxy product, PPG developed a full coating process. As a complete process, the FrameCoat System consists of:

- Pretreatment
- Electrocoat
- Powder (optional for applications that require UV-sunlight durability)

This process results in optimized corrosion performance in an environmentally friendly package (Figure IV).

FrameCoat Pretreatment provides improved cleaning to provide uniform coating on hot rolled steel, reduces fusion weld corrosion and edge delamination, and uses a non-chrome rinse. It entails a two-step cleaning system: 1) alkaline cleaning process designed to remove mill oil rolled in carbon; and 2) optional acid cleaning to remove scale and weld

Table I ++ Very Good, + Good, 0 Neutral, – Poor

	Hot Wax	Coventional Electrocoat	FrameCoat Process
Corrosion Protection (Hot Rolled Steel)	—	+	++

contaminants. Next, a robust zinc phosphate is applied that is easy to control and results in low operating cost. Finally, a non-chrome rinse, which reduces cost for disposal and meets OEM hazardous metal reduction needs, is applied.

This electrocoating results in improved edge/face corrosion resistance and reduced applied cost. The electrocoat stands out due to its high throwpower for better control of internal/external film builds, high edge coverage formulation designed to eliminate hot rolled steel corrosion (> 20 cycles), low bake temperature resulting in energy savings, and higher coating temperature resistance to exhaust, eliminating costly heat shields.

Cure Temperature	++	0	+
Heavy metals	++	++	++
Weight Loss	++	+	++
Edge Coverage	—	+	++
Gravelometer	—	+	++
Pencil Hardness	—	+	++
Oven Maintenance	—	0	++
Temperature Resistance	—	+	++

FrameCoat Powder Coat provides UV durability for applications requiring UV protection. Trailer hitches are often exposed to sunlight, causing the cationic epoxy electrocoat to chalk and degrade. Therefore, when hitches are exposed to sunlight, a UV durable coating must be applied.

Figure VI: FrameCoat electrocoat vs. hot wax: 20 cycle Ford

Comparing Technologies

The table above compares the performance properties of hot wax, conventional cationic epoxy electrocoat, and FrameCoat Electrocoat.

Why Ford Motor Company Chose FrameCoat Electrocoat

Ford Motor Company first used FrameCoat Electrocoat on the Sport Trac frame in August 1999. They found it to be a cost-competitive high-performance alternative to wax on hot rolled steel chassis components. Ford has used this electrocoat as a way to improve performance while achieving weight reduction requirements for CAFE improvements (Figure VI). FrameCoat Electrocoat meets the ten-year durability and two-year no red rust requirement. Therefore, expensive galvanized steel engine cradles and control arms can now be replaced with hot rolled steel. The excellent edge coverage protection eliminated rust on fastener hole edges and improved corrosion protection on fusion welds. The electrocoat is a high temperature resistant coating (> 400F). Therefore, hot engine compartments do not affect the coating, extending corrosion protection; and heat shields can now be removed from vehicle exhaust systems, resulting in significant cost savings. High throwpower allowed complex-shaped parts to be coated both inside and outside at close to the same film build, reducing total paint consumption. The complexity of the frame is reduced, as an integral trailer hitch is now possible. Rear truck frame cross members can extend out past the rear body of the vehicle and be used as a trailer hitch. The need to purchase and use assembly plant labor to install hitches was eliminated. The low bake temperature of the electrocoat has allowed Ford Motor Company to install bushings prior to being coated, eliminating material handling (the need to unstack frames and insert bushings and restack for shipping), and also results in oven (energy) savings. The electrocoating also meets Ford's need to be a green manufacturer. Lead was eliminated and solvent was dramatically reduced, while improving corrosion resistance.

The development of FrameCoat Electrocoat has provided a new, improved process for coating truck frames. The introduction of this technology will provide significant enhancements in the corrosion resistance of frames, as well as other automotive parts. The benefits to consumers will be in longer lasting automotive parts, resulting in less corrosion-induced repair costs over the lifetime of the vehicle and greater customer satisfaction. More significantly, there are major environmental benefits in the removal of lead and chromium from the coating and any effluent from the coating process. Also, additional environmental benefits include less volatile emissions and reduced energy use. For these reasons, the introduction of FrameCoat Electrocoat will have significant benefits to consumers and the environment. With the use of Frame Coat, this substrate can now meet the 10-year durability requirements of the automobile manufacturer.

Figure V: FrameCoat electrocoat: 60 cycle Ford APG