

# Surface Preparation and Pretreatment with Powder Coating Systems

**GALE SEAMONS**  
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# SURFACE PRETREATMENT

## ...Maximize the Benefit of your POWDER QUALITY!

The highest quality powder coating will show you excellent results **ONLY** if the pretreatment (cleaning and phosphatizing) is done correctly and the overall system is maintained up to its potential. To maximize a new system, a thorough understanding of the total system is necessary. Have all your vendors work together on your behalf, lay out the objectives you need to accomplish, then allow the vendors to help you meet those objectives.

1. *Pretreatment Chemical Vendor*
2. *Pretreatment Process Equip. Vendor*
3. *Powder Coating Vendor*
4. *Powder Application and Curing Vendor*
5. *Process Mediator*

### What to Find Out for a New Business

If you are new to in-house finishing, rely on your vendors, make visits to four or five systems, and ask candid questions. Work closely with your proposed vendors. On the other hand, if the situation is where you are converting from a liquid coating (solvent, water, high solids) to a powder system, your past experience and knowledge will be invaluable.

Powder brings pretreatment back to the basics of cleaning, rinsing, phosphatizing,

and seal rinsing. In order to maximize the benefit derived from powder, it is imperative to insure your pretreatment system is capable of providing a clean conversion coated product in a dry state to the powder booth.

### The Six Biggest Mistakes!

1. **Parts Not Clean**
2. **Parts Not Dry**
3. **Parts Not Cured**
4. **Fixtures Not Clean**
5. **Poor Communication**
6. **Poor Maintenance/Control**

#### 1. **CLEANING**

You can powder coat over a nonchemically clean substrate! This is evident by manufacturers who employ vapor degreasing only. Vapor degreasing certainly has had its place as one effective method of gross soil removal. It does not however produce a chemically clean surface free of surface tension. Soil or any contaminants left on a surface may detract from dry film adhesion quality. Whenever you have a loss or reduction of adhesion, you can expect a greater loss in salt spray and humidity accelerated testing.

## 2. PARTS NOT DRY

Powder is unlike solvent coatings in some cases where the solvent will actually displace standing moisture during application. Powder must be applied to a dry surface. Should you apply powder over a wet surface, you are likely to find a puddle of cured powder with rusted bare metal after curing!

## 3. PARTS NOT CURED

The easiest way to have powder come off in sheets is to undercure the coating! Any **drastic** loss of adhesion properties should point your investigation at cure!

Metal temperature for the time indicated by the powder vendor is critical. Should there be any questions to the oven capabilities, a device which measures metals temperature should be used to exactly determine what temperature **your** metal receives and for what duration!

## 4. FIXTURES NOT CLEAN

Most powders offer tenacious film characteristics when applied to a clean substrate and cured properly. Applying electrostatically charged particles and providing the adhesion of those particles prior to cure means you must have ground. Ground is only possible when good contact is made. **Effective, consistently cleaned racks and hanging devices** are critical.

## 5. POOR COMMUNICATION

Communicate to the pretreatment vendor and the powder vendor what you require for a list of final film characteristics.

A powder can be tailor-made to your specifications. Pretreatment and your purchased coating work together in offering the final results. Be specific and communicate those needs. This allows the necessary variables to be built into the process.

## 6. POOR MAINTENANCE-CONTROL

A pretreatment and finishing process is a generated process, one which will deliver a known goal or results when a process is controlled. Your pretreatment system will be a tested process that should come with a list of controllable variables by stage. These items may be the following:

- a. Product recommendation*
- b. Concentration range*
- c. Temperature range*
- d. Pressure range.*
- e. Nozzle recommendation*
- f. pH range*
- g. TDS range*
- h. Addition recommendations*
- i. Bath life recommendations*
- j. Contact time recommendations*

The pretreatment washer and chemicals, along with the recommendations for process control must be insured through testing monitoring, and a recording process.

## QUALITY STANDARDS

### BE REALISTIC :

Your finished product, what kind of durability must it meet, what criteria will you use to lay out a **Quality Assurance Program**. When setting guidelines for humidity, salt spray testing, **be realistic**. In reality you may not receive the number of salt spray hours the powder company tells you the powder is capable of! **Why?** Many suppliers present their powder on Q-panels or pretreated panels with high quality C.R.S. time saved (sanded) panels. The commonly available panels represent a seven stage pretreatment system with chrome seal. If your pretreatment is not seven stage with chrome seal, or your production steel is not lightly soiled, time saved, high quality C.R.S., then you are not comparing "apples to apples". How do you resolve this? Develop a two tier **quality evaluation**:

1) **One which addresses the quality of powder only** (in pristine conditions). Here is where you can use the professionally manufactured high quality panels.

2) **And one which addresses your production soils, base metals, water quality, and quality of existing pretreatment and maintenance control**. Use your own manufactured panel fabricated with your metal. You may want to include a weldment or another unique feature which your parts exhibit.

By monitoring both tiers of testing, you can maintain the incoming quality of your powder and the quality of your in-house pretreatment system.

### ADHESION AND SALT SPRAY:

The beauty of powder over a clean surface is great adhesion. If you cannot achieve good, dry film adhesion, don't even consider salt spray.

Salt spray is sometimes blown out of proportion not because it is a bad test, it's the industry standard! The real reason is in how the test is done and how the results are interpreted.

### ASTM-B-117 SALT SPRAY PARAMETERS:

- a. Angle of exposure=15-30°
- b. Salt solutions=5% b.w.±1%
- c. pH of salt solution=6.5-7.2
- d. Air pressure to nozzle=10-20 PSI
- e. Collection rate=1.0-2.0 ml/hr per 80 cm<sup>2</sup>.
- f. Temperature=92-97°F
- g. Specific gravity of collected solution =1.0255-1.0400

Based on the above information both of the following lists of parameters are within the accepted range of ASTM-B-117.

	<u>Cabinet I</u>	<u>Cabinet II</u>
Angle	15°	30°
Salt Concentration	4%	6%
pH	7.0	6.5
Air Pressure	10°	25°
Collection Rate	1.0	2.0
Temperature	92°F	97°F
Specific Gravity	1.0255	1.0400

Both cabinets meet ASTM-B-117. The same test part could have a 50% difference in results of hours. The point here is, if you will place a great emphasis on salt spray, then place great emphasis on the details, and interpretation, not just hours. The final analysis is to be sure, buy your own cabinet and be realistic!

