Metal Finishing 101

Part 1: Metal Finishing & Electroplating

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40 CFR 413 - Electroplating

- Original "surface finisher" regulation promulgated in 1979 and 1981
- Covers 6 main or “Core” processes
  - Electroplating
  - Electroless Plating
  - Anodizing
  - Coatings
  - Etching and Chemical Milling
  - Printed Circuit Board Manufacturing

40 CFR 433 – Metal Finishing

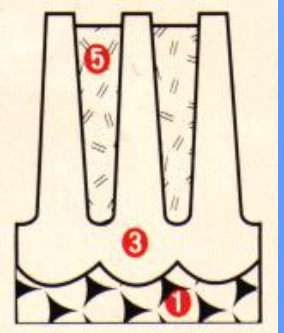
- Promulgated in 1984
- Most 413 CIUs moved to 433
- Covers same 6 main “core” processes as 413
  - Electroplating
  - Electroless Plating
  - Anodizing
  - Coatings
  - Etching and Chemical Milling
  - Printed Circuit Board Manufacturing
- 40 other ancillary metal finishing operations
  - Cleaning, painting, machining, grinding, polishing, barrel finishing, burnishing, impact deformation, pressure deformation, shearing, heat treating, thermal cutting, welding, brazing, soldering, flame spraying, sand blasting….

Basics of 433 and 413

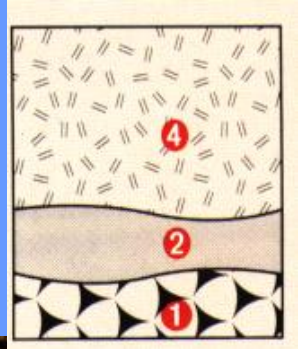
- Both use various chemical processes to **change the surface of a piece of metal**, either adding a layer or taking a layer off - often referred to in the business as "surface finishing"
- Some, like plating, very easy to see the surface change.
- Some, like iron phosphating, sometimes difficult to detect with the untrained eye.

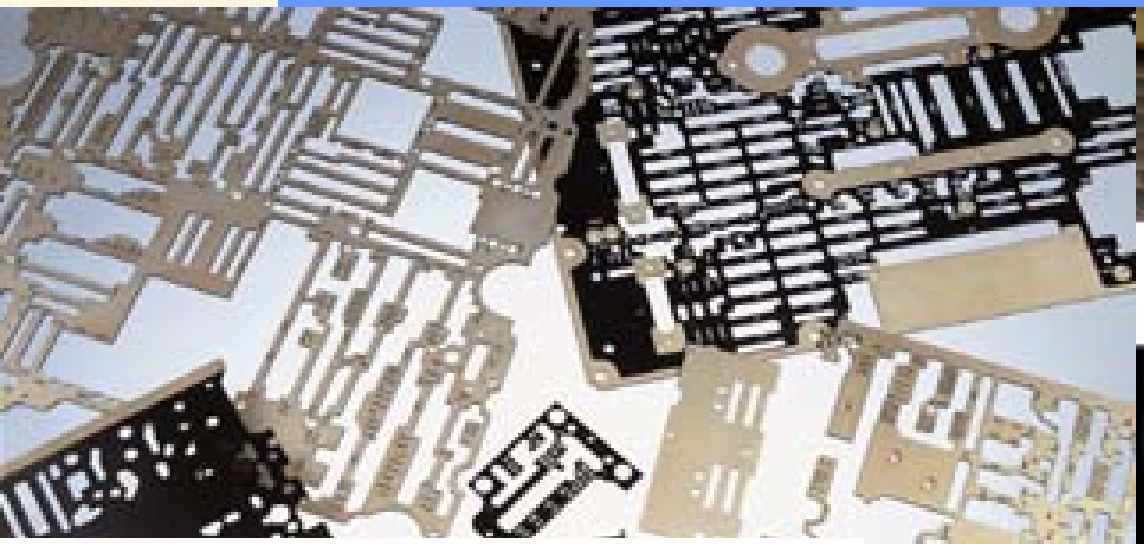
Basic? Electro-plating Process

Step 1	Identify Base Metal	For Example: Steel, Cooper , Brass
Step 2	Clean	For Example: Degrease, Soak, & Electroclean
Step 2R	Rinse	
Step 3	Acid Descale & Activate	For Example: Hydrochloric, Sulfuric, or Fluoboric Acids. (Some cases Peroxide Descale or Brite Dip
Step 3R	Rinse	
Step 4	Pre-Plate (If required)	For Example: Copper, Sulfamate Nickel, or Nickel If more than one is specified Repeat Steps 4 & 4R as needed.
Step 4R	Rinse	
Step 5	Final Plate	For Example: Cadmium, Chromium, Copper, Gold, Lead, Nickel. Silver, Solder, & Tin
Step 5R	Rinse	
Step 6	Post Treatments (As Specified)	For Example: Chromates, Lacquers, & Seals
Step 6R	Rinse	
Step 7	Dry & Package	For Example: Box or Hot Air Spin Dryers



The Big 6





Core #1 - Electroplating

- Electroplating is the deposition of a metallic coating onto the surface of an object by putting a negative charge onto the object and immersing it into a solution which contains a salt of the metal to be deposited.

