

Barriercoat Process Paint Stripping: Mask Washing Without Solvents

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Paint masks have been used for many years in repetitive decorative painting. A paint spray mask having accurately formed openings is positioned adjacent the workpiece to be painted. The openings in the mask define the areas of the workpiece surface that are to be painted. Paint is applied to the workpiece surface by use of a spray gun, and after a number of workpieces have been painted—producing an accumulation of paint on the paint spray mask—the mask must be cleaned. Barriercoat process paint stripping has become the dominant mask washing process replacing solvents.

Prior to World War II, most masks were hand cut and fabricated out of soft malleable metals such as sheet copper. Some repetitive decorative painters used "Woods Metal" masks. These early masks were difficult to fabricate reproducibly, and were fragile in production. After World War II, several mask makers refined the electroforming process, allowing masks to become more accurate and easier to fabricate and repair. Electroforms are typically positioned in place with low eutectic 50/50 or 60/40 tin-lead solders used to fabricate the masks. The electroforms were bridged into steel frames and typically given a copper flash prior to nickel plating. In the late 1980s, fabricated masks returned to popularity, with new Tig welding fabrication techniques allowing stainless steel to be used for more durable masks with sharper fabricated paint lines, and providing an easier to clean substrate with only the electroforms being nickel.

SOLVENT MASK WASHING

A number of methods have been developed to remove paint from paint spray masks. The most common method employed prior to 1966 was to spray the painted mask with reclaimed solvents such as chlorinated hydrocarbons or a blend of ketones and aro-

matic hydrocarbons including acetone, methylethylketone, and toluol. While the use of such solvents is effective, solvents in general have several disadvantages: the more volatile solvents with low vapor pressure represent a serious fire hazard, and other solvents such as methylene chloride are toxic. In recent years, it has become difficult and expensive to dispose of or recycle solvent paint cleaning residues. More stringent government regulations regarding use, storage, handling, and disposal of hazardous wastes have been promulgated by the Environmental Protection Agency and administered by the states.

Initially, the largest disadvantage for solvent mask washing was the uncontrolled loss of VOCs, i.e., if you started with 100 gallons of reclaimed solvent, typically at the end of two production shifts, you would have lost 50 to 60% of your solvent through evaporation and you would have 40 to 50 dilute gallons of paint and solvent to be removed from the mask washer, stored, and sent out for distillation. After distillation and separation of the paint sludge (for incineration), 25 to 30 gallons of reclaimed solvent would come back into the paint shop for mask washing. After several trips through the shop, 100% of the reclaimed solvents would end up in the environment as an uncontrolled loss of VOCs.

SOLVENTLESS MASK WASHING

Finding a better way to strip masks in a production environment, without solvents, took place concurrently with the original Federal Air Quality Act in 1967, which authorized the Environmental Protection Agency to set minimum air quality standards and set about eliminating photochemically reactive solvents from the environment.

Engineers at General Motors, Ternstedt Division, Flint, Mich., experimented with emulsions of grease, oils, and waxes as a protective coating over

masks so that the paint could be stripped in hot water. The most successful wax emulsion was Mobile's MZD201. The emulsion was sprayed on the mask and allowed to dry and solidify on the mask's surface. The accumulation of paint over this surface can then be removed by immersing the mask in hot or boiling water, whereby the wax converts from a solid to a liquid and floats off carrying the paint with it. Although such a system has been effective in eliminating the use of solvents, it also has some notable disadvantages. For example, it requires a specialized coating on the mask surface, thus adding an extra operation to the cleaning process. Further, the applied wax tends to create a fairly heavy film, which may interfere with fine painting details in use, and thus the kind of mask on which such a wax system can be utilized is limited. More particularly, wax systems applied by spray have a tendency to emit wax particles into the atmosphere, resulting in the deposit of wax particles on production parts, which eventually must be rejected, as paint will not adhere where the wax particles have been deposited.

