Metal Preparation Prior to Painting

Phosphate 101 - The Basics

Doug Van Duyne
Metal Pretreatment

• Paint does not adhere to dirty surfaces
• Utilizing controlled chemical attack, metal surfaces can be enhanced to hold paint and reduce corrosion
• Cutting, Grinding, Honing Fluids
• Pressworking Fluids
• Rust Inhibitors
• Mass Finishing Compounds and Solutions
Typical Soils

- Rust and Corrosion
- Lubrication Oils
- Adhesives
- Weld smut or heat treat scale
- Everyday dust and dirt and grime
Different soils require different chemicals

• Alkaline Cleaners-typically used for fatty/oily soils
• Solvent Cleaners-good for oily soils -- adhesives
• Acidic Cleaners-good for soils such as oxidation, rust and scale
• Physical-when all else fails
pH scale

- pH measures the acidity or alkalinity of a solution
- pH scale is from 0-14 with 7 being neutral
- Solutions with a pH lower than 7 are acidic
- Solutions with a pH higher than 7 are alkaline
- pH intensity is greater as the solution moves away from neutral in either direction
# pH Scale & Examples

<table>
<thead>
<tr>
<th>pH Value</th>
<th>$\text{H}^+ \text{ Concentration Relative to Pure Water}$</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10 000 000</td>
<td>battery acid</td>
</tr>
<tr>
<td>1</td>
<td>1 000 000</td>
<td>sulfuric acid</td>
</tr>
<tr>
<td>2</td>
<td>100 000</td>
<td>lemon juice, vinegar</td>
</tr>
<tr>
<td>3</td>
<td>10 000</td>
<td>orange juice, soda</td>
</tr>
<tr>
<td>4</td>
<td>1 000</td>
<td>tomato juice, acid rain</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>black coffee, bananas</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>urine, milk</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>pure water</td>
</tr>
<tr>
<td>8</td>
<td>0.1</td>
<td>sea water, eggs</td>
</tr>
<tr>
<td>9</td>
<td>0.01</td>
<td>baking soda</td>
</tr>
<tr>
<td>10</td>
<td>0.001</td>
<td>Great Salt Lake, milk of magnesia</td>
</tr>
<tr>
<td>11</td>
<td>0.000 1</td>
<td>ammonia solution</td>
</tr>
<tr>
<td>12</td>
<td>0.000 01</td>
<td>soapy water</td>
</tr>
<tr>
<td>13</td>
<td>0.000 001</td>
<td>bleach, oven cleaner</td>
</tr>
<tr>
<td>14</td>
<td>0.000 000 1</td>
<td>liquid drain cleaner</td>
</tr>
</tbody>
</table>
Purpose of Pretreatment

- To help make paint adhere to metal
- Make a painted surface last longer
- Enhance rust and corrosion resistance of metal
Purpose of Pretreatment

• Metal needs to be clean to allow good paint adhesion
• Good paint adhesion ensures long life of the painted surface
Purpose of Pretreatment

• Properly applied pretreatment when coupled with quality paint enables metals to resist rust or corrosion much better than paint alone
The Basics

• Chemical application methods:
  – Hand wipe
  – Immersion
  – Power Spray Wand
  – Cabinet or Tunnel/Conveyor Spray Wash
The Basics

- Hand wipe application is labor intensive
- Least favorable for best performance
- Worker & Environmental Hazards
The Basics

- Power spray wand is usually reserved for large parts that will not go into an immersion or cabinet/tunnel spray wash
- Operator dependant on cleanliness
- Single use of chemistry – straight to drain
• Immersion application is used for parts whose configuration is such that spray application can not ensure complete chemical contact and soil removal.
The Basics

• Cabinet/tunnel wash most popular for mass production parts
The Basics

• Selection of method relies upon:
  – Quality of paint finish desired in end product
  – Soil type
  – Part configuration
  – Equipment space limitations
  – Capital budget
The Basics

• Typical pretreatment consists of:
  – Alkaline Cleaning
  – Rinse
  – Acidic phosphate or non-phosphate coating
  – Rinse
  – Acidic or alkaline sealing rinse
The Basics

• In some cases the pretreatment process can be shortened to consist of:
  – Acidic cleaner/phosphate/non-phosphate
  – Rinse
  – Acidic or alkaline sealing rinse
The selection of 3 stage versus 5 stage pretreatment depends primarily on the soils anticipated to be cleaned and the overall under paint corrosion protection to be achieved or required.
The Basics

- 3 stage washers use an acidic pretreatment chemical with cleaning ingredients added
- When difficult oily soils are encountered this system may not be satisfactory and will require a pre-cleaning step
The Basics

- Typically when rusty parts enter a washer, rusty parts will come out of a washer.
- Parts can rust in a washer due to drying between stages and starting and stopping the conveyor line.
- In immersion systems the parts need to be submerged in the rinse section before they dry.
The Basics

- W-A-T-C-H
  - water
  - action
  - time
  - chemical
  - heat
The Basics

• “W” refers to water in W-A-T-C-H
• Water quality is extremely important in pretreatment
• Impurities in water can affect bath life and paint finishes
• Typical chemical baths consist of 95%-97% water
• Rinses are 100% water
The Basics

- Good water is soft water 0-7 grains or 0-119 PPM
- Fair water is medium hard water or 8-13 grains or 136 PPM-221 PPM
- Barely acceptable water is 14-19 grains or 238 PPM-323 PPM
- Bad water is 20 grains/340 PPM or higher
The Basics