Core #1 - Electroplating

Before - dull

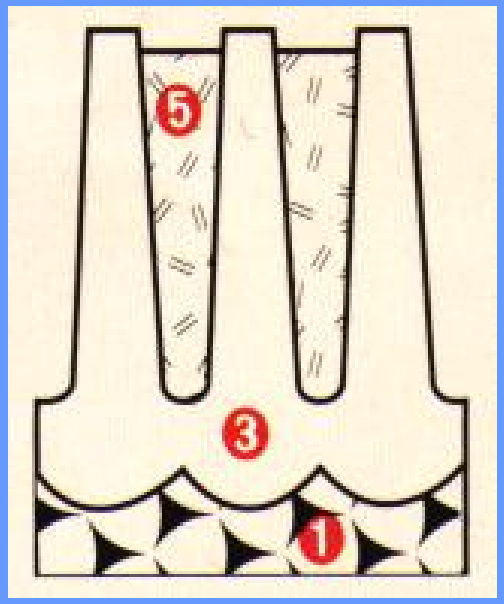
After - shiny

Core #2 - Electroless Plating

- Electroless plating is “plating **without the use of electrical energy**”**-** a chemical reduction process which depends upon the catalytic reduction process of metal ions in an aqueous solution (containing a chemical reducing agent) and the subsequent deposition of the metal.
- Typical choice for irregularly shaped, highly detailed part shapes because of completely uniform deposit thickness and high precision.

Core #3 - Anodizing

- Anodizing is the electrochemical process by which **the surface of a metal part** is converted into a metal oxide
- Aluminum is the most common metal anodized



Anodizing

1- Aluminum base metal

3- **Aluminum oxide layer** (Core #3)

5- Coloring matter

Core #3 - Anodizing

•A cathode is connected to the negative terminal of a voltage source and placed in the anodizing solution typically made up of sulfuric acid. **A metal part is connected to the positive terminal of the voltage source** and also placed in the anodizing solution. When the circuit is turned on, the oxygen from the water molecules in the anodizing solution will be liberated and combine with the metal molecules? ions? on the surface of the part, forming a metal oxide coating.

Core #4 - Coating

- Any operation that includes:
  - Chromating,
  - Phosphating,
  - Metal coloring, and
  - Passivating

Core #4a – Chromating

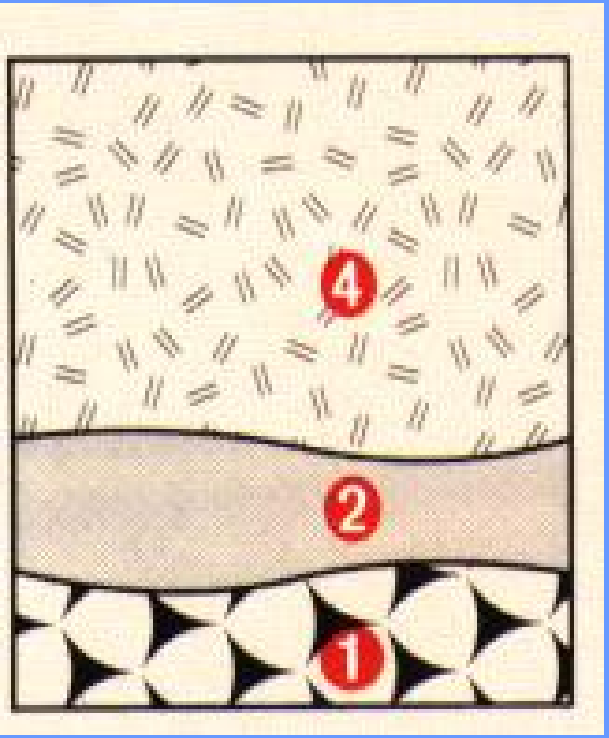
- Portion of the base metal is converted to a component of a protective film.

•Film is composed of:

–Base metal

–Hexavalent chrome

–Active inorganic or organic compounds

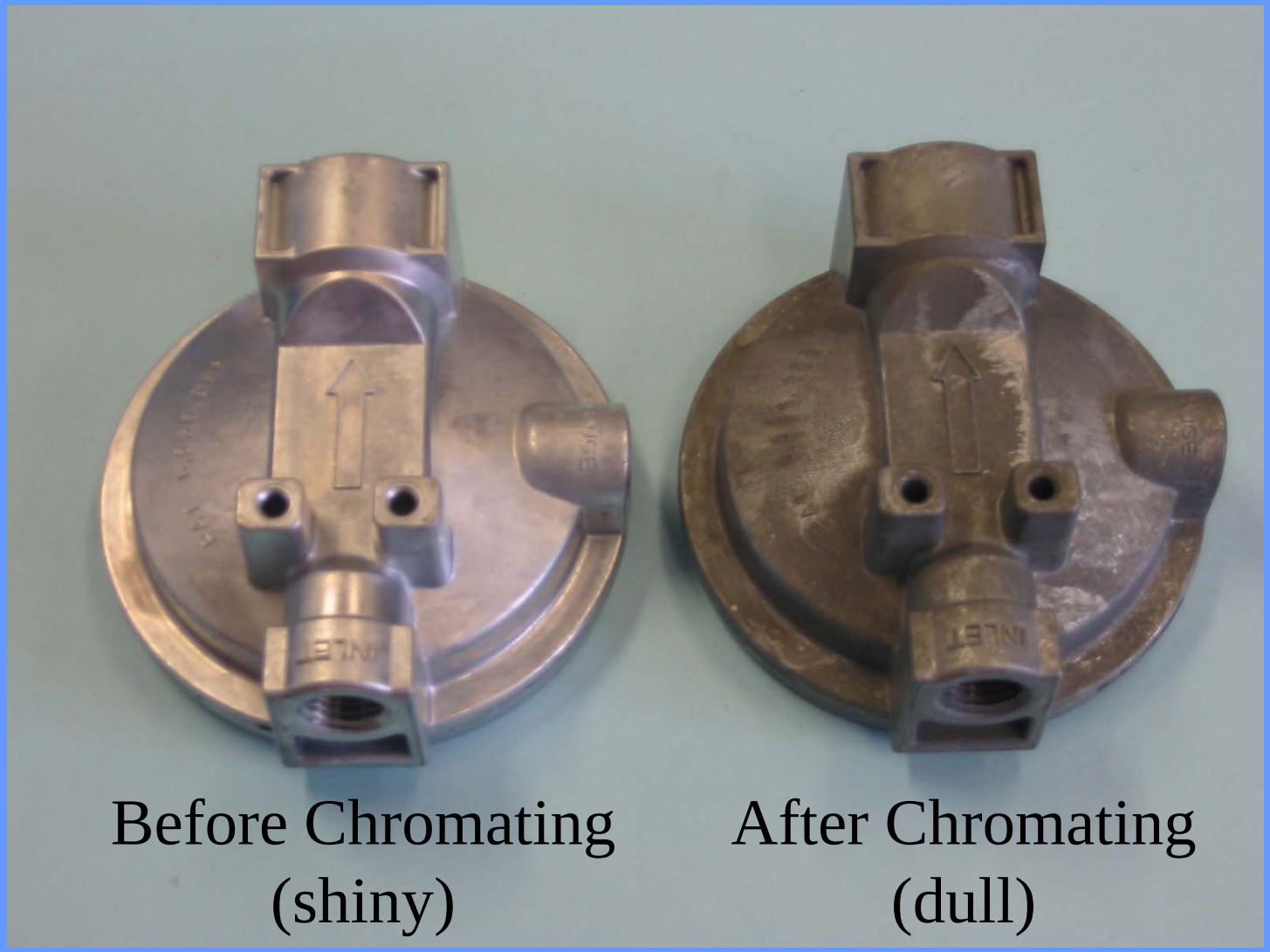


1- Aluminum base metal

2- Chromate coating-core #4

4- Lacquer coating

Core #4a – Chromating



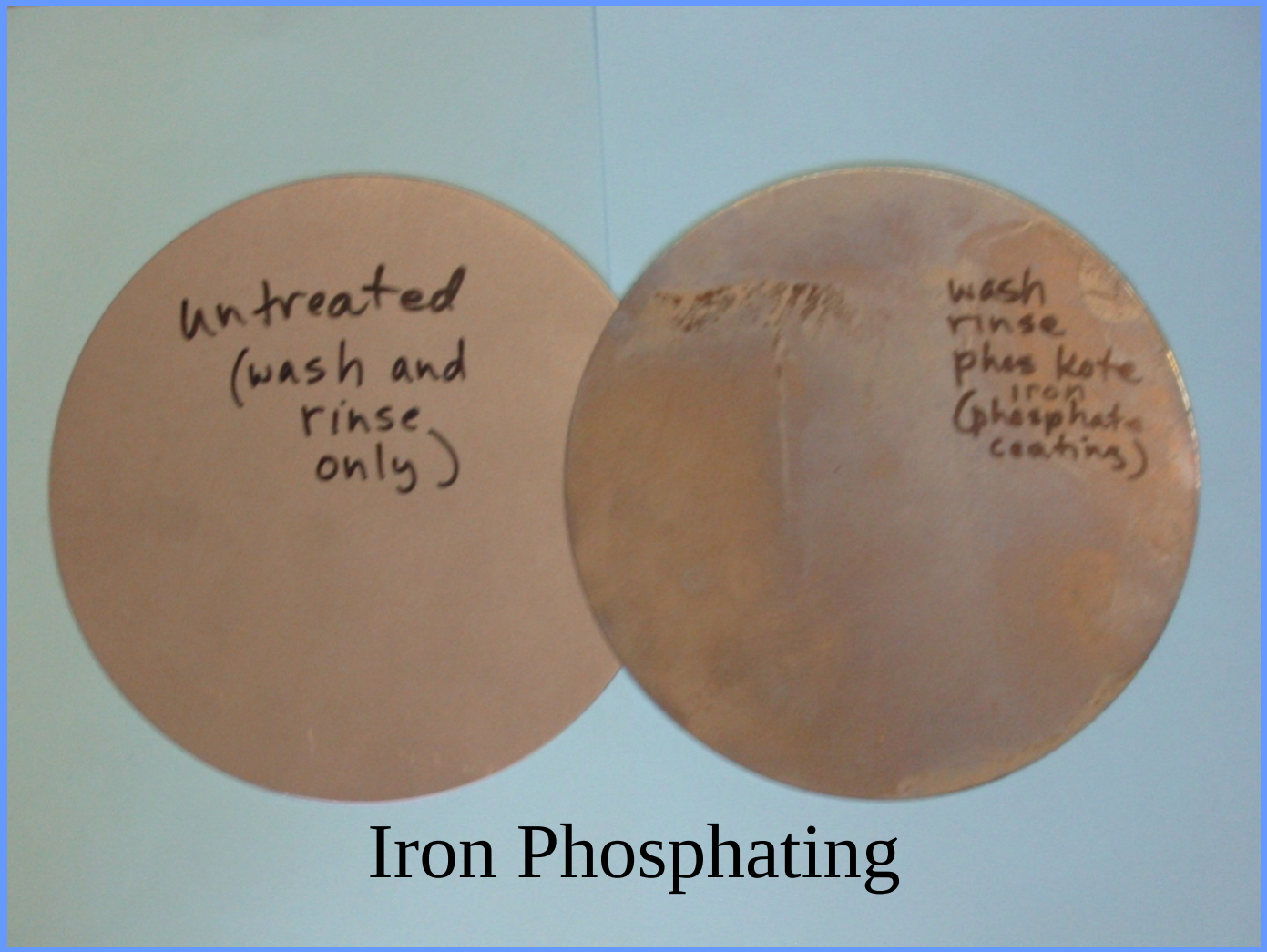
Before Chromating (shiny)