### **CONTROL**

- \*BE CONSISTENT IN TESTING
- \*BE CONSISTENT IN EVALUATION
- \*CONSIDER YOUR OWN CABINET!
- \*TEMPERATURE
- \*NOZZLES
- \*RISERS
- \*SCREENS
- \*RECORD KEEPING

### **WASHER MAINTENANCE**

**NOZZLES:** Should be checked daily by physical inspecting nozzles with a flashlight, look for debris, blocked, misaligned and worn nozzles. If plugged remove and replace with backup inventory.

**RISERS:** Should be checked for scale buildup on I.D. and the end caps removed to allow debris to clear the tube. Total riser direction

should be checked and adjusted for stage to stage overspray and blow by.

**TEMPERATURE:** Heat tubes and temperature gauges should be maintained. Scale over heat tubes drastically reduces efficiency. 1/32" scale gives an energy loss of 2%. For plate and frame external systems a scheduled cleaning program should be done to maintain efficiency.

**FILTER SCREENS:** Not only protect pump intakes but they drastically reduce plugged nozzles. Double screen systems are the best. Screens should be removed one at a time and cleaned by high pressure rinse daily.

**DESCALER:** Annual or bi-annual cleaning and descaling should be done (based on water quality). The additional cleaning efficiency achieved with a clean washer, and the dollars saved in energy consumption, more than justifies the associated costs. (Follow all safety and ventilation procedures.) See Table I on the following page.

**RECORD KEEPING:** Chemical pretreatment systems are in constant change in terms of temperature, chemical concentration, pH and age of bath. It is necessary to consistently monitor and record the findings in order to produce a running log book of variables and results. This information can be a valuable reference should problems develop and the recorded variables are the data which make up a solid S.P.C. program. See Table II and Table III for record keeping examples.

**TABLE I.**  
**WASHER DESCALING PROCEDURE FOR REMOVAL OF**  
**ORGANIC SOIL AND INORGANIC SCALE**

- |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>1) While solution is hot and static, overflow to displace surface oils or allow automatic skimmer to remove as much free oil as possible.*</p> <p>2) Drain solution from tank.*</p> <p>3) Flush sludge and solids to drain.*</p> <p>4) Refill tank with water.</p> <p>5) Add sufficient proprietary type high caustic, high chelate alkaline descaler material to reach 4-6 oz./gal.</p> <p>6) Heat and circulate solution for 1-2 hours at maximum obtainable heat. Proprietary type low foam detergent may be added at 0.5-1.0% v/v to help displace oils.</p> <p>7) Allow solution to remain static for 20-30 minutes.</p> <p>8) Overflow to displace surface oils or allow automatic skimmer to remove oils.*</p> <p>9) Drain solution from tank.*</p> <p>10) Flush solids and sludge to drain.*</p> <p>11) Remove nozzles.</p> <p>12) Fill tank 2/3 full with cold fresh water.</p> | <p>13) Add 10% v/v proprietary type inhibited descaling acid (muriatic). To minimize fuming to air and plant environment, use low volume chemical hand pump with discharge line immersed below liquid level in tank.</p> <p>14) Circulate and heat solution to 120°F for 1-2 hours.</p> <p>15) Drain solution from tank.*</p> <p>16) Flush sludge and solids to drain.*</p> <p>17) Inspect, clean and replace nozzles to header assembly.</p> <p>18) Refill tank with fresh water and heat.</p> <p>19) Add 0.1-1.0% v/v proprietary type phosphate. Circulate washer for 5-10 minutes.</p> <p>20) Drain solution from tank.*</p> <p>21) Rinse solids and sludge to drain.*</p> <p>22) Fill tank to operating level.</p> <p>23) Charge solution with processing chemical product.</p> |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

\*Denotes a possible treatment prior to disposal to effluent. Wear all safety equipment as outlined on the material safety data sheet.



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**RULES**  
S.F.T.-UP:  
RUN:

PREL. & INV. CURANT  
PRE COLORED

5 Consecutive Green to Quality  
Sample 2: 1st in Green - Run  
1st in Yellow, 2nd in Green - Run  
2 in Yellow or 1 in Red - Adjust & Rerun

STAGE  
CONTROL

FILL IN DIMENSIONS HERE

Lower  
Tolerance

P/C(1/2)

Nominal

P/C(1/2)

Upper  
Tolerance

DATE TIME



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Table III  
THREE AND FIVE STAGE  
PHOSPHATE CONTROL CHART

REPRESENTATIVE \_\_\_\_\_

METALS \_\_\_\_\_

PHONE \_\_\_\_\_

METAL MIX, % \_\_\_\_\_

NAME																			
DATE																			
TIME																			
(STAGE 1)	F-	CONC.																	
		pH																	
GAL. _____	°F	TEMP.																	
CHARGE	PHOS.	ADD.																	
_____	CL.	ADD.																	
_____	F-	pH ACID																	
_____	F-	DET. ADD.																	
(STAGE 2)		COND.																	
GAL. _____		pH																	
(STAGE 3)	F-	CONC.																	
GAL. _____		pH																	
CHARGE	°F	TEMP.																	
_____		COND.																	
_____																			
_____																			
(STAGE 4)		COND.																	
GAL. _____		pH																	
(STAGE 5)	F-	CONC.																	
GAL. _____		pH																	
CHARGE		COND.																	
_____	°F	TEMP.																	
_____	SR	ADD.																	
_____	DATE	CHARGED																	



## WHAT IS SOIL?

Soil is matter out of place.

### SOIL AUDIT:

- \*What soils are incoming?
- \*In-house applied?
- \*Substrate type(s).
- \*Substrate flow.
- \*Process control.

Today you can demand a Material Safety Data Sheet from your steel supplier. What oil or preservative do they apply? Is it heat sensitive? Does it contain waxes? When you buy steel from many vendors do you have control over the quality and consistency? When you determine that you can clean the incoming soils make sure your vendors do not change soils without notifying you!

In house metal fabricating; what soils do you apply? Do you use rust inhibitors, forming oils, coolants, lubricants? If so, pretest all soils in your pretreatment system. Once you determine you can successfully clean these soils in a fresh or aged state do not make changes unless you pretest.

How many different types of metal substrates make up your product or products? Combinations of ferrous and non-ferrous metals require different chemistries to effectively clean without metal attack! The use of zinc bearing metals such as die-cast or galvanized metals may require post effluent treatment.

Effective pretreatment and process control cannot be accomplished unless you have control over incoming soils, in-house applied soils, and the substrates in use!

## IS THE PART CLEAN?

If you can determine that the part is clean, your powder will adhere. In most cases, if the chemical vendor can produce a clean part, the phosphate will also be sufficient.

