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Topic Hub: Metal Finishing **Subsection : P2 Opportunities**

The P2 Mantra for Finishers:

- Extract the most life (use) out of process chemistries
- Keep process chemistries where they belong - in the tanks
- Return as much dragout solution as possible to the tanks

The P2 Mantra for Spray Painters:

- Reduce overspray
- Optimize transfer efficiency
- Mix paints precisely

This section discusses alternatives to conventional metal finishing processes that can reduce or minimize environmental impacts. The subject areas cover:

- Cleaning and Surface Preparation
- Alternative Coatings
- Coating Application Equipment
- Metal Plating
- Additional Best Management Practices for Metal Finishing

Cleaning and Surface Preparation

Oil removal
Oil is usually applied to metal parts during machining and forming operations as a coolant or metal working lubricant. An oil coating may also be applied to parts specifically as a rust inhibitor. Such oil coatings must be cleaned from part surfaces before metal finishes or coatings are applied. Methods to reduce excess oil on part surfaces include:

- thoroughly drain oil from part surfaces before finishing
- reduce storage time between metal working and finishing to offset the need for rust inhibition
- use a lower viscosity oil consistent with machining and storage requirements, and
- use concentrated alkaline baths instead of oil to provide temporary rust protection.

Supercritical fluid cleaning - Supercritical fluids can be effective for cleaning parts with small openings and for precision or intricate components. The process works well for removing liquid contaminants, including silicone, petroleum and dielectric oils, flux residues, lubricants, adhesive residues, fats and waxes. Effectiveness is limited with heavy soils, particles and salts, except when used in combination with agitation or ultrasonic cleaning.

Aqueous and semi-aqueous cleaning - Aqueous products rely on water and detergent action to clean surfaces. For best results, these products should be formulated with sequestering agents, surfactants and rust inhibiting additives. Aqueous cleaners work best in pressure spray applications, requiring the use of alternative parts washing equipment. Several types of aqueous and semi-aqueous cleaning processes are described below:

- **Rotary basket equipment** - The rotary basket removes dirt, light oils and greases from small parts, such as gears, nozzles, nuts, bolts and screws. Baskets of parts are placed on brackets and rotated in a mechanically agitated, spray-under-immersion tank filled with an aqueous wash solution.
- **Steam cleaning** - Steam cleaning is suitable for removing oily or greasy residue. The process' heat accelerates emulsification break-down, and removal of caked-on dirt and grease. Steam's temperature characteristics allow surfaces to be heated to relatively high temperatures. High temperature is maintained on the surface long enough for the steam to vaporize or liquefy contaminants.
- **Spray power washing** - High-pressure spray power washing equipment has gained in popularity since the phaseout of chlorofluorocarbon cleaners and fits with the trend to reduce halogenated solvent use. Spray washing equipment typically uses water-based alkaline detergents or semi-water based cleaners, supplemented by low toxicity solvents. The soil-contaminated metal parts are run through a power washer either in a batch or continuously on a conveyor system.
- **Multi-stage conveyor spray power washers** - There are typically three to five separate stages in which the cleaning/degreasing, surface preparation and drying of the production parts take place. Because these stages are required for adequate cleaning, floor space requirements

must be taken into account when considering this alternative. Generally, the stages consist of a heated alkaline cleaning tank, rinse tanks, zinc or iron phosphating baths and a sealant tank.

- **Honeycomb cleaning** - Parts are positioned on a cart that is rolled along a track into the washer. A nozzle spray bar moves back and forth beneath the parts, spraying a heated wash solution followed by a deionized water rinse. Overhead nozzles wash and rinse the parts' top sections.
- **Ultrasonic cleaning** - Ultrasonic cleaning is an enhancement that improves the cleaning efficiency of most liquids, including neutral, alkaline and acidic aqueous solutions, and semi-aqueous solutions. Ultrasonics can be used for cleaning requirements ranging from gross to precision levels, and effectively removes particles, machining chips, grease, oils, and other contaminants.
- **Dual-use ultrasonic cleaning** - Dual-use ultrasonic cleaning uses aqueous/semi-aqueous solutions to clean parts with contaminated surface areas. The system includes a solvent wash station, emulsion rinse tank, three cascading water stages, and a hot-air dryer.
- **Advanced immersion equipment** - Advanced immersion is an aqueous or semi-aqueous process to clean external and internal surfaces of delicate and intricate parts.

Biochemical cleaners - Derived from natural plant-based sources, biochemical cleaners have been used for years as cleaning agents and degreasers in many industries including the printed circuit board industry. Terpene-based cleaners are extracted from citrus and pine oils; two common forms of terpene cleaners are d-limonene and a-pinene.

