Surface Preparation— Meeting & Exceeding Today's Requirements

By Stephen F. Rudy, CEF

We all make plans before beginning a project or going on a trip. It's not only logical, but the only way to go. Preparation is a key to success.

Having just witnessed the birth of the New York Mets in 1961, Casey Stengel, their legendary manager, was asked what position player he'd draft first. Without hesitation he replied, "a catcher." "Why?," the reporter asked. Casey shot back: "Because we need someone to catch the pitcher's delivery, otherwise the ball rolls to the backstop." That logic explains why, only eight years later, the team won a World Series.

In the wonderful world of plating and surface finishing, we are challenged to make decisions based on careful planning. Whatever the process cycle, its completion must adhere to some given quality or specification requirements. Every cycle begins with surface preparation. Parts must be conditioned in a specific manner, permitting the application of metallic or organic coatings. As the earliest metal finishers realized, the first step is very critical to obtaining a quality finish. It is still critical today. From Skylab to the Airbus, from sports cars to golf carts, from hand tools to medical devices, the list of items that "we can't do without" seems endless. A multitude of items for consumer and industrial markets are fabricated, finished, and assembled, to meet or exceed specific service life applications. Surface preparation, in the form of cleaning and activation, is very important to an international workforce of more than 40,000 dedicated finishers and suppliers.

Over time, the predominant treatment method has been, and still is, done by immersion in solutions. Tanks have evolved from wood to exotic plastics and polymers.

Have solutions changed? You bet! So have requirements, safety, discharge limitations, parts, soils, and other related items. Changes, refinements and updates now occur with ever-increasing frequency as our industry meets the challenges of a new century. Surface preparation includes any of these steps:

Cleaning technology has been improved significantly in recent years.

- Removal of contaminants (organic and inorganic)
- Stripping of metallic or organic coatings
- Chemical or mechanical polishing
- Conditioning and activation for accepting organic or metallic coatings

The first step in most cycles begins with surface preparation. The degree of this step varies according to requirements and how to best achieve them. A finished part may include superior wear-resistant coatings, anti-corrosive properties, or aesthetic depth and brilliance. There is no guarantee, however, that any of these coatings or treatments will perform as intended if the surface preparation quality is poor or marginal. Consequently, an excellent surface preparation cycle may substantially improve the qualities of otherwise marginal top coats. The first step—surface preparation—is certainly the most important one. Some of today's process sluggers are swinging for tomorrow's challenging fences by strengthening existing methods and introducing new technologies. Just what is new and changing with regard to surface preparation? Let's check it out.

Soak Cleaning

A great deal of improvement has occurred, and the necessity to change has been a strong driver. The use of various synthetic oils, paraffins, mineral types and their mixtures have

increased in stamping, forming, cutting, and rust-proofing applications. Cleaners, primarily alkaline, provide emulsion or displacement action to remove various oils and grease. For many years, emulsion cleaning was the main performer. During the past 10-15 years, displacement cleaning has grown in preference. That's because displacement cleaning lifts or displaces soils off the substrate surface. These soils, primarily less dense than water, will float so they can be removed by mechanical devices. Two benefits are realized: The soil or contaminant is continually removed, and the cleaner bath's service life is prolonged. Not to be overlooked is emulsion cleaning, a method still "kickin' and contributing." That's because new, more powerful surfactants and wetting agents have evolved, increasing the emulsion or holding capability for oils and grease. Today's emulsion cleaners may hold up to 15 percent by volume of soils before requiring replacement. Placing displacement and emulsion cleaning side by side, the following general process improvements benefit both systems:

- New generation of biodegradable surfactants and wetting agents
- Suitable replacements for chelates and phosphates
- Powerful, SARA Title III exempt solvents
- Low to high foaming
- Improved rinsing characteristics
- Expanded operating temperature range
- More rapid, efficient cleaning (especially favorable in continuous strip lines)
- Clean mixed loads of ferrous and nonferrous metals
- Longer bath service life (less solution dumps and downtime)
- Simpler, more complete waste treatment
- Concentrated liquid blends meet OSHA safety guidelines, readily comply with SPC analysis control, and are significantly less sludging than equivalent powders
- Single (self-contained) and dual additive systems
- Efficient heating, thermostatic control, and process resistant tanks and materials of construction

Both cleaning methods benefit from chemistry and application improvements. Advantages include: reducing cleaning time, increasing the cycle throughput of parts, ability to eliminate solvent cleaning & other bulk precleaning steps, and complying with local and regional effluent requirements. With good recordkeeping, most finishers acknowledge lower cleaning costs per surface area of parts being processed, when using the optimum cycle and operating parameters.