• “A” refers to action in W-A-T-C-H
• Action describes the physical scrubbing action in a wash bath
  – Hand wipe is physical wiping
  – Immersion can be static or agitated
  – Spray wand is pressure spray combined with wand motion and distance from part
  – Spray wash uses pressure spray as action
The Basics

• “T” refers to time in W-A-T-C-H
• The time spent in a cleaner, rinse, pretreatment bath or sealing rinse is critical for getting the proper results
The Basics

- Typical times for 3 stage pretreatment immersion systems:
  - cleaner phosphate/non-phosphate 3-5 minutes*
  - rinse 2 minutes
  - sealing rinse 30 seconds
  - *note it is important not to let parts dry between steps
The Basics

• Typical times for 5 stage immersion pretreatment:
  – alkaline cleaner 3-5 minutes
  – rinse 2 minutes
  – iron phosphate/non-phosphate 3 minutes
  – rinse 2 minutes
  – sealing rinse 30 seconds
The Basics

• Typical times for zinc phosphate immersion paint pretreatment:
  – always done in 5 or more stages
  – alkaline cleaner 3-5 minutes
  – rinse 2 minutes
  – activating rinse 1-2 minutes
  – zinc phosphate plus accelerator 3 minutes
  – rinse 2 minutes
  – sealing rinse 30 seconds
The Basics

- Typical times for a three stage spray wash system:
  - cleaner phosphate/non-phosphate 1 minute
  - rinse 30 seconds
  - sealing rinse 30 seconds
The Basics

• Typical times for a 5 stage spray wash system
  – alkaline wash 1 minute
  – rinse 30 seconds
  – iron phosphate/non-phosphate 1 minute
  – rinse 30 seconds
  – sealing rinse 30 seconds
The Basics

- Times are established through trial and error in a laboratory (hopefully) prior to building a wash system.
- 5 stage washers are more forgiving than 3 stage washers when soil types and levels change.
- It is easier to adjust time in most immersion systems and cabinet washers than conveyor wash systems.
The Basics

• The “C” refers to Chemical (Concentration/pH)
  – Alkaline Cleaning
  – Chemical in the pretreatment stage
  – Chemical in the seal stage
The Basics

- Pretreatment coatings consist of
  - iron phosphate conversion coating
  - zirconium non-phosphate deposition coating
  - zinc phosphate conversion coating
  - manganese phosphate conversion coating
Surface Coating

**Figure 1**
Cell formed by PEAK
Cell formed by OCCLUSION
Cell formed by STRESS

**Figure 2**
ALKALINE
RUST

**Figure 3**
LAYERS OF PHOSPHATE CRYSTALS
ELECTRICAL DIFFERENCES ELIMINATED
Iron Phosphate conversion coatings are popular because they have been around a long time:

- iron phosphate forms an amorphous coating
- more flexible than zinc or manganese
- typical accelerators used are molybdate, chlorate, hydroxyl ammonium sulfate and sodium nitrobenzene sulfonate, they are part of the formulated product.
The Basics

• Non-phosphate pretreatment is becoming very popular and widely recognized due to the increasing environmental concerns with phosphorus (The element “P”)
• The advancement of non-phosphate pretreatment chemistries has produced definitive advantages
• Non-phosphate systems produce less sludge thus reducing maintenance and provide excellent performance for coated surfaces
The Basics

- Non-phosphate pretreatment typically operates at lower temperatures
- Non-phosphate pretreatment is a deposition coating
- Non-phosphate pretreatment is easy to maintain and reduces washer maintenance
The Basics

• Zinc phosphate conversion coatings form a crystalline structured coating
  – they can range from light to medium to heavy
  – light to medium, 200-800 mg/ft²
  – heavy, 1000mg/ft²
  – accelerators are added tank side, sodium nitrite
The Basics

- Manganese phosphate is typically used to hold lubrication for part break-in
  - it is a heavy somewhat brittle crystalline structure
The Basics

• The quality of paint pretreatment is measured by:
  – visual observation- coating should be uniform without streaks, blotches, spots or bare areas
  – Verified by a number of ASTM test Standards
The Basics

• Pretreatment quality is measured by:
  – coating weight- typically 25-60 mg/ft² (iron phosphate coatings have no measurable dimensional thickness), coating weights are dictated by a particular system and are not easily adjustable
The Basics

• Pretreatment quality is also measured by performance in conjunction with the paint finish
  – cross hatch adhesion
  – conical mandrill
  – impact resistance
  – humidity
  – salt spray
The Basics

• “H” in W-A-T-C-H refers to heat
  – heat will help remove soils faster and help form quality pretreatment
  – optimum temperature for pretreatment baths is 90°-140°F
  – optimum cleaning temperatures for ferrous metal is 100°F to 180°F
  – optimum cleaning temperatures for non-ferrous metal is 100°F to 150°F
  – wand phosphatizing temperatures range from 180°F to 190°F
Troubleshooting

• Investigate each segment of W-A-T-C-H
  – understand the influence of water quality in baths and rinses, overflow rinses
  – check spray nozzles to ensure the chemical and rinse water gets to the part
  – be sure parts are racked, or hung for maximum impingement
  – give the chemical enough time to do its job
Troubleshooting

- check concentrations every shift or as needed
- maintain proper temperatures
- clean screens every day or as necessary
- de-scale washer at least once per year or as needed
- periodically conduct white hank test
- monitor dry off between stages
- check results
Troubleshooting

• For every adverse condition within the WATCH concept an action plan/remedy must be initiated
  – for example (H) too low of temperature
    • More time (T)
    • More chemical (C)
    • More action (A)