After Chromating (dull)

Core #4b - Phosphating

- Immersion of steel, iron, or zinc plated steel in phosphoric acid to add a coating to the surface so that paint or some other substance will stick to the metal
- Zinc phosphating – new layer is easy to see, shiny, but not as shiny as electroplating
- Iron phosphating – new layer is more difficult to see. Iron phosphated surface looks like it has a grayish scaly layer on it – look closely!
  - Some, especially line workers, will call iron phosphating “cleaning” – “just cleaning up the part prior to painting!”

Core #4b - Phosphating



Iron Phosphating

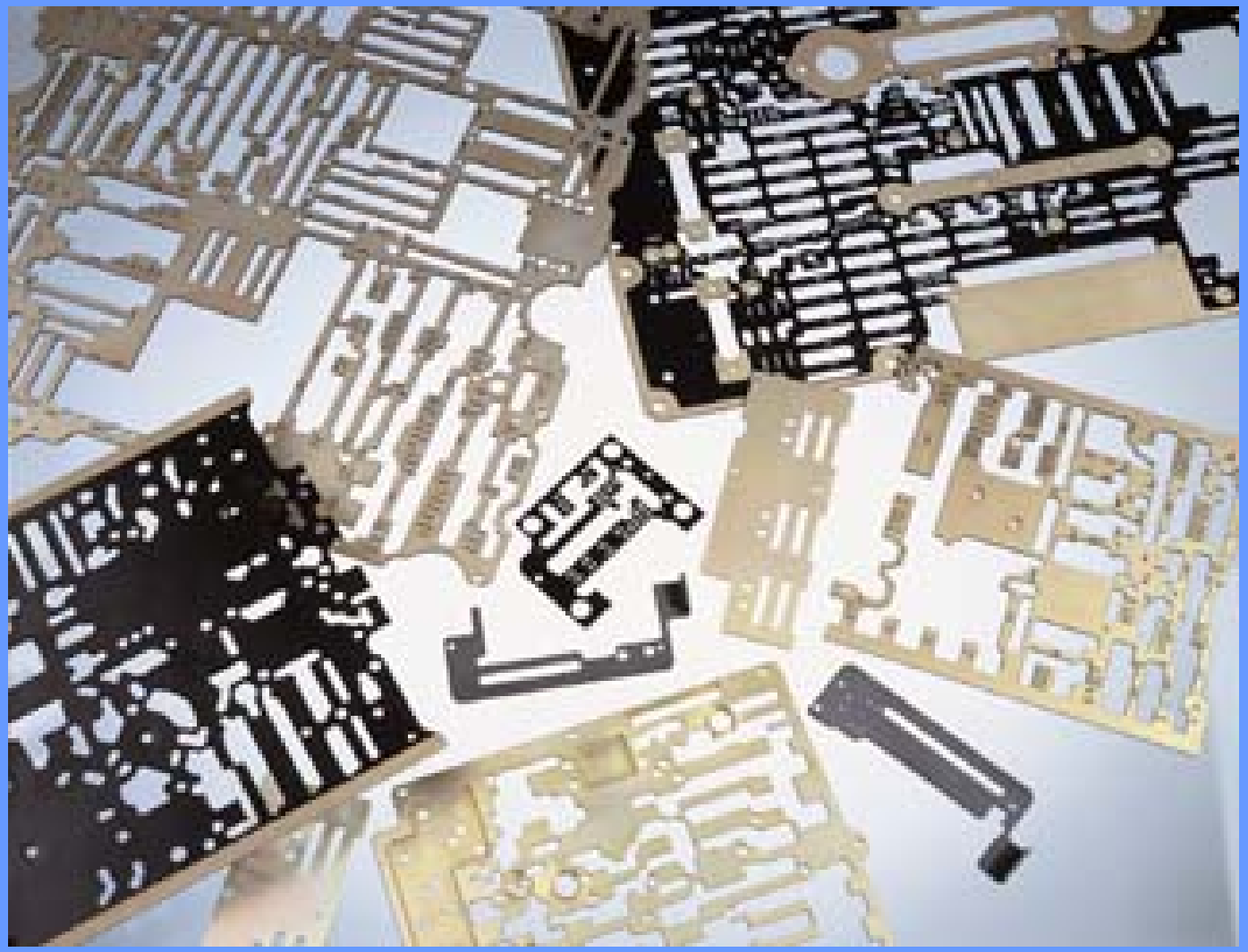
Core #4c - Metal Coloring

- Chemical method of converting the metal surface into an oxide or similar metallic compound to produce a decorative film.