Alternative Coatings

Powder coatings - Powder coatings are 100 percent paint solids in a powder form. Transfer efficiencies can reach 95 to 99 percent while achieving a durable, corrosion-resistant finish. Product overspray collected in the paint booth exhaust system can be recovered and reused. Powder coating is extremely sensitive to part cleanliness, making multi-stage washers a prerequisite. Powder coating requires electrostatic application equipment and a heated curing oven, but essentially eliminates drying ovens, and volatile organic or hazardous air pollutants (HAP) emissions typical with conventional liquid paints and coatings.

Ultraviolet (UV) coatings - UV coatings are available in liquid and powder form, and transfer efficiencies can reach 95 to 99 percent while achieving a durable, corrosion-resistant finish. UV is excellent for heat-sensitive parts such as assembled motors and shock assemblies. Some of the P2 advantages are shorter cure times and increased production speed, reduction or elimination of volatile emissions, and reduced heat (and thus energy) requirements because of shorter melt flow duration, lower temperatures, light cure instead of oven cure, and elimination of drying ovens.

High solids paints - High solids paints are solvent-based products with 50 percent or more solids content. Because of the higher solids content, the desired film thickness can be accomplished with fewer spray applications. Quality characteristics include improved abrasion and mar resistance. High solids paints are sensitive to temperature and humidity and may require heating to obtain an acceptable cure time.

Water-borne paints - Water-borne paints use water as a solvent, which reduces volatile emissions. However, some water-borne coatings may contain up to 30 percent petroleum-based solvents.

Coating Application Equipment

High-volume low pressure guns (HVLP) - HVLP spray guns operate with a high volume of air delivered at 10 psi or less to atomize the paint. Atomization reduces overspray and the resulting paint waste. Transfer efficiencies up to 60 percent are possible with proper training in spraying technique.

Ergonomic HVLP guns - Ergonomic HVLP guns result in paint savings of up to 50 percent over conventional air spray guns, and savings of 35 percent over conventional HVLP guns. Reject rates also are reduced substantially. The gun's design allows increased painting efficiency without strain and fatigue on the operator.

Air-assisted spray guns - Air-assisted spray guns combine conventional atomization with increased (150 to 800 psi) paint fluid pressure. These guns reportedly achieve a transfer efficiency of up to 70 percent. The fluid delivery rate also can be varied based on part size or shape to optimize paint application. Conversion to air-assisted guns likely will require painter training and increased equipment maintenance.

Electrostatic systems - Electrostatic systems impart a positive charge to atomized paints or coatings at the tip of the spray gun. The part being painted is electrically neutral, causing the charged paint to be attracted to the part. Because of the electrical attraction, electrostatic painting offers a potential transfer efficiency of 68 percent to above 95 percent. Other benefits include good edge cover, wraparound, and uniform film thickness. Electrostatic painting is more sensitive to the cleanliness of the part than HVLP and conventional painting practices. Electrostatic spray guns tend to be bulky and delicate, which may increase maintenance costs.

Two-component systems - Two-component systems allow mixing of the paint and catalyst at the gun tip. This feature eliminates the need for pre-mixing excess quantities of paint to ensure an adequate supply of paint is available, and reduces the frequency of equipment cleaning, thereby reducing paint and solvent waste. Two-component painting systems are compatible with most liquid/catalyst paints and either electrostatic or non-electrostatic applications. Transfer efficiencies are assumed to be similar to HVLP or electrostatic systems.

Heated Spray - When paint is heated, its viscosity is reduced allowing it to be applied with a higher solids content, thus requiring less solvent. When the paint is heated in a special container and supplied to the gun at 140 to 160 dF, coatings of 2 to 4 millimeters dry-film thickness can be applied in one operation, resulting in considerable savings in labor cost. In addition, much of the associated solvent emissions are eliminated.

Metal Plating

Alternative Platings and Solutions

- Replace cyanide-based plating with non-cyanide alternatives for copper, silver, cadmium, zinc, and gold plating. Substitute processes include alkaline non-cyanide and acid non-cyanide. The environmental advantages are significant, however, non-cyanide processes require tighter control of bath conditions.
- Replace decorative and hard chrome plating with non-cyanide plating finishes, including zinc, zinc alloy, and tin alloy.
- Replace chromic acid anodizing with alternative materials such as boric-sulfuric acid, sulfuric acid, and phosphoric acid. Although chromic acid anodizing offers excellent corrosion resistance, it is strictly regulated due to its toxicity and suspected carcinogenic.