The next step in the evolution of process paint stripping was related to the granting of two process patents. The first U.S. Patent (3,531,311) was awarded to William Prior in 1972, for a two-step barriercoat process for removing water-insoluble coatings applied to a substrate. An abstract of the patent is that water-insoluble coatings, such as paint and the like, are effectively removed from spray masks and other substrates by applying to the surface of the substrate by spraying and aqueous solution of a film-forming material. The film-forming material is dried, then the mask is placed into the painting operation. After subsequent use, when the paint has accumulated on the coated mask, the mask is then immersed into a heated bath containing an alkaline detergent with no free caustic. The aqueous solution of film-form-

ing material dissolves, allowing the paint overspray to separate from the mask. The mask is removed from the solution, dried, and the aqueous solution of film-forming material is applied again by spray and the mask is returned into the paint operation after drying.

The second process, U.S. Patent 3,846,172, was awarded to Charles G. Fossati in 1974, for a one-step method for removing water-insoluble coatings applied to a substrate. An abstract of the patent is that water-insoluble coatings, such as paint and the like, are effectively removed from spray masks and other substrates by applying to the surface of the substrate an aqueous solution of a film-forming material; drying the solution to form a film; and after subsequent use, when immersing the substrate in a heated bath of the same aqueous solution, thereby removing the paint therefrom and concurrently redepositing the film onto the surface of the substrate.

Currently, both the two-step method and the one-step method are being practiced in industry. The one-step method is the predominant method. The chemistry of water-soluble film-forming materials has made significant improvements. The quality and functionality of the barriercoat and the life of the chemical compositions are quite good. The equipment has evolved from vats of boiling water to sophisticated pressure mask washers, with all of the elements of the process automated to deliver clean, dry barriercoated masks into production on a typical 3-min wash cycle.

BARRIERCOAT CHEMISTRY

Numerous materials have been evaluated as water-soluble film-forming barriercoatings. The materials must meet the following criteria:

1. Water solubility.
2. Film-forming (to hold out paint overspray).
3. Resolubility.
4. Compatibility of chemical composition with machinery and masks (i.e., must contain no free caustic). Free caustic will dissolve tin-lead solder, making the solution a hazardous waste and causing serious damage to mask tooling.

5. No solvents or VOCs.
6. Biodegradability.

The wax emulsions used in the initial process gave wax to other film-formers including sugars (glucose, gluconate); starches (gum arabic); proteins (soy proteins, sodium lactate); and inorganic detergent builders.

Inorganic detergent builders, such as sodium silicate blended with sodium orthophosphates, initially proved to be the least costly, most reliable, water-soluble film-formers. Both process patents relied on silicate chemistry as the preferred embodiment. Since both processes initially were performed in tank-type machinery heated to 200°F, when a fresh bath was constituted, it took several weeks for the disadvantages of barriercoating materials based on sodium silicates to become apparent.

Those disadvantages come from the chemical nature of silicates and the byproducts formed in their use in the barriercoating process. Liquid sodium silicates are solutions of water-soluble glasses, manufactured from varied proportions of Na_2CO_3 and SiO_2 . Depending on their composition, they provide a wide range of chemical and physical properties.

Sodium silicates are manufactured by fusing Na_2CO_3 and high purity silica sands at high temperatures. The resulting product is an amorphous glass, which can be dissolved by a special process to produce hydrated sodium silicate in a variety of forms.

The silicate-based materials that are currently offered are chemically very close to the preferred embodiment of the Fossati patent and have not changed over the years. The buildup experienced on tooling and machinery is due to a precipitation reaction and the insoluble material formed is known as "Macatite."

Solutions of sodium silicates with orthophosphates react with dissolved polyvalent cations and form precipitates. Depending on the conditions of the reactions, such as pH, concentration, and temperature, either insoluble metal silicates or hydrated silica with absorbed metal oxides or hydroxides will result. All of the above are formed in this process. The source for polyvalent cations Ca^{2+} and Mg^{2+} are in the form of carbonates. Calcium and magnesium carbonates are present in the

feed water and are normally referred to as hard water.