**CLEAN SURFACE:** One which is free of oil and other unwanted contaminants.

**ORGANIC SOILS:** Oily, waxy, films such as mill oils, rust inhibitors, coolants, lubricants, and drawing compounds can be classified as organic soils. Alkaline cleaning solutions are most effective on organic soils. **\*Alkalines clean organics.**

**WATER BREAK-FREE SURFACE:** This condition tells you that you have removed all organic soils. The parts exiting the last pretreatment stage prior to drying will show a uniform sheeting of the rinse water indicating an organically clean surface.

**WATER BREAK SURFACE;** This condition tells you that you have not sufficiently cleaned and that there is remaining organic soils still present. The part will exhibit a surface which would resemble a freshly waxed car surface after a good rain. You will not see uniform sheeting of the water, but you will see beads of water.

**INORGANIC SOILS:** Rust, smut, heat, scale, and inorganic particulate. These soils reduce adhesion and gloss. They most commonly can be found after allowing the part to pass through the dry-off oven. Check for smut and other loosely adherent inorganic solids by using a clean white towel and wiping over a dry surface. Normally poor cleaning is most often found on or

near weldments, or in areas which receive poor spray impingement to the part. Acidic cleaning solutions are most effective on inorganic soils.

**\*Acids clean inorganics.**

**WHITE TOWEL TEST:** Wiping a white towel across clean and dry surfaces will indicate the effectiveness of inorganic soil removal. Check flat surfaces and those areas most likely not to receive direct spray impingement.

### **WHERE TO LOOK FOR POOR CLEANING**

There are only two places you can look at to see if the basic pretreatment is succeeding. The first place is where the parts exit the last stage. Are they water break free?

The second place to look is where the parts leave the dry-off oven. What is their condition? At this point, the rinse water has been evaporated and driven from the part. All parts should exhibit a clean surface with no powdering or heavy streaking. A powdery film indicates poor rinsing or excessively contaminated cleaning stages.

Smut, the black gritty substance found on weldments and hot rolled pickled and oiled steel should be removed at this point although sometimes it is almost impossible to remove all soot, carbon, and smut without some form of mechanical or abrasive cleaning.

## **ORGANIC SOILS**

- \* Alkalines Clean Organics
- Water Break Free Test

## **INORGANIC SOILS**

- Acids Clean Inorganics
- White Towel Test

## APPLICATION METHODS

### MECHANICAL CLEANING

\*Abrasive Cleaning

### CHEMICAL CLEANING

- \*Immersion systems
- \*Spray wand/hand held
- \*3-Stage spray
- \*5-Stage spray

## MECHANICAL

Mechanical or abrasive cleaning is very suitable where steel surfaces have been subject to abuse such as **severe corrosion, rust, and oxidation**, or steel surfaces which exhibit large amounts of **heat scale or controlled oxidation**. Especially loosely adherent accumulations found in improperly stored steel, or hot rolled steel of poor quality. These contaminants make it very difficult to achieve any form of quality adhesion.

Three types of mechanical surface preparation have somewhat wide acceptance. They are:

### 1. AIR/MEDIA BLAST

The most common type generally referred to as sandblasting is a combination of compressed air and media or sand. This can be accomplished automatically or manually. Problems associated with employee safety, referred to as "silicosis", has altered wide spread use in open air environments. A specially designed cabinet or enclosed area along with air induced breathing apparatus, has insured continuing growth of this method of mechanical surface preparation.

### 2. WATER/MEDIA BLAST

This method is gaining popularity because of the reduction of silicosis associated problems. Wet spot blasting of weldments has become accepted because of these reasons:

- a. During the welding process, oily soils are carbonized, creating an impossible cleaning condition through a three or five stage washer.
- b. The surface of weldments are basically inert to the development of a conversion coating because of the scale and glassing developed. Wet spot blasting units are relatively inexpensive, low in labor requirements and prove to provide the best possible substrate conditions prior to phosphatizing.

### 3. CENTRIFUGAL WHEEL (AIRLESS)

This airless process is quite popular for larger, heavier bodied parts where rust and scale must be removed. Centrifugal wheel is most often done in an enclosed cabinetry operation. The media is normally steel shot of varying sizes, depending on the substrate profile required.

For optimum results, centrifugal wheel should employ additional chemical pretreatment to insure quality long term finish life.

#### Note:

- **Media picks up oil from metal, peens into surface.**
- **Blast profile may interfere with coverage.**

## MECHANICAL CLEANING BENEFITS

- Removes Scale
- Removes Rust
- Provides Adhesion
- Carbonized Welds

## MECHANICAL CLEANING NEGATIVES

- Media Wear
- Media Smut
- Oil Peeling
- Consistency

# ZINC PHOSPHATIZING

## ZINC PHOSPHATIZING, WHAT IS IT?

Phosphate coatings are produced on ferrous and non-ferrous metal surfaces and are composed of tiny crystals of iron, zinc, or manganese phosphates. The inorganic coatings produced on metal surfaces retard corrosion and promote better paint bonding. Phosphate coatings are produced after precleaning or formed in a combination bath known as cleaner-phosphate. Phosphate coatings are generally used by the metal finishing industry for the following reason:

- 1) To provide a base for bonding organic finishes such as paints, lacquers, plastics, rubber, adhesives, and powder coatings.
- 2) To provide a base for oils, waxes, and rust preventives to reduce corrosion.
- 3) To provide a base for lubricant on bearing surfaces to reduce friction.
- 4) To aid in drawing and forming of metals.

However, phosphate coatings are used primarily for the bonding of paint. Coatings produced on metal are not only stable and chemically inert toward organic finishes, but they are also absorptive and bind organic finishes to the metal. The most important aspect for use of a phosphate coating is to prevent or retard the spread of corrosion under paint including the areas near ruptured film.

## HOW DOES PHOSPHATIZING OCCUR?

When the metal comes in contact with the phosphatizing solution, some pickling occurs which results in a reduction of acid concentration at the liquid metal interface. At this point iron is dissolved, hydrogen is evolved, and phosphate coating is deposited. Should the solution contain additional metal ions such as zinc or manganese, phosphate coatings of these ions will also be deposited.

Accelerators such as nitrite, nitrate, chlorate, peroxide or special organic chemicals may be added to increase the rate of coating deposition.

In general, iron phosphate coating weights of 25-70 mg/ft<sup>2</sup> and zinc phosphate coating weights of 100-300 mg/ft<sup>2</sup> are commonly accepted as bases for paint bonding.