Core #4d - Passivating

- Process of forming a protective film on metals by immersion on an acid solution
  - Nitric acid
  - Nitric acid with sodium dichromate

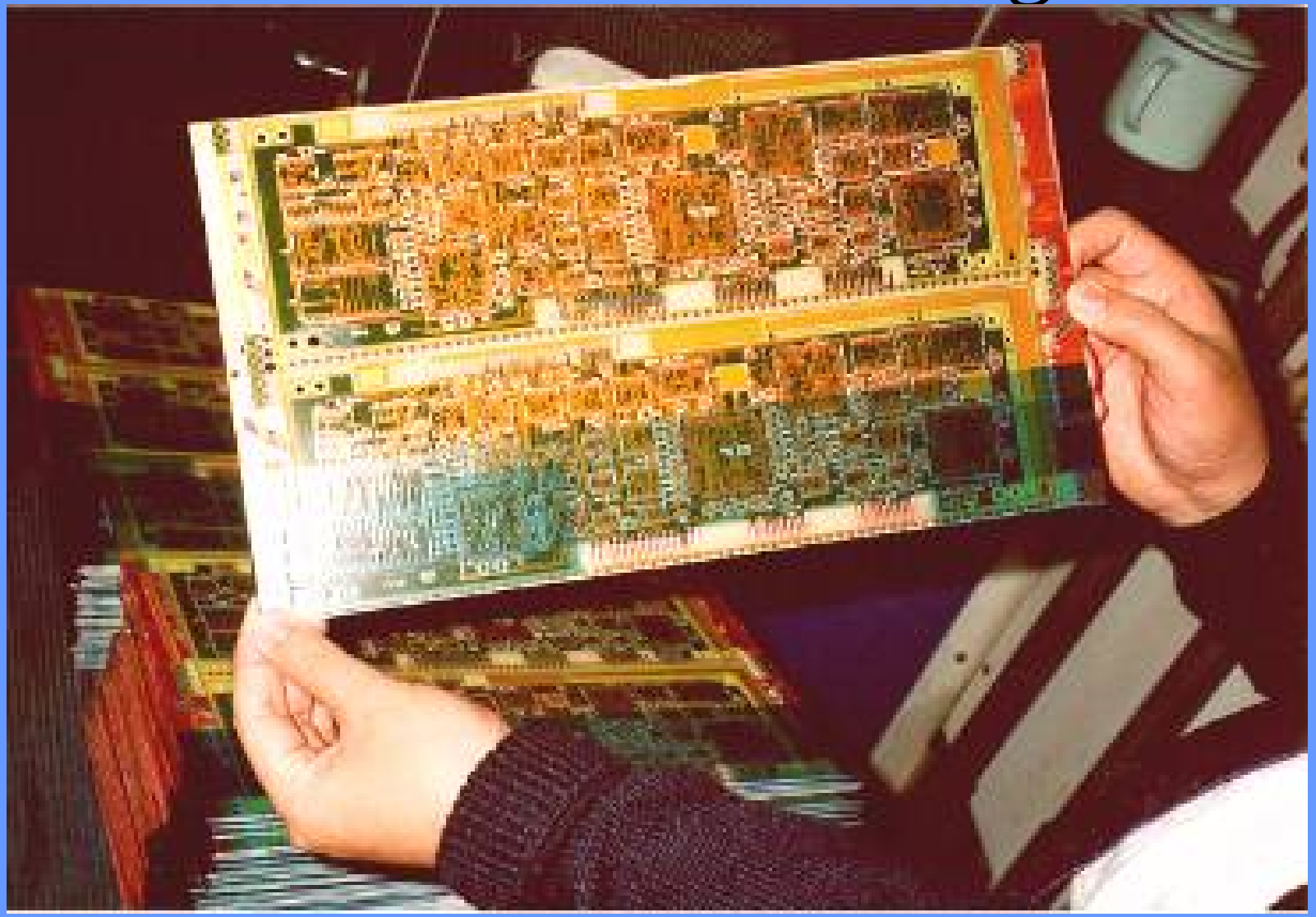
Core #5 - Etching and Chemical Milling



Core #5 - Etching and Chemical Milling

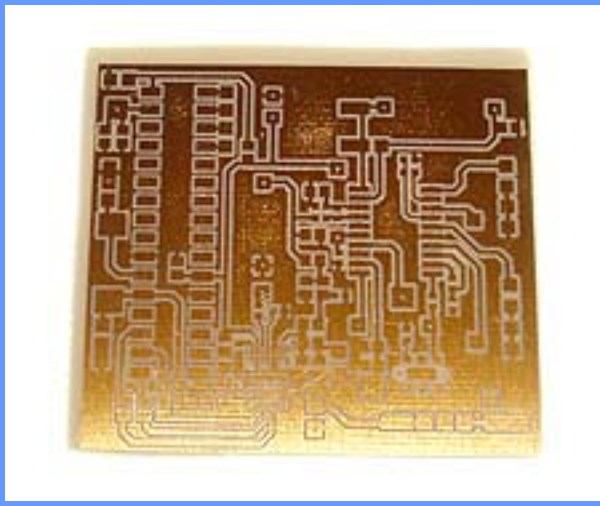
- Etching is the controlled removal of metal by dissolving it with chemical reagents or etchants to produce a specific design configuration.
- Chemical milling is the same process except the rates and depths of metal removal are much greater in chemical milling.