Using only soft water slows the process and does not cure the problem. At the temperature, pH, and concentration of the solutions, even in the presence of soft water, the insoluble precipitates of silicates and phosphates are still formed.

This process of precipitation is more extreme with the use of argent paints. Argent paints typically have from 0.5 to 1.0 lb/gal of finely ground aluminum. Aluminum, Al^{3+} , forms metal oxides and hydroxides with silicates and phosphates, which build cumulatively with the insoluble precipitate that is naturally formed.

Sodium silicate-based film-formers typically have a high pH, which poses a problem of neutralization prior to disposal. Sodium silicate systems operate at a pH of 12.0 and above. Most municipalities require alkaline solutions to be reduced in pH to 9.0 or lower prior to discharge to sanitary sewers.

In 1980, two concurrent events improved the process so significantly that barriercoat process paint stripping now is recognized as a best available control technology accepted and used around the world. Thierica in Grand Rapids, Mich., introduced the pressure flood mask washer, and the additional energy of spraying under pressure made the equipment able to remove two-component coatings and difficult-to-remove enamels. Simultaneously, Challenge Inc. introduced biodegradable anionic-polymer-based barriercoatings that greatly reduce the buildup on tooling and machinery of insoluble precipitates. Anionic polymer chemical compositions could also be disposed of directly to sanitary sewers in many communities with no environmental consequence for disposal.

The advantages of polymer barriercoats include that they are infinitely soluble and resoluble; they form little insoluble precipitate; they are biodegradable; they are able to be compounded at neutral pH or buffered to low alkaline pHs 8.0 to 9.0; and pressure flood machinery worked with all types of paints.

In the late 1980s, the paints used for decorative painting made an irreversible shift toward water-based coatings. This change to water-based technology required new chemistries for bar-

riercoat process paint stripping. In the early 1990s, Challenge introduced new cationic polymer barriercoatings that are capable of denaturing most water-based coatings. Prior to this introduction, water-based coatings were solvated into the solution of silicate-based and anionic-polymer-based film formers and made a dilute water-based paint that was easy to strip but expensive to dispose of in the barriercoat solution. The new barriercoats for water-based paints are based on unique cationic polymers.

MACHINERY

The original equipment used for process paint stripping was as simple as a waterline attached to an insulated box with immersion heaters to bring the water or the water with an alkaline detergent to a rolling boil. Simple ventilation to draft the steam out of the paint shop and a hanger bar to hang the masks in the solution to dissolve the barriercoating allowed the paint to be removed with the dissolving barriercoat.

This worked well for masks with lacquer paints and limited bridging. As the one-step method became more popular using silicate phosphate barriercoatings, the tank-type equipment added baskets with conveyors to allow the masks to travel into the solution and back out more safely. Devices were added to the bath to improve agitation of the fluid. Pumps and other agitation devices were used to reduce the process cycle times. As bath life improved, systems to remove paint soils like filtration and side stream separation were added to the equipment.

This configuration of equipment was successful with solvent-based lacquers, but was only marginally successful with two-component paints and enamels commonly used in exterior automotive application. The low energy of the tank-type systems often denatured the paint, but highly detailed bridged tooling did not strip completely, and a great deal of hand detailing with air knives to break the cigar bands of denatured paints surrounding the bridge wires was required.

The introduction of pressure flood mask washers has provided the necessary energy to overcome many of the limitations of the tank-type units, as

well as moving the solution so that the process of soil removal can be more easily automated.

A number of quality manufacturers offer completely automated pressure washers capable of 3-min cycles of washing and drying in the mask washing process.

Completely automated pressure mask washers offer the following elements:

1. Immersion-heated reservoir capable of maintaining a wash temperature in the range of 175–200°F.
2. Semienclosed impeller pump capable of maintaining pressures at the appropriate number of nozzles to wash the mask in the pressure range of 40–80 psi. Some special units operate as high as 120 psi.
3. An enclosed cabinet with a ventilation stack capable of removing the steam from the cabinet.
4. A blow-off vented into the enclosed cabinet to speed the ventilation of steam and provide room air for drying the tool.
5. Risers and spray nozzles typically 1–3 gpm.
6. Movable rack fixture to hold the tooling and rotating the mask to ensure the fluid under pressure is capable of impinging the entire tool surface.