Control bath composition and chemistry to yield consistent workpiece quality and longer bath life. First, determine critical operating parameters, then set up a system to monitor and maintain the parameters within acceptable limits. Work with suppliers to optimize concentration specifications and other operating parameters. Specific suggestions for optimizing bath temperature, plating solution concentration, and use of additives (e.g., wetting agents and non-chelated process chemicals) are discussed in greater detail in *Metal Finishing Industry: P2 in the Plating Process (NEWMOA)*

Additionally:

- Consider using deionized water when operating plating solutions at higher temperatures since deionized water will minimize the natural contaminant buildup in the process bath. Improve bath purity by using deionized water for bath makeup
- Filter the bath continuously
- Maintain each bath by measuring pH, temperature, and concentration daily. Add chemicals only when needed
- Use bath additives, which can replenish process chemicals and add chemical agents to boost bath performance
- Remove impurities in the process tank through membrane filters, ultrafiltration, and ion exchange.

Reduce rinse water

- Have rinse water flow counter-current to part processing and use several rinse tanks for each process tank, usually the most economic results are obtained by using two or three rinse tanks in series.
- Add rinse water automatically only if contaminants exceed an acceptable level. Use either rinse bath pH or conductivity sensors to activate rinse water addition.
- Whenever possible, add rinse water directly onto the parts as they leave the rinse.
- Use rinse water from the most concentrated rinse (the first rinse) to make up the process bath in processes (such as plating) where chemicals can be recovered without compromising part quality. Never use rinse water from a cleaning process, such as an acid or alkaline etch, to make up the process bath because the rinse water will contaminate the bath.

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- Place flow restrictors on rinse flows that are not automatically controlled by pH or conductivity.
- Use oil-free air to agitate rinse baths to improve rinse efficiency, encourage evaporation, and remove clinging solution from the part.
- Reclaim rinsewater.
- Use high-pressure spray on highly viscous solutions (etches, chrome baths, zincates) instead of immersion. And, rather than using all fresh water, install a recirculating pump.

Reduce Dragout

- Use a 'dragout recovery tank'. This tank functions as a pre-rinse to the counter current rinses and concentrates rinsed-off process chemicals so they can be added back to the tank.
- Allow parts to drip over tanks for a period of time, usually around 30 seconds is optimum.
- Place drain boards between tanks so that drips run back into the bath the part just left.
- Rack the parts to minimize the amount of solution 'carried out' of the bath. To do this, rack the part to minimize horizontal surfaces, so depressions open downward and slant parts diagonally to provide a drip tip.
- Withdraw parts slowly from the solution, using the surface tension between the part and solution to keep more of the solution in the tank.
- Lower bath chemistry concentrations to the minimum effective concentration. Rinses will be contaminated less by an equal amount of drag in.
- Use air knives, squeegees, or rollers on the part so excess will run into the process bath to remove excess solution from the part.

Other Equipment, Facility and Process Opportunities in Plating:

- Properly match the anode to the process. Maintain anodes.
- Place cloth bags around anodes to minimize contamination to anodes.
- Use corrosion-resistant tanks and equipment to protect anode bars from corrosion.
- Keep plating areas clean and keep out foreign material.
- Quickly remove parts that fall off the rack into the bath.
- Maintain racks so they are intact, clean and free of contaminants.
- Filter incoming air to reduce airborne contaminants.
- Ensure adequate ventilation and exhaust.
- Regenerate acid solution via distillation, acid sorption, membrane electrolysis, crystallization, or diffusion dialysis.
- Implement reactive rinsing to recover spent acid bath for use in other processes.
- Reuse spent solution bath in other processes such as metal precipitation, chrome treatment, chelated metals treatment or cyanide treatment

Additional Best Management Practices for Metal Finishing

Production planning and sequencing ensures that only necessary operations are performed and that no operation is needlessly reversed or obviated by a following operation. For example:

- Sort out substandard parts prior to painting or electroplating.

Loss prevention and housekeeping

- Perform preventive maintenance and equipment and materials management to minimize chances for leaks, spills, evaporative losses, and other releases

Waste segregation and separation

- Segregate different wastes
- Avoid mixing different types of wastes, especially mixing hazardous wastes with non-hazardous wastes

Recycling and reuse

- Reuse wastes and production byproducts as a feedstock in the production process, or have suppliers take or convert the wastes into reusable feedstocks. Examples may include acid regeneration, reactive rinsing to recover spent acid bath, and rinsewater reuse.

Training and supervision

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- Provide employees with knowledge, skills, and the incentive to minimize waste generation in their daily duties.

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