Core #6 - Printed Circuit Board Manufacturing



Core #6 - Printed Circuit Board Manufacturing

- Formation of circuit pattern of conductive metal (usually copper) on nonconductive board materials such as plastic or glass. Employs “cores” # 1, 2, and 5 in sequence.
- Five basic Steps
  - Cleaning + surface preparation
  - Catalyst + electroless plating (#2)
  - Pattern printing + masking
  - Electroplating (copper) (#1)
  - Etching (#5)



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What about all the rinsing and cleaning?

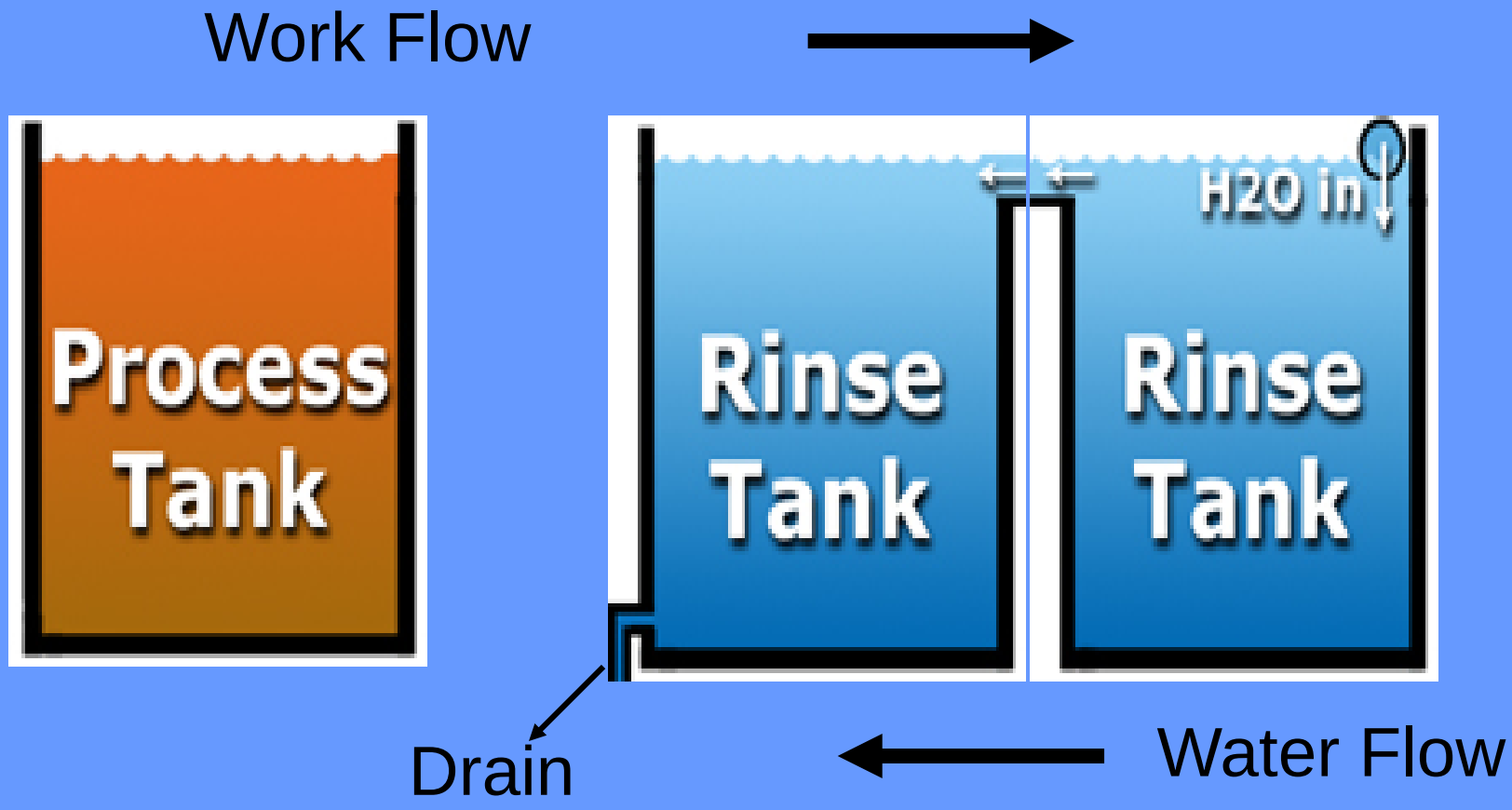
Cleaning – Ancillary #7

- Only action is to remove dirt, oil, etc. from the top of the surface of the metal.
- Does not change the character of the actual metal surface or the color of the metal itself
- Will only look different because dirt layer is gone
- **Often confused with phoshating (#4b)**
  - **Usually a 5 stage process: alkaline cleaning, rinse, phosphate, rinse, and sealer or chromating or something**

