Importance of Cleaning and Rinsing in the Pretreatment Processes

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expect more

FABTECH CANADA
Thank You CCAI/Fabtech Canada!

Any coating process is as successful as its base metal preparation!

Consistently producing a cleaned surface is very important in any conversion coating process!
What Happens When You Have a Poor Foundation?
Poor Cleaning and Rinsing Results In!

- Impact on subsequent stages – conversion coating
- Poor adhesion
- Higher rework costs
- Higher warranty claims
- Process delays
- Customer dissatisfaction
- *Impacts bottom-line*
Building Blocks of a Painted Part

If one block is bad, everything on top of it collapses!
Before You Build the Foundation…

...You Need A Solid Plan!
Agenda

■ Why Clean?
■ Cleaning Fundamentals and Methods
■ Cleaning Process and Selection
  ● Substrate
  ● Soil
  ● Cleaning Selection
  ● Cleaning Mechanics
■ Process Equipment
■ Rinsing
■ Cleaning Test Methods
■ Maintenance and Troubleshooting
■ Safety
Why Clean?

- **Purpose:** Remove soils, collected in previous operations, from the substrate surfaces, and prepare them for subsequent operations – **in this case, conversion coating!**

- **In Pretreatment:** *Poor cleaning and rinsing* is the major cause of painted part defects!

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Cleaning Fundamentals

- Cleaning metals involves not only the selection of the type(s) of cleaners, but also the proper cleaning cycle and process equipment.

- Having a **SOLID PROCESS**, which meets or exceeds expectations, must be all encompassing to address soils, metals, water quality, and the process control and maintenance of the system.
The best way to begin the cleaning process is with a series of questions designed to promote both specifics and generalities that have an impact on the process!

Fact-Finding Questionnaire:

■ What base metals are cleaned?
■ What soils are on incoming parts?
■ What soils are applied to metal in-house?
■ What is the production flow of the products?
■ What production assemblies are premanufactured and stored? Do they corrode in storage? Do the soils age or become more difficult to remove later on?
■ Is the cleaning process capable of removing all soils e.g. mill scale?
Cleaning Fundamentals

Fact-Finding Questionnaire:

- What are the physical size limitations of your products?
- During welding and fabricating, are soils entrapped or sandwiched between metals?
- Do you preclean prior to welding? If not, how much carbonaceous residue is left on or near weldments? Is oil entrapped?
- What is the quality of the water to be used in the cleaning operation? Conductivity? Hardness? Chlorides and sulfates?
- Process mechanics
- And others
Cleaning Methods

**Mechanical: Solid Media Impingement**
- Alumina blasting, steel shot, plastic media blasting, etc.

**Solvent**
- Wipe cleaning, flow over (sink-on-a-drum), vapor degreasing

**Aqueous: Our focus!**
- Alkaline, acid, neutral
- Single, multi-stage processes
- Spray, immersion, ultrasonic, electrolytic, vibratory, barrel
Cleaning Methods

Mechanical

Advantages
- Reclaim & reuse lowers cost of use for media
- Single step process
- Removes most inorganic contaminants
- Impingement roughs up metal surface, good for paint adhesion

Disadvantages
- Not applicable for thorough removing of organics
- Imbedded media, dust can interfere with subsequent coatings
- May damage or change dimensions of critical parts
- Provides no under paint corrosion protection
Cleaning Methods

Solvent Cleaning

Advantages

- Excellent removal of organic contaminants
- Can be used cold or hot
- Does not require water rinsing to remove process chemistry

Disadvantages

- Wipe, immersion processes can redeposit soils
- No ability to remove inorganic contaminants
- Flammability, worker exposure issues
- Provides no increase in either paint adhesion or corrosion resistance
- Heavily regulated
Cleaning Methods