When considering or using powder to gain the environmental benefits, iron phosphatizing is the most widely used pretreatment because of the more suitable effluent considerations. Iron phosphatizing and powder coating create environmental benefits and produce quality results.

## IRON PHOSPHATE

**PURPOSE:** To promote adhesion of powder and prevent short term corrosion and maximize the life of powder.

**IRON PHOSPHATIZING:** The development of an amorphous coating on iron bearing metals.

**PRIMARY METALS:** Phosphatize steel. Etch/activate aluminum, zinc, terneplate, galvanized, and other nonferrous metals.

**PROCESS:** One stage, three stage, and five stage.

**pH:** 3.0-5.8

**TIME:** 60-90 seconds for spray; 3-5 minutes for dip.

**TEMPERATURE:** Ambient to 160°F.

**MG/SQ.FT.:** 20-70

### BENEFITS

- + Low cost
- + Wide parameters
- + Application easy to maintain
- + Disposal not complicated
- + Works well with powder on many metals
- + Industry standard for powder

### NEGATIVES

- Less corrosion protection than zinc phosphate
- Line speed requires planning

# WAND HELD APPLICATION METHODS

**SPRAY WAND PHOSPHATIZING:** Best suited for large bulky parts where dip tanks or monorail would require huge cost.

**STEAM CLEANING:** For small volume of heavily soiled small parts. Melts grease.

**HIGH PRESSURE HOT WATER:** Best cleaning for large bulky parts; should have 4-5 GPM, 1,000 psi plus heat capacity at nozzle of 160-200°F.

**METALS:** Ferrous and nonferrous.

**TIME:** 5-15 minutes (size dictates).

**TEMPERATURE:** 160-180°F at nozzle.

**CONCENTRATION:** 1% by volume.

**MG/FT<sup>2</sup>:** 20-40

## BENEFITS

- + Low initial cost for quality delivered
- + Ease of installation and mobility
- + High quality with low labor costs
- + Wet sandblast attachment for weldments
- + Cleans items too large for monorail spray systems

## NEGATIVES

- Needs a conscientious employee
- Not all systems deliver chemical at 1000 PSI
- Systems must be designed to deliver acidic chemicals



## THREE STAGE APPLICATION METHODS

THREE STAGE: Best suited for large and small parts for iron phosphate.

### THREE STAGE SPRAY

STAGE 1	STAGE 2	STAGE 3
Clean and phosphate	Rinse	Seal Rinse

**METALS:** Phosphatize for iron bearing.  
Etch/activate for nonferrous.

**TIME:** 90 seconds Stage 1; 30 seconds Stages 2 and 3.

**TEMPERATURE:** 90-140°F Stages 1 and 3.

**CONCENTRATION:** 2-3% by volume.

**pH:** 3.5-5.0

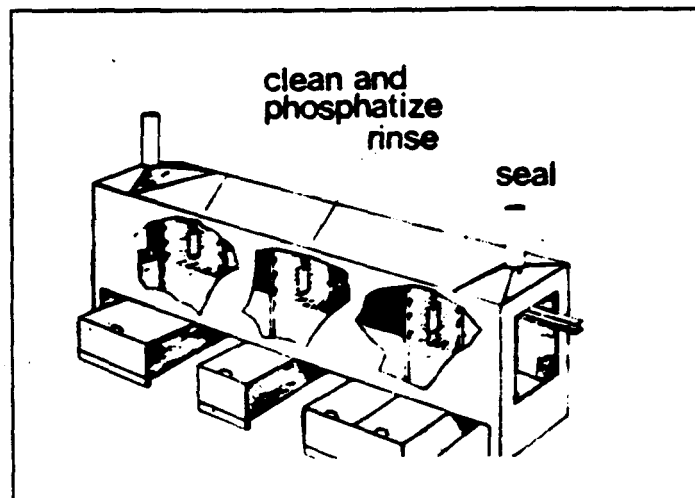
Cleaner coaters or cleaner phosphate systems are the most prevalent spray systems for powder coating pretreatment.

**\*Cleaning is critical to ultimate success in three stage.** Acidic detergent systems are not as effective as alkaline cleaning products. This requires the manufacturer to have very tight controls over incoming soil types and soil loads. The window for successful cleaning is much narrower, requiring full knowledge of incoming soils and very tight control over washer maintenance and overall cleaning efficiency.

**\*The type of iron phosphate and how the coating weight is accelerated or produced is limited in the currently available chemistries.** This sometimes limits the phosphate coating and the ultimate corrosion resistance offered!

Three stage iron phosphate systems can offer high quality results when the pretreatment chemicals are chosen for their ability to clean.

### 3 STAGE PHOSPHATIZING



(Illustration provided by AFP/SME)

# THREE STAGE SYSTEM

## STAGE ONE: CLEANING

Stage One is a multi purpose stage where cleaning or oil removal must take place first. Displacement of soils are produced through spray impingement and wetting afforded by the detergent packages built into acidic solutions. A fine balance of the surfactants are necessary to adequately remove these normally alkaline sensitive soils. Upon completion of soil removal, the acidic solution dissolves a minute layer of the metal substrate. A slight pH rise takes place at the substrate solution interface causing an insoluble reaction and producing the iron phosphate coating. Typical iron phosphate coatings range from 20-40 mg/ft<sup>2</sup> (milligrams of phosphate per square foot) on steel substrates. The wide range of soil types and soil loads distributed unevenly across metal surfaces places severe demand on the cleaner portion of cleaner phosphate chemistries.

## STAGE TWO: RINSING

The continuous overflowing rinse stage is designed to flush non-adherent soils and phosphate solution from all parts.

## STAGE THREE: SEAL RINSING

This final step in a three stage spray pretreatment accomplishes the following:

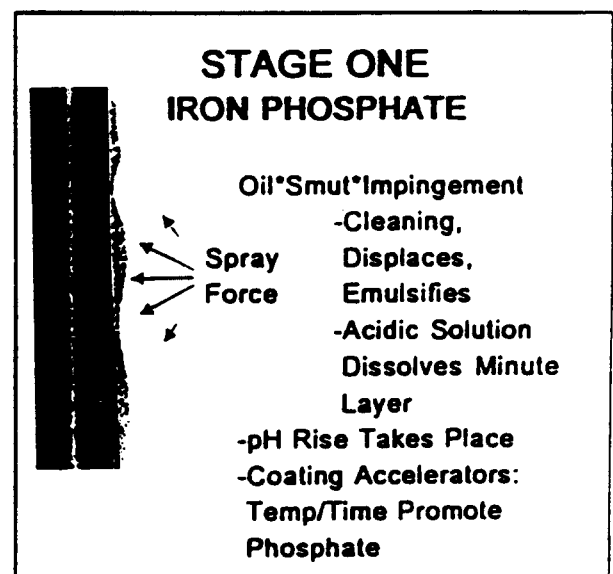
- \*Removal of trace chemical residue.
- \*Prevention of flash rusting.
- \*Sealing the porosity of the iron phosphate coating.