Rinsing

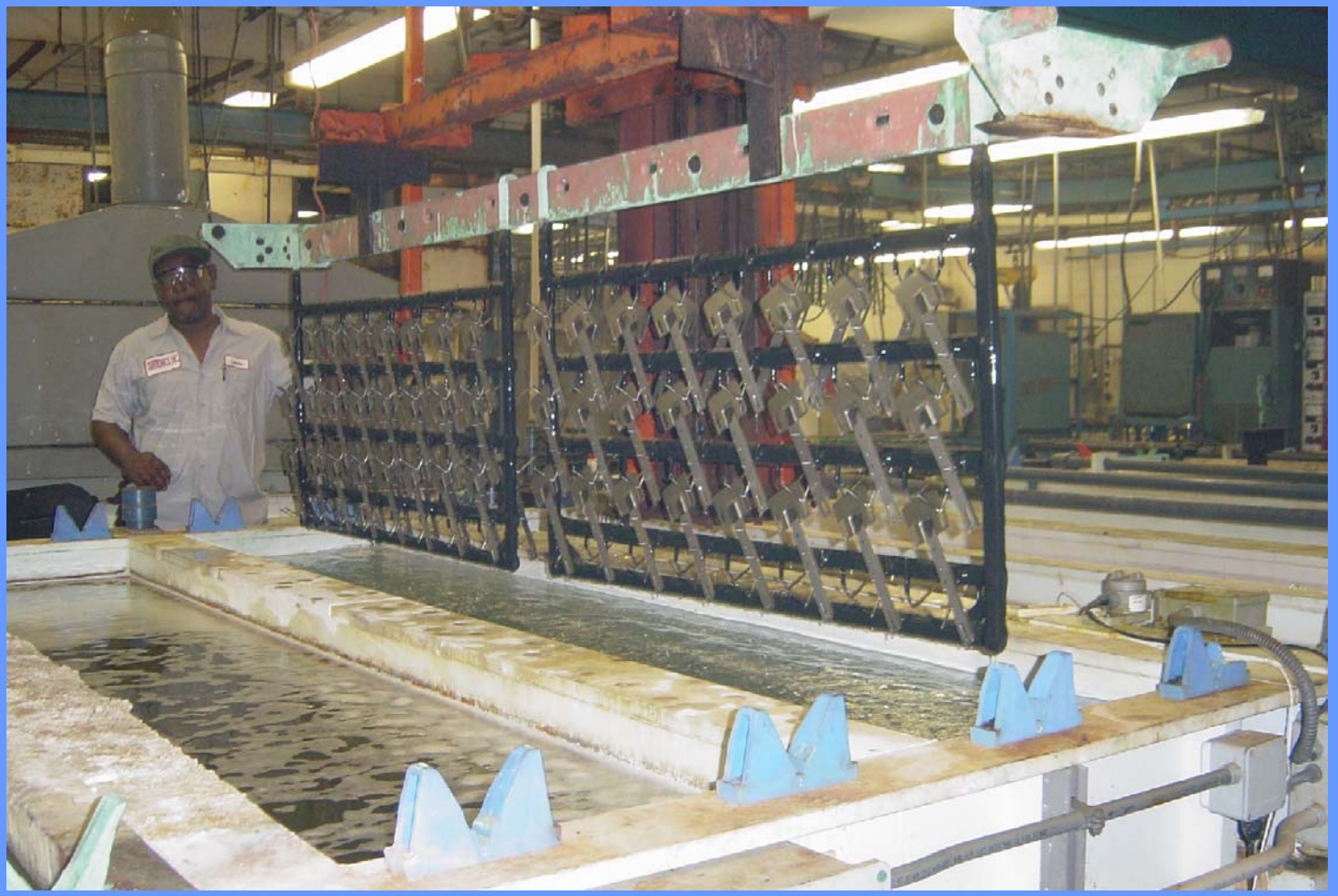
- Generally rinsing is required after each (core or ancillary) process step.
- Removes chemicals from the previous process step that are lingering on the surface of the part, thus preventing cross-contamination of process tanks.
- **Rinse tanks are generally discharged continuously or in batches to the WWTF.**
- **Rinse water is considered part of the operation for the purposes of deciding whether an IU <u>discharges</u> from an operation**