The predominant cleaning methods are still done by immersing parts in solution.

Electrocleaning

The majority of parts are anodically treated. Several of the soak cleaning advantages mentioned may also apply to electrocleaners. Additional process benefits that have improved electrocleaning include:

- Effective, quick-reacting hexavalent chromium reducing agents
- Inhibitors to prevent over-cleaning, etching, and smutting
- Buffers and inhibitors that permit conditioning of ferrous parts, zinc base, copper alloys, and brass in the same process bath
- Powerful descalers & desmutters that eliminate cyanides, EDTA & NTA chelates
- Sufficient reserve alkalinity to prevent etching of steel and surface ferric hydroxide formation
- Better surface conditioning facilitates activity of the acid treatment
- Available conductivity meets moderate to aggressive surface treatments
- More tolerant to contaminants dragged in from the first acid, in double cleaning cycles
- Specialized blending for dual soak and electrocleaning functions, conserving line space and reducing water use
- Reliable equipment and rectifiers to provide optimum performance and accurate current densities

Electrocleaning is generally the second step in most surface preparation cycles. Quality completion of this procedure may constitute 60–70 percent of treatments to be performed before reception or deposition of coatings.

Acid Treatment

For many years, the most commonly used acid treatments were mineral acids—primarily hydrochloric and sulfuric. Even today, for some applications, nothing pickles or descales better than these. Additives and alternative acid blends have been developed as suitable replacements for mineral acids, or to reduce the amounts of mineral acids required. Acid treatments include: neutralizing and activating the surface; removing surface oxides, rust and scale; desmutting; stripping metallic coatings; and activating existing metallic coatings. Any of these functions can be accomplished by immersion or by application of direct current. Several process-relate§ÿimprovements, as unique additives, enhance activity of the acid. Some of these include:

- Surfactants and wetting agents to emulsify residual oils and improve acid penetration into the surface by lowering solution surface tension
- Inhibitors that prevent over-pickling or attacking the base metal surface
- Fume suppressants offering two mechanistic benefits: lowering surface tension or forming a stable surface foam blanket

- Inhibitors to prevent immersion deposition of dissolved metals on the substrate
- Dispersion agents to prevent redeposition of smuts
- Accelerators for more rapid stripping of metal deposits

Some of these additives are combined, providing more effective action to the acid. In fact, they permit the acid solution to operate at up to 160°F (71°C), for specific treatments. The right additives in optimum proportions increase the acid bath life, typically up to six times longer vs. simple mineral acid solutions. Additives may also reduce the mineral acid requirement by 20–50 percent. These benefits are realized and realistically experienced in process lines: less acid dumps, less acid treatment-related rejects, less acid required, less burden on waste treatment, and reduced chemical cost per square feet of parts processed.

Another improvement is the use of specially blended powdered salts. These formulations offer another series of benefits in addition to the ones already mentioned:

- Dry equivalents to sulfuric and hydrochloric acids, eliminating the handling of these highly corrosive materials and heat generated when adding them to water
- Accelerators to increase activity of the acid
- Fluorides and chlorides to provide balanced ratios of hydrofluoric and hydrochloric acid equivalents
- Buffers to maintain optimum activity of the acid over time
- Easily used as cathodically charged solutions for surface treatment and activation of passive nickel deposits

The acid treatment has experienced many improvements: process related, safety, waste treatment, and handling. All these enhance this typical step, which comprizes 30–40 percent of the surface preparation cycle.

Solvent Alternatives

Until the Montreal Protocol initiated their reduction in use, most cold, chlorinated solvents were industry workhorses for bulk cleaning applications. Chemicals such as 1,1,1 trichloroethylene and methylene chloride are on the hit list. Alternatives are in demand. Viable candidate materials, however, must not contribute to air pollution, because its prevention is a major consideration to their acceptance. We have described improvements and benefits of soak cleaning. In this respect, soak or aqueous cleaning is a suitable replacement for solvent cleaning. Three major differences exist between aqueous and solvent cleaning:

- Aqueous cleaners typically require 3–6 times longer to remove oils and grease than banned solvents.
- Solvent cleaned parts water break and exit dry. Aqueous cleaned parts preferably exit without water breaks and wet.
- The aqueous solution is not as readily regenerated as boiling solvents to separate oils and grease.

Several viable chemical alternatives have been introduced and developed into good working bulk cleaning solvent alternatives. Some of these require additional capital equipment and technology expense.