## BENEFITS

- Multi-metal preparation.
- Good cleaning of controlled soils.
- Dry film adhesion characteristics.

## NEGATIVES

- Lack of alkaline cleaning stage.
- Limited ability of phosphate accelerator choices.
- Narrow window for control.
- Non-uniformity of phosphate.





# FIVE STAGE APPLICATION METHODS

## FIVE STAGE: IRON OR ZINC PHOSPHATE

STAGES	STAGE 1	STAGE 2	STAGE 3	STAGE 4	STAGE 5
Process	Clean	Rinse	Phosphate	Rinse	Seal Rinse
Time	90 Sec.	30 Sec.	60 Sec.	30 Sec.	30 Sec.
Temp.	90-140°F	Ambient	90-140°F	Ambient	70-140°F
Conc.	2-4%	N/A	2-4%	N/A	1/10-1/4%
pH	Alkaline	Neutral	Acidic	Neutral	Acidic Neutral

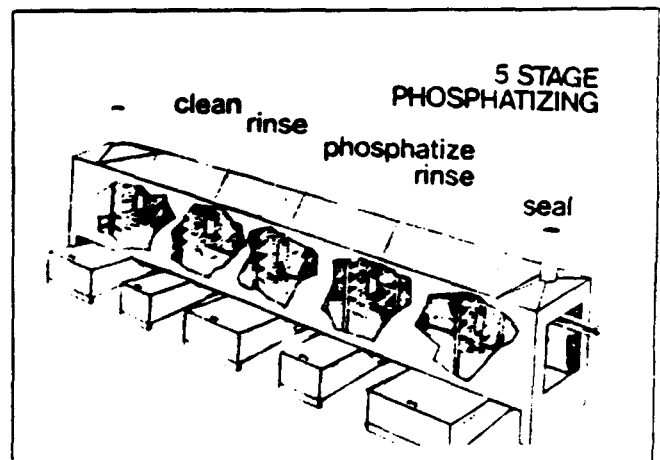
- Five or more stages, additional stages may include additional cleaning, rinsing, and D.I. rinse stages.
- Five stage systems best suited for delivering high quality phosphate development and long term coating life!
- Six stage systems most often include a final deionized water mist rinse.

## STAGE ONE: CLEANING

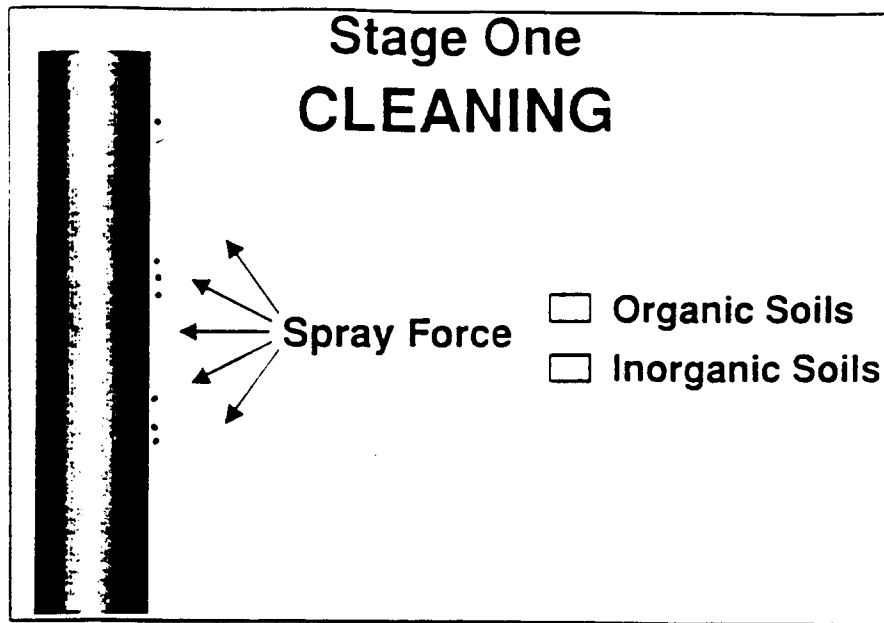
Cleaning, typically alkaline cleaning produces a metal surface free of organic and inorganic reactive soils. Alkaline cleaners incorporate:

- \*Detergents and surfactants to wet the soil.
- \*Alkaline builders to degrade, emulsify, and saponify organics.
- \*Water conditioners to soften and control contaminants.

Cleaning chemistries generated with alkaline systems offer a much wider range when looking at difficulty of removal and heavier loads of soil.



(Illustration provided by AFP/SME)

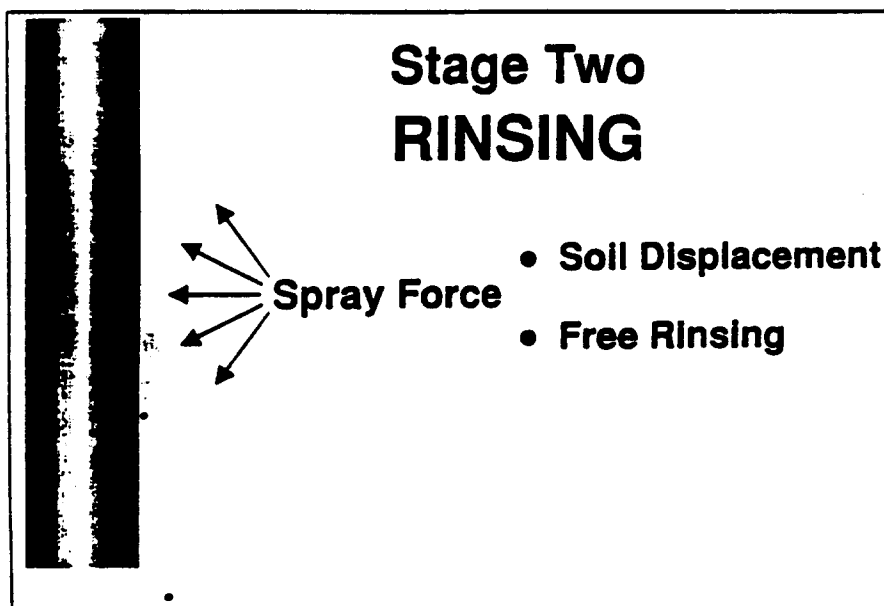


## **STAGE TWO: FRESH WATER RINSING**

The purpose of Stage Two is:

- Flush all remaining organic soil from the part.
- Neutralize alkalinity and prevent pH contamination to Stage Three.