Aqueous Cleaning

Advantages

■ Environmental advantage over solvents – VOC, etc.
■ Numerous washer designs to match application need – spray, immersion, vibratory, etc.
■ Can be matched to next step in process – i.e. phosphating, etc.
■ Soils can be separated from solution via separation/filtration techniques

Disadvantages

■ Cost of chemical, water, energy
■ Cost of equipment
■ Maintenance of equipment – nozzles, clean-outs, etc.
■ Requires control, testing
Cleaning Process

- Continuous and Batch
- Multi-stage processes
- Spray/Continuous – focus of our discussion!
Cleaning Process

Aqueous Cleaning – Spray Washer/ Continuous
Cleaning Process

Aqueous Cleaning – Immersion/ Continuous
Cleaning Process

Aqueous Cleaning – Spray Wand
Cleaning Process

Aqueous Cleaning - Typically part of a multi-stage process – i.e. 5-stage Iron Phosphating
Cleaner Selection is VERY important!
Different Types of Foundations...

...Different Types of Cleaners!
Cleaner Selection

- Substrate
- Soil
- Cleaning Mechanics – and basic Knowledge is critical to troubleshoot the system
- Process Equipment
- Water Quality
- Environmental and Disposal concerns, such as;
  - NPE-free surfactants
  - Phosphate-free cleaners
Substrates

- Steel – CRS, HRS, and HRP&O
- Aluminum
- Hot Dipped Galvanized (HDG)
- Electrogalvanized (EG)
- Galvalume
- Galvannel
- Brass, Bronze, and Others (Yellow metals)
Types of Soils

**Organic contaminants**
- Oils, Coolants, Waxes, Greases, Hydraulic Fluids, Buffing Compounds, and Mold Release Agents

**Inorganic contaminants**
- Metal Oxides, Rust, Laser Scale, Water Stains, Mill scale, Sanding Fines, and Shop Dust & Dirt

**Difficult to remove contaminants**
- Silicones, Heavy High Temperature Greases, Surface Defects, Burnt on Soils, Old/Polymerized Soils, Paraffinic Soils
Factors Affecting Organic Soils

- Age of the soils:
  - Soluble oil and semi-synthetic fluids dry out and invert
  - Some soils polymerize over time

- Exposure to heat:
  - Metal working operations
  - Welding, annealing, heat treating

- Extreme Pressure (EP) Agents – Chlorinated, Sulfonated, Esters
Cleaner Selection Consideration

- **Substrates**
- **Soils**
- **Type of Cleaning Process – spray, immersion, etc...**
- **Acid, Alkaline or Neutral?** Acid cleaners are used to attack problems like oxides from laser cutting and mill scale. Neutral cleaners are typically used when substrate soil is very limited. Alkaline cleaners do the bulk of the work when surface contamination is organic in nature.
- **Operating temperature?** What is the temperature capability of the cleaner stage? Lowering the operating temperature can save some significant energy dollars.
- **Powder or liquid?**
Cleaner Selection Consideration

- **Oil Splitting or Emulsifying?** Amount and types of oils to be removed? Type of oil removal equipment – designed for floating/skimming, ultrafiltration, etc.

- **Etching or non-etching?** Galvanized and aluminum substrates can be severely etched by some cleaning products. Be mindful of what you’re trying to accomplish when selecting a cleaner.

- **Phosphated or phosphate free?** Certain areas of the country have strict phosphate discharge limits for wastewater. Keep in mind the type of substrate and nature of the surface contaminants (oil, grease, dirt, lubes, etc) may necessitate using phosphates.

- **Others** such as workers safety, environmental concerns, wastewater treatment costs, and used-costs!
New Trends...