- Natural products such as soy derivatives, citrus extracts, wood terpenes
- Bioremediation in conjunction with aqueous cleaning
- Glycol ethers and propylene glycol ethers
- Hydrocarbons and methyl siloxanes
- Propyl bromides and fluorocarbons
- Carbon dioxide (solid - liquid)

Many of the natural products are not water soluble. They are used either 100-percent concentrated or specially emulsified into water. Some of these compounds are flammable, requiring care in handling and application. Bioremediation is an interesting method. It uses naturally occurring micro organisms to "digest" sludges of oil and grease that have been cleaned off parts in a mildly alkaline soak cleaner. Glycol ethers and propylene glycol ethers are excellent grease cutters, some highly water miscible, with the latter being SARA Title III exempt. Carbon dioxide offers two options: solid pellets that blast away soils, and a liquid version to remove soils similar to an aqueous system. The other materials listed are used full strength and require specific handling considerations.

Mechanical Cleaning

This is an old, reliable method that has experienced some practical improvements. Spray cleaning takes advantage of many updates as described in soak cleaning. Especially beneficial are powerful, low-foaming, displacement cleaning surfactants and wetters. Novel spray heads, projecting very effective spray patterns, improve surface wetting and increase pressure to help dislodge soils. Ultrasonic cleaning has also progressed, with new formulas designed to facilitate more rapid and efficient removal of buffing and polishing compounds. Supplementing this have been new, powerful, reliable transducers. Industrial washers have evolved into units providing synchronized, multidirectional agitation. Mass finishing offers a combination of mechanical tumbling, with or without media, and chemical action to clean parts. There are many media types available (natural and man made). Blended chemicals offer several surface conditioning options, such as: deburring, burnishing, oil and grease removal, and descaling.

Cleaner Filtration Equipment

There has been much work, innovation, and progress made to utilize oil and grease removal in mechanical devices. Several different types are accepted by industry. All of them share a common focus: They extend service life of the cleaner, concentrate the waste oil and grease, and simplify waste treatment. Some of the field popular filtration equipment is:

- Belt and disk—A rather simple concept. Displaced soils adhere to a rotating belt or disk (made of material compatible to the soil), cycle until removed by a squeegee, and channeled into a waste container. Many soak cleaner tanks are equipped with overflow dams leading to side collection tanks, where oils and grease collect and concentrate.
- Coalescer—A specially designed unit into which the cleaner bath is pumped. A series of channels and baffles effectively separate the oil from water, directing the rejuvenated cleaner back to the process tank and oils to waste.
- Air/Filter—Technology combines a filter with compressed air. The system pumps cleaner through the filter, using compressed air. Oils, grease, sludges, and metal chips are separated. The contaminants are held in the filter and conditioned cleaner is returned to process tank.
- Ultrafiltration—Emulsified oils and suspended soils are concentrated using ceramic membrane technol-

ogy. The aqueous phase is separated, passing through the membranes, back to the cleaner tank. Contaminants are highly concentrated as the separate waste phase.

Cleanliness Verification

For many years, a reliable method for detecting surface cleanliness has been the water-break test. It's still popular and a good evaluation method. Another good test has been the immersion copper method. Some oils are UV (ultraviolet) active. Exposure to a UV light will expose their presence. To a lesser degree, parts can be washed with a hexane-type solvent. The recovered solvent is then analyzed for presence of any oils. Development of new finishing systems and the need for critical cleaning specifications led to new, more sophisticated cleanliness detection procedures. Some of these include:

- Contact angle measurement—A bead of water is placed on the cleaned substrate. Actual cleanliness is determined by the angle of contact which the top of the bubble makes with the substrate. The tendency for water beading (increased angle) is related to subsequently poorer cleaning.
- Fluorescence—Some oils have fluorescence characteristics. Exposure to fluorescent light will highlight residual soils on the surface.
- FTIR detection—This is an infrared type scanning detection method. It's accuracy is rated at below 1 microgram of soil / sq cm. Talk about squeaky clean!

Just like the world we live in, surface preparation never stops. It spins, rotates, and completes a full cycle somewhere in a multitude of finishing installations, covering six continents, every minute. (I guess it would be cost prohibitive to keep a cleaner hot in Antarctica.) Wherever the surface preparation line is located, whatever the process requirements are, improvement and quality should be in focus every day. Technology presents us with continuous innovation. Include surface preparation when it comes to practical upgrading. Change is imminent., change is good, and change is on-going. *P&SF*

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