Many systems do not have adequately sized rinse tank volumes or overflow capacity to effectively flush and neutralize. Part density and configuration dictate the most suitable overflow rate. Control of this stage is monitoring of pH and Total Dissolved Solids.



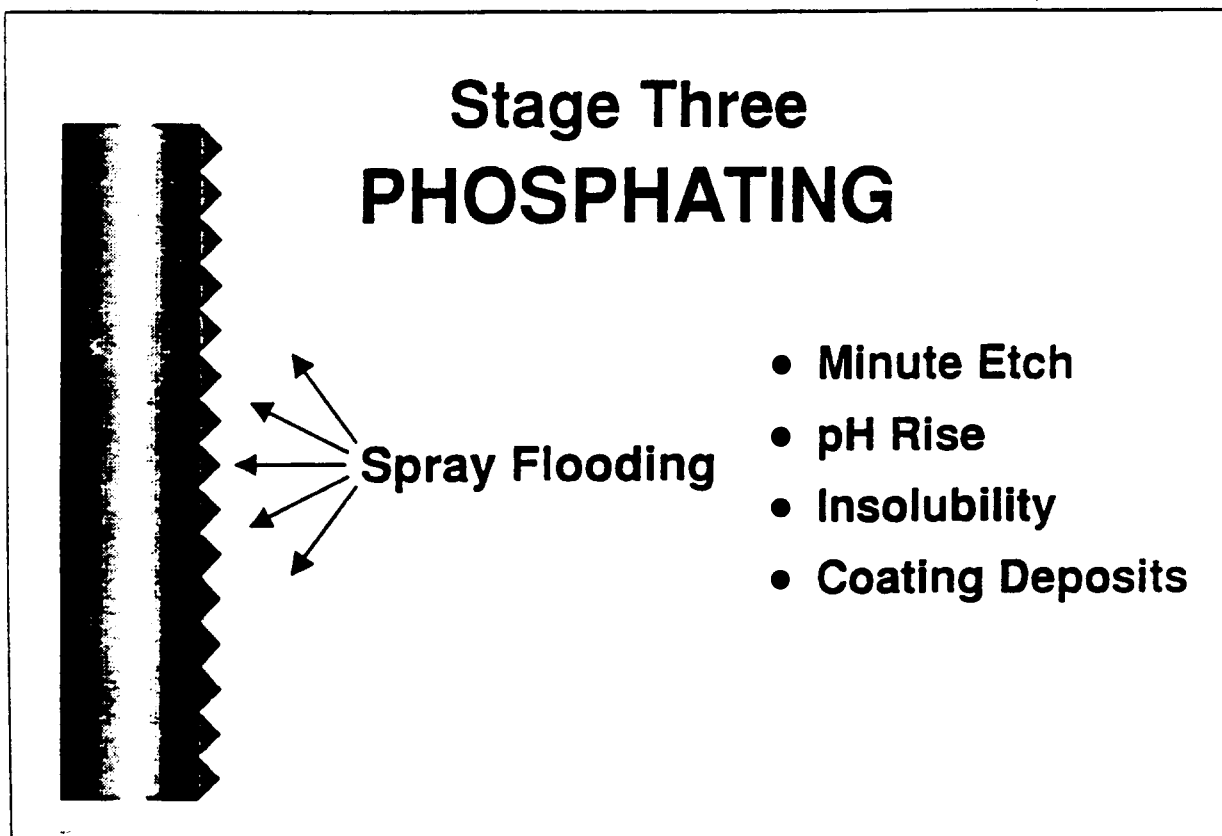
## STAGE THREE: PHOSPHATIZING

Iron phosphatizing is the most common form of conversion coating in general industry for powder coating. The clean and rinsed part enters the phosphate stage and receives a uniform acidic attack.

Unlike Three Stage Systems where the chemistry relies both on removal of soil and phosphate deposition, the Five Stage System employs a single function; phosphating. This allows a wider range of chemistries for phosphatizing and

the ability to use ingredients that produce a much higher quality type of phosphate coating.

Similar chemical reactions occur at the substrate solution interface. The deposition of phosphate is not only more uniform, it is also heavier in nature and quality. Most Five Stage Iron Phosphates deliver 40-70 mg/ft<sup>2</sup> of coating.



## STAGE FOUR: FRESH WATER RINSING

The purpose of Stage Four is:

- Flush any remaining phosphate solution.
- Prevent the subsequent stage from becoming chlorinated.

## STAGE FIVE: SEAL RINSING

The purpose of final seal rinsing regardless whether its the final stage in either a three or five stage system is to:

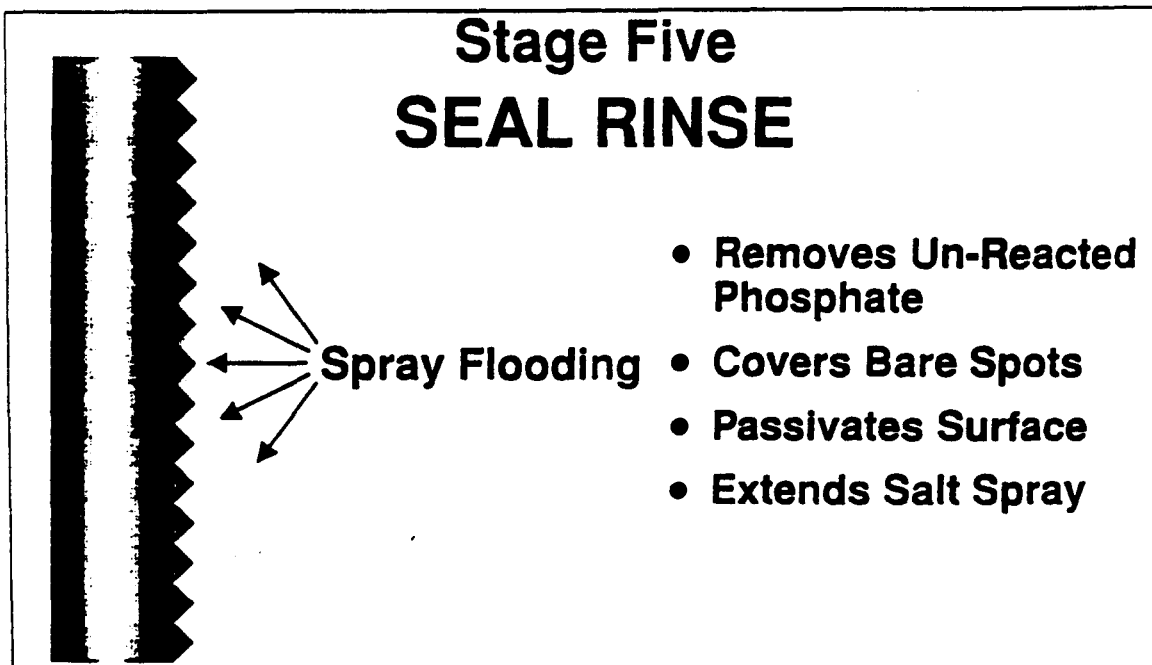
- Remove unreacted phosphate and other contaminants.
- Cover bare spots in the coating.
- Prevent the surface from flash rusting.
- Extend salt spray performance.