Multi-Stage Countercurrent Flow Rinse

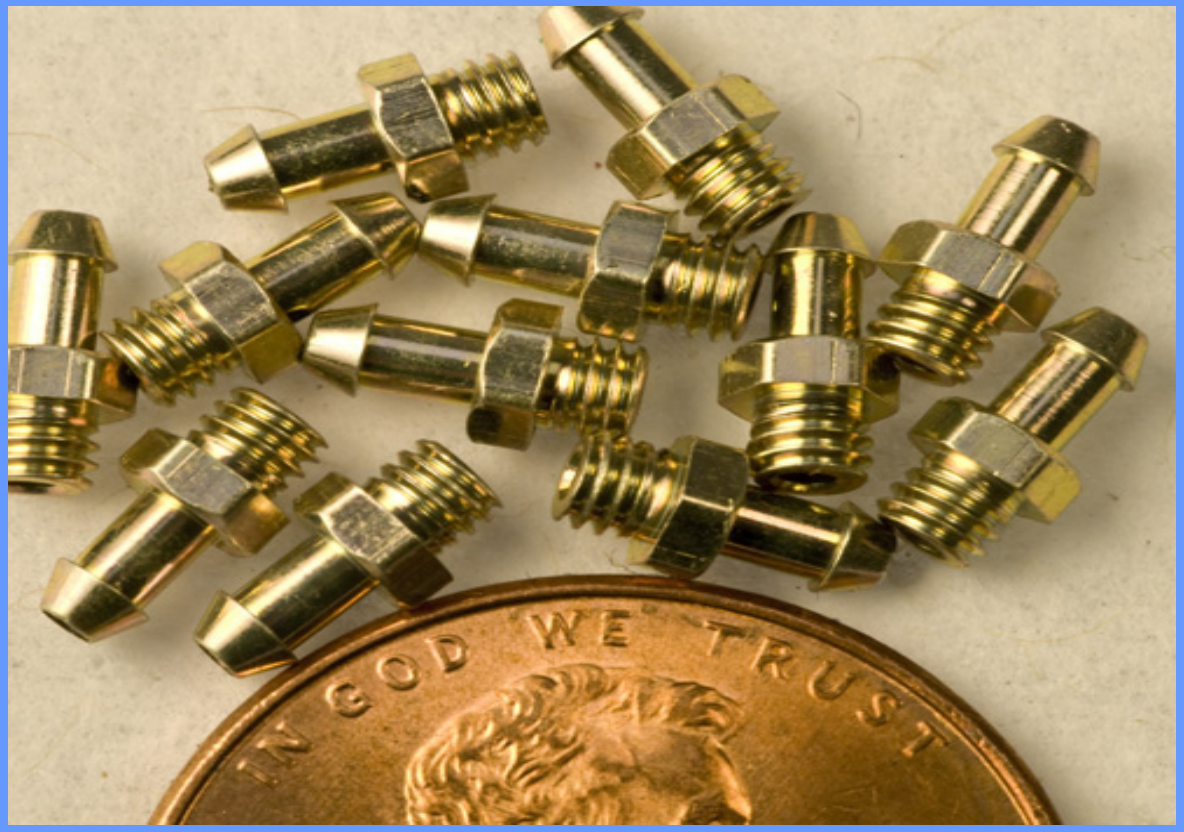


Two Stage Rinse Tank – Hand Dunking

Two Stage Rinse – Power Assisted Dunking



Cadmium Plated Parts with Hexavalent Yellow Chromate



Cadmium Plating Properties

- Ductile, malleable with complex compounds
- Great lubricity to assist tightening fasteners with min. torque
- Very efficient on various base metals
- Even high/low current distribution

Cadmium Plating Uses

- Military, DoD, aerospace, municipals
- QQ-P-416, AMS 2400, ASTM B766
- Fastener Quality Act in 1999
- NADCAP accreditation
- National Aerospace and Defense Contractors Accreditation Program

Cadmium Plating Chromates

- Hexavalent chromates
- No technology that allows Trivalent chromates as of right now
- Cadmium is not RoHS compliant
- RoHS stands for the Restriction of the Use of Certain Hazardous Substances

Cadmium Plating Problems

- Driven out in automotive industry
- Toxic and a carcinogen
- Cyanide bath are common
- POTW have strict discharge limits making it hard for platers to comply
- US government is the biggest user, yet they are the ones that make it the hardest to use.

Cadmium Plating Alternatives

- Zinc-Nickel - Usually Acid baths
- Process developed by Boeing
- Hydrogen embrittlement issues and expensive to run and maintain
- Zinc plating is common alternative

Zinc Plated Parts with Trivalent Yellow Dichromate

Zinc Plating Properties

- Inexpensive and easy to come by
- Sacrificial coating to create galvanic cell with base metal
- Not considered highly toxic
- Moderate appearance, excellent abrasion resistance and paint adhesion

Zinc Plating Uses

- Automotive, hardware, fasteners
- Ease of EPA and OSHA regulations make it widely used worldwide
- Good over all types of base metals
- Spec work to ASTM B633

Zinc Plating Chromates

- Can use both hexavalent and trivalent chromates with good success
- Application of topcoats change the number of salt spray hours that can be achieved
- Depends on how much time and money one is willing to spend

Zinc Plating Problems

- Metal by itself only give about 12 hours to failure
- While metal is inexpensive, the use of top coats to achieve protection is expensive and time consuming
- Military, DoD, and aerospace are not willing to risk use in field

Hex and Tri Chromates

Protection Criteria

- Salt Spray Hours
- Hours to white/red rust
- White – chromate layer has broken down and starts affecting plating
- Red – plated metal has broken down and the starts affecting base metal
- ASTM B-117 – 96 Hours to white/red

Qualities

- Hexavalent has self healing properties and a thick layer
  - This ensures higher protection by itself

- Trivalent are thinner and require the use of organic topcoats to achieve results
  - Involve the use of dyes to achieve color
  - Often offers challenges to achieve consistent aesthetic appeal.

Environmental Benefits

- Tri Chromates are less toxic than Hex chromates.
- Easier to treat wastewater
- End of life use of parts are not putting hexavalent chromates in the environment

Conclusion

Questions? Thank You!

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