- **Phosphorous – Free Cleaners**: All forms!
  - Phosphorous (P) - Organic
  - Phosphate (PO4) - Inorganic

- **NPE – Free** (NonylPhenol Ethoxylate – free surfactant) Cleaners
  - Banned in Europe and Canada
  - US EPA intends to initiate action to restrict NPE use

- **Low-Temperature Cleaners**
Some Phosphorous - Discharge Limits

Mostly watershed areas, 1 - 25 mg/l

- Areas of Minnesota
- Areas of Wisconsin
- Chicago
- Areas of Canada, Toronto, Montreal for example
- Chesapeake Bay, Virginia
- Spokane River, Washington
- Great Lakes, New York, Michigan, etc
- Hudson River, New York
- Chattahoochee River, Georgia
- Others
What are NPEs?

NonylPhenol Ethoxylates (NPEs) have many uses, but they are primarily used as surfactants in cleaning chemical formulations, as wetting agents and as dispersants or emulsifiers in some pesticide formulations.

NonylPhenol Ethoxylates (NPE) and NonylPhenol (NP) are bad for the environment, bad for wildlife and bad for US!

Potential Effects of NPE on Humans
- Reproductive disorders
- Endocrine disruption
- Decreased sperm count in men
- Learning disabilities
- Birth defects
- Cancer (suspected)

Potential Effects of NPE on Animals
- Reproductive disorders
- Endocrine disruption
- Feminization of males
- Birth defects
- Significantly reduced populations
Cleaning - Mechanics

Key factors affecting cleaner performance

T.A.C.T.

■ Contact Time

■ Physical Action:
  ● Spray Pressure / Coverage
  ● Agitation of immersion tanks
  ● Ultrasonic
  ● Electrolytic cleaning
  ● Brushes/Wiping

■ Cleaner Concentration, Type

■ Cleaner Solution Temperature
Cleaning - Mechanics

Other factors affecting cleaner performance

- Water quality – the “universal solvent”
- pH
- Contamination

- T.A.C.T. and other factors are the problem solver and key to optimum cleaning results
- Variance of one factor will often require the adjustment of one or more of the other factors
Help!!!

I am Out of Control!

Process Control Options
SPC - Manual Control

Strong
Excess Chemical Usage

Weak
Poor Quality

Time
SPC – Timer/Counter Control

- Strong Excess Chemical Usage
- Weak Poor Quality
- Empty Chemical Drum

Time
SPC - Automatic Control

Strong
Excess Chemical Usage

Weak
Poor Quality

Time

High Alarm

Low Alarm

Empty Chemical Drum
Automation/Control

Conductivity controller: Electrodeless sensor

- Chemical reaction and drag-out causes bath conductivity to decrease
- Conductivity sensor detects the decrease
- Pump chemical at assigned feed rate till pre-set level is reached

Especially good for lines with variable throughput of metal surface area
Time Feed

Feed pump

Especially good for lines with constant throughput of metal surface area
Auxiliary Equipment

- Less Oil and Grease = Extended life for bath
- Free Oils (Visible Oils), Can be removed physically
  - Belt skimmers
  - Tube skimmers
  - Rotating drums
  - Disks
  - Weir separators
  - Dissolved Air Flotation
  - Ultrafiltration
- Soil Removal
  - Filters – Bag, cartridge, filter press
  - Centrifuges
Oil Removal Equipment

Washer Skimmer/Side Oil Separation Tank

Disk Skimmer

Belt Skimmer

Rope Skimmer
Soil Removal Equipment

Filters – Bag, Cartridge

Filter – Traveling Media

Press Filters

Centrifuges
Benefits of Oil/Soil Removal

- Extend cleaner bath life
- Increase efficiency of cleaner
- Reduce cleaner usage
- Reduce Maintenance costs
- Improve OVERALL part cleanliness/quality
Building Blocks of a Painted Part

<table>
<thead>
<tr>
<th>CLEANING</th>
<th>RINSING</th>
<th>PRETREATMENT</th>
<th>PAINT</th>
</tr>
</thead>
</table>

If “clean” means that all unwanted soils have been removed in the cleaning step, then the downstream step of RINSING is necessary to achieve THAT CLEANLINESS!