Three types of Seal Rinses exist:

- 1) Deionized water rinses.
- 2) Acidified Rinses.
- 3) Reactive Rinses.

The deionized rinse is the most widely used and successful over the widest range of powder coatings today. Deionized rinses leave the least amount of potential contaminants which may reduce the life of the coating. The remaining two types of seal rinses fall into the non-chrome type or chromic acid type.

Most honest seal rinse suppliers will claim that the chromic acid type of seal rinses provide the highest salt spray resistance over the widest range of powder formulations. Claims that some of the reactive non-chrome seal rinses are better than chrome can be agreed to with certain specific powder chemistries.



The only effective way the metal finisher can protect himself from claims is through a qualified controlled evaluation of the substrate through the existing system and powder and then alternating the seal rinse choices. Testing and subsequent production duplication is the only way!

Should your part quality dictate the use of a compounded chromic acid type of seal rinse, there are two methods for controlling the effluent (classified as a hazardous waste):

- 1. Conventional Chemical Reduction Method**
- 2. Proprietary Ion Exchange Method**

#### **BENEFITS OF REDUCTION METHODS**

- + Reduces total volume of waste.
- + Many different existing technologies.
- + Handles other metals and organics.

#### **NEGATIVES OF DESTRUCTION METHODS**

- Requires additional capital and process.
- Requires good control and recording.
- Generates hazardous waste

#### **BENEFITS OF ION EXCHANGE METHOD**

- + No hazardous waste generated.
- + Return all water to process or drain.
- + Simplicity of process.

#### **NEGATIVES OF ION EXCHANGE METHOD**

- Requires additional capital and process.
- Few vendors.
- Limited tolerance to oils in last stage.



#### **COATING EXPOSURE**

##### **Scratch**

- Cut to Base Metal


##### **Chrome Seal Provides**

- Creeping or Self Healing
- Stops Underfilm Moisture/Corrosion

# WATER

Water Quality	
D.I.	Deionized 0-15 TDS
R.O.	Reverse Osmosis *50-250 TDS
T.D.S.	Total Dissolved Solids
P.H.	Potential of Hydrogen
G.P.G.	Grains per Gallon Hardness
Soft H <sub>2</sub> O	Calcium/Sodium

Aqueous chemical pretreatment consists of solutions made up with 90-96% of existing water sources and only 1-4% chemicals. The rinse and seal rinse stages employ 98-99%+ existing water sources. Therefore, understanding the resource is important!



## DRY OFF EFFECTS OF POOR WATER

**Water Hardness**

- Pure Water Driven Off
- Water Drains Downward
- Solids and Salts Remain

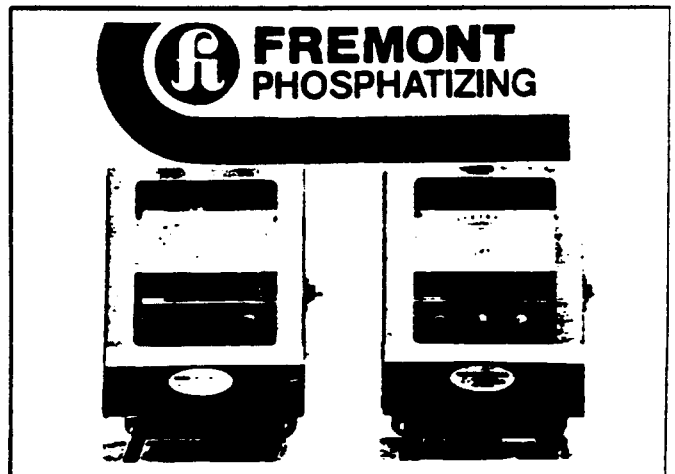
← Drip Line Concentrated Solids

## COATING LIFE EXPOSED



- Air and Moisture Penetrate
- Solids Resolubilize
- Film Bubbling
- Corrosion Begins and Spreads
- Part Failure

Water quality, whether in terms of rinse water or final seal rinsing has an impact on the final corrosion resistance your product offers. The knowledge of what constitutes your initial raw water quality can be provided by your pretreatment vendor. Suggestions for the control of rinses and final seal rinses are based on specific chemistries. The T.D.S. (Total Dissolved Solids) meter is one tool all pretreatment finishing systems should utilize.



Nonferrous substrates include aluminum sheet, coil, cast, extrusions, zinc diecasting, and galvanized or zinc alloy coated steel sheet stock.

The pretreatment for these metals can be classified into three different approaches where the one constant remains as cleaning.

#### APPROACH #1:

### NONFERROUS PRETREATMENT

1. Clean
2. Etch

The first approach includes cleaning of organic soils without attack to the nonferrous metal. This is followed by a rinse and the application of an acidic cleaner to slightly etch or remove the oxide layer of the metal. Careful consideration for both the alkaline cleaner and acidic material must be determined. The limiting factor becomes the alloy and the amount of etch without over-attack and the subsequent development of smut.

The second approach for pretreatment of non ferrous metals includes a third step of conversion coating. This approach is common when the metal finisher runs a combination of ferrous and nonferrous metals through the same system.

The etch portion and conversion coating portion is usually accomplished in the same stage by incorporating fluoride accelerators into the iron

### NONFERROUS PRETREATMENT

1. Clean
2. Etch
3. Conversion Coat

phosphate bath. The ultimate deposited coating is a combination of surface etch and a combination conversion coating of the dissolved alloys found within the particular nonferrous substrate.