HOW BARRIERCOAT SYSTEMS WORK

1. Prior to painting, a *clean* mask is placed in the mask washer and immersed in the water-based material. This applies a uniform barriercoating to the tooling. This protective film, once dried, keeps paint overspray from adhering to the mask.
2. The mask is then placed into the normal painting process.
3. When the paint-covered mask needs to be cleaned, it is placed in the mask washer (see Fig. 1). Here, it is immersed in the mask washing/barriercoat solution. The paint overspray is removed as the barriercoat dissolves, carrying the paint overspray into the solution. As the cleaning solution and barriercoat are the same material, the mask acquires a new film while shedding the old one.
4. The paint soils are then collected by

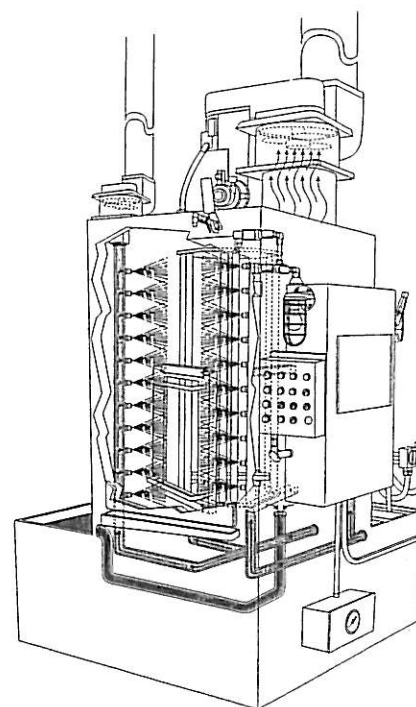


Figure 1. Mask washer. Paint overspray is removed as the barriercoat dissolves, carrying it into the solution.

the filtration system for prompt easy removal and proper disposal.

THE FIVE ESSENTIAL ELEMENTS

Tooling (Mask/Shield)

Clean, smooth tooling with ground solder joints and nickel-plated or stainless steel tooling is preferred for solventless mask washing. Rough mask tooling with numerous points of mechanical attachment can interfere with the cleaning process. Rough tooling requires a higher concentration of barrier chemical.

Heat

Heat helps to denature the paint film, making it easier to remove. Heat also aids in the drying of the barrier film, so there is no transference of the film to the parts being painted.

Impingement

Impingement is the force of the liquid being sprayed on the tooling, which separates the denatured paint film from the mask surface and re-coats the tooling with barriercoat. Improper impingement (plugged nozzles or improper nozzle direction) causes

paint to resist separation from the mask.

Chemical Concentration

The chemical in the system provides the water-soluble barriercoat in sufficient concentration to effect complete removal of the paint overspray. The chemical also denatures certain paints to ensure their removal from the mask. The chemical in the system is run at a minimum concentration called a base-line. The base-line chemical concentration is determined to be the *minimum* concentration necessary for the paints run in your system.

Soil Removal

Soil removal is the most critical maintenance element in solventless mask washing. The cleaning solution and barriercoat are one and the same. By removing soils on a regular basis, you ensure trouble-free, cost-effective operation. When you *do not* remove the paint soils from the bath, the following problems can occur:

1. Bath life is short, chemical must be prematurely dumped, and chemical operating costs are high.
2. Heavy soil buildup can plug nozzles, thus reducing impingement, which reduces cleaning efficiency.

3. Soil can physically clog the pump.
4. Soil can affect the operation of the water-level controls.
5. Ground-up argnet and other paint particles can damage and remove nickel plate, reducing tool life.
6. Alkyd resins found in some paint soils can react to create foaming problems.
7. Finely ground soil at the saturation point can impede barriercoating. Once soil is embedded in the barriercoat, the cleaning efficiency is greatly reduced.

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