The only way to produce perfectly cleaned parts is to rinse them with GOOD quality water!
Rinsing – Why Rinse?

- Stops chemical reaction from previous stage
- Removes chemicals from previous stage
- Prevent contamination of subsequent stage
Poor Rinsing

Poor rinsing leads to:

- Cross-contamination of process chemicals
- Visually objectionable parts
  - Streaks
  - Spots
  - Powdery coatings
  - Particulate matter on surface
- Field failure of finished parts
  - Blisters
  - Delamination
  - Corrosion

“If rinsing is poor, it doesn’t matter how good the rest of the process is!”
Rinsing - Performance Factors

- Contamination (chlorides, sulfates, hardness, acidity and alkalinity)
- Temperature
- Contact Time
- Solution Movement
  - Pressure
  - Agitation
Rinsing - Control

- Conductivity / TDS
  - 350 ppm TDS above fresh water
  - 500 - 1000 ppm TDS Maximum

- Titration
  - 3% of Previous Stage

- Temperature
  - 100°F Maximum

Other Considerations:
- Counterflow
- Misting after chemical stage
- Fresh water riser after rinse stage
- Conductivity / TDS of Drip Water
Rinse Water Preferences

- Reverse osmosis
- Deionized
- City water
- Well water
- Recycled water
Water Quality

Deionized Water (DI)

Hard water salts removed by resin:
- Ca and Mg replaced by H
- Cl and SO$_4$ replaced by OH
- TDS typically < 7 ppm
- Conductivity typically < 10 mS/cm

Reverse Osmosis (RO)

- Removes most organic and many inorganic molecules by membrane separation at high pressure
- TDS typically 7 - 35 ppm
- Conductivity typically 10 - 50 mS/cm
- Hard water salts (Ca) often first removed by water softener
Automation – Rinse

- Digital and Analog Rinse Tank Controllers
  - Conductivity
  - Operates a solenoid valve
Drying

**Methods:**

- Air Evaporation
- Compressed air blow off
- Air Knife
- Drying Oven
- Infrared Lamp Bank
- Cloth Wipe

Cleaner chemistry can also affect drying characteristics. Cleaners with low surface tension tend to have reduced drag-out and subsequently dry faster.
How clean is clean?
How clean the parts are?
Measuring Surface Cleanliness

Wipe Test

Water Break

Gravimetric

Tape Test
Other Methods

- Visual
- Coulometric Surface Carbon
- Fluorescence
- Radiotracer
- Scanning Electron Microscopy, SEM
- Energy Dispersive X-ray Analyzer, EDXA
- Fourier Transform Infra-Red, FTIR
Maintenance – Typical Schedule

Daily to Weekly to Monthly - As needed?

- Screens
- Filters
- Nozzles
- Descale Tank, Heat Exchangers
- Pumps, Exhaust, Skimmers, Conveyor, etc...

Always keep GOOD records of maintenance and process parameters

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Troubleshooting

- Define Problem
- What changed?
- Locate Source of Problem
- Chemical vs. Mechanical Problem
- Test One Variable at a Time
- Implement Change
- Verify
Cleaning – Troubleshooting

- Poor Cleaning
- Corrosion/Rust
- Streaked/Spotted Parts
- Foaming

- Each of these conditions can lead to trouble...
- Learn to spot them and methodically troubleshoot one variable at a time!
Safety

MSDS - Material Safety Data Sheet

- Lists Hazardous Ingredients
- Defines Hazards
- Recommends Personal Protective Equipment
- Recommends Accident Remediation
- Keep it in a Convenient Location
Summary

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- **Low-Temperature Cleaners**
Summary

Anyone can purchase and use an aqueous cleaning system which will remove soils from the parts!

The “Trick” to continually producing Clean parts requires a Solid process and robust Rinsing!

Cleaning and Rinsing are the most critical steps in any Coating process!!!
Thank You

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Questions?