The third approach to nonferrous pretreatment for powder coating is the chromate process, associated with the highest quality underfilm corrosion protection.

Chromate conversion coatings serve as effective pretreatments for powder coatings. These pretreatments are used extensively on aluminum and also find application with zinc and magnesium. Two types of chromate coatings are in use:

1. Chrome oxide (amorphous chrome).
2. Chrome phosphate.



Coatings formed with chrome oxide, the amorphous type, are based primarily on hexavalent chrome which is extremely corrosion resistant. Chrome phosphate coatings contain primarily trivalent chrome which is less corrosion resistant than hexavalent. The advantage of chrome phosphate coatings is that they are generally more mechanically sound and stress durable than chrome oxide types.

### APPROACH #3:

## NONFERROUS PRETREATMENT

1. Clean
2. Etch
3. Desmut
4. Conversion Coat

Chromate conversion coatings can be applied by spray or immersion. See Table below.

Cleaners used in these applications are usually alkaline and are designed to remove process oil from the metal. The deoxidizer on the other hand is acidic and functions by etching the metal surface to remove surface oxide and other inorganic soils such as scale, smut, and metal particulate. In doing this the metal surface becomes activated and is more receptive to conversion coating formulation.

In some immersion systems where soil accumulations are light, cleaning may be accomplished using an acidic detergent product, similar to the

deoxidizer in chemical makeup. Immersion systems can also employ a caustic etch following alkaline cleaning for surface activation. Caustic etching usually generates gray to black metallic oxide smut which must be removed with a desmutter prior to conversion coating. This assures a tightly adherent and uniform coating.

Seal rinses are used in chrome phosphate systems to provide additional corrosion protection. These rinses contain hexavalent chrome.

## CHROMATE CONVERSION COATING PROCESS STEPS

### CHROME OXIDE:

<u>Spray</u>	<u>Immersion</u>
1. Clean	1. Clean
2. Rinse	2. Rinse
3. Coat	3. Deoxidize
4. Rinse	4. Rinse
	5. Coat
	6. Rinse

### CHROME PHOSPHATE:

<u>Spray</u>	<u>Immersion</u>
1. Clean	1. Clean
2. Rinse	2. Rinse
3. Coat	3. Deoxidize
4. Rinse	4. Rinse
5. Seal	5. Coat
6. DI Rinse*	6. Rinse
	7. Seal
	8. DI Rinse*

\*Optional

# PRETREATMENT TROUBLESHOOTING FOR POWDER

The pretreatment finishing system **must** be maintained from both a mechanical washer system point of view and a chemical solution point of view. Included with this is an initial training of the operators or line personnel and

## TROUBLESHOOTING

- Poor Control
- Poor Education
- Poor Maintenance

the continuing education as new personnel enter the finishing area of responsibility. Poor control and maintenance and lack of training leads to either a reduction in quality or costly rejects.

## TROUBLESHOOTING

- Part Racking

Part racking includes a number of potential possibilities for error, starting with:

- 1) *Loss of electrical ground.*
- 2) *Positioning of parts for proper impingement, cleaning, and phosphatizing.*
- 3) *Positioning of parts for elimination of cupping and draining.*
- 4) *Part density for bottom line impact.*

## TROUBLESHOOTING AGED SOILS

- Varnish Like
- Storage Conditions
- Storage Time

The application of soils and the duration of time allowed for soils to cure has an impact of changing easily cleaned parts to that of noncleanable parts. This is further complicated by poor storage conditions.

One of the most often made mistakes which leads to total failure is undercure of the powder.

## TROUBLESHOOTING

- Parts Not Cured
- Part Density

Close évaluation of all parts in terms of metal thickness and oven efficiency should be evaluated prior to the start up of a new product introduction or new powder system. The use of a mechanical device which measures:

- \*Metal Temperature
- \*Temperature Duration
- \*Air Temperature

is highly recommended to insure total cure.



## TROUBLESHOOTING

- Inorganic Soil
- Smut-Residue

High amounts of remaining inorganic soil or smut residue may interfere with dry film adhesion properties. A loss of adhesion almost always provides a greater loss in salt and humidity performance.

## TROUBLESHOOTING

- Poor Cleaning
- Soil Entrapment
- Crimped/Sandwich Surfaces

Soil entrapment found in parts with crimped, sandwiched, or roll formed edges leads to failure when the curing process is performed. Close attention to these types of parts should be made along with addressing how to eliminate this occurrence through in-process cleaning steps or through insuring that the process chemical solutions are capable of removing these soils prior to cure.

## **TROUBLESHOOTING**

- **Poor Cleaning**
- **Nozzle Placement**
- **Washer Condition**
- **Nozzle Selection**

Poor cleaning is the result of improper control of the chemical solutions, or nozzle placement and overall washer condition.

Providing the opportunity for the solutions to effectively reach the part and perform is essential to producing clean parts.

## **TROUBLESHOOTING**

- **Chemical Residue**
- **Poor Rinsing**
- **Drying Residue**
- **Line Stoppage**
- **Flash Rust**

Powdering and flash rusting is often a result of line stoppage, or contaminated rinse stages. Control measures for line stoppage should be addressed and minimized.

## **CONCLUSION**

- **Powder requires a clean surface!**
- **Maximize the benefit of powder through control of pretreatment!**
- **Test - Test - Test**
- **"To get a good finish, you need a good start".**

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## Other Resources

Chemical Coaters Association 513-474-2030

National Paint and Coatings Association 202-462-6272

**POWDER COATING SYSTEMS** order from:

Powder Coating  
1300 East 66th St.,  
Minneapolis, MN 44423

**USERS GUIDE TO POWDER COATING** order from:

Society of Manufacturing Engineers  
Publications Department  
One SME Drive  
P.O. Box 930  
Dearborn, MI 48121

## ADDITIONAL CONTACTS

Bruce Brian  
National Sales Manager  
Gema - Volstatic  
317-298-5088

Dave Moore  
Marketing Manager  
EVTECH, A Kodak Company  
800-333-8236

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As a statewide industrial extension program of The University of Tennessee, CIS is dedicated to helping industrial managers of Tennessee manufacturing firms find practical solutions to the technical and managerial problems they face. CIS operates a statewide Waste Reduction Assistance and Technology Transfer program with funding from the Tennessee Department of Environment and Conservation. Through this program, the Center provides on site waste reduction assessments, information on waste reduction technologies, technical assistance, and waste reduction training for state industries. For more information about the Center or its programs, contact:

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