COATINGS
PART I: PLATED & CONVERSION COATINGS

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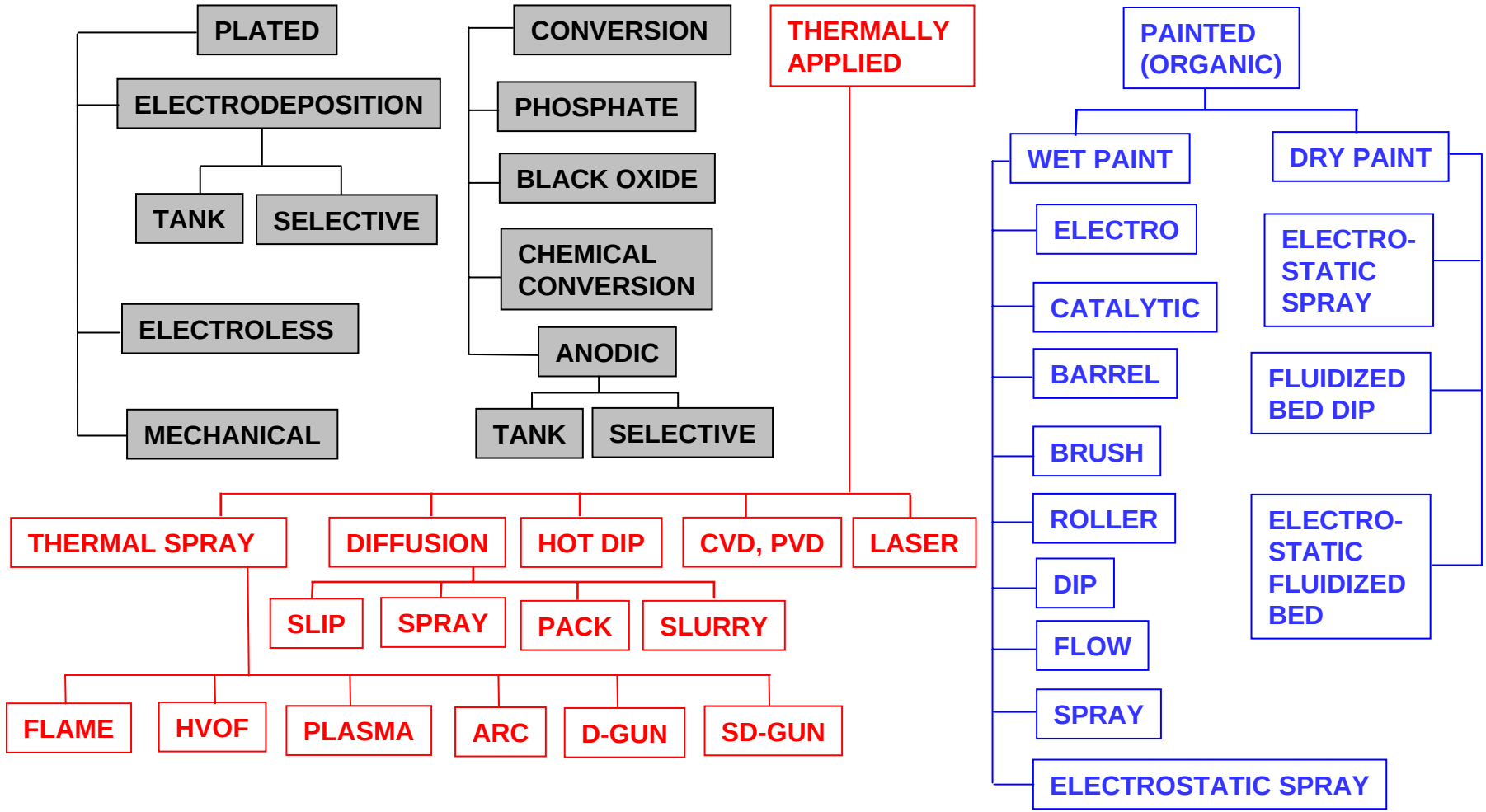
WHY COAT?

FOR ONE OR MORE OF FOLLOWING REASONS:

- ❶ **TO PROVIDE CORROSION PROTECTION**
- ❷ **TO ACHIEVE GALVANIC COMPATIBILITY**
  - ◉ **E.G., Cd ON STAINLESS IN CONTACT WITH ALUMINUM**
- ❸ **TO PROMOTE / IMPROVE SPECIFIC CHARACTERISTICS**
  - ◉ **CASE: ACHIEVE EMC (ELECTROMAGNETIC COMPATIBILITY)**
    - ⌦ **E.G., ELECTROLESS Ni ON MATING ALUMINUM DETAILS**
  - ◉ **CASE: COMPLY WITH OPTICAL / COLOR REQUIREMENTS**
    - ⌦ **E.G., PAINTING, COLOR ANODIZING**
  - ◉ **CASE: PROMOTE ADHESION**
    - ⌦**E.G., PHOSPHATE BEFORE PAINT**
  - ◉ **CASE: IMPROVE WEAR RESISTANCE:**
    - ⌦ **E.G., HARD ANODIZE ON ALUMINUM**
  - ◉ **CASE: PROVIDE LUBRICATION**
    - ⌦ **E.G., Ag ON FASTENERS FOR ELEVATED TEMPERATURES**
- ❹ **TO SALVAGE / REPAIR DAMAGED / WORN DETAILS**

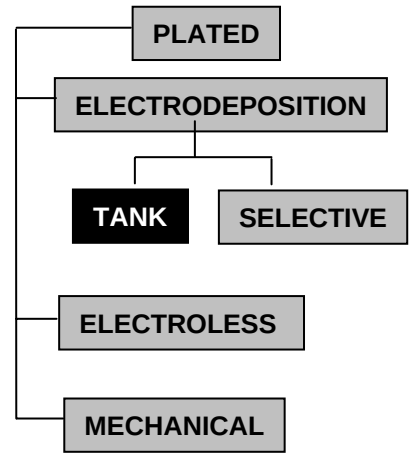
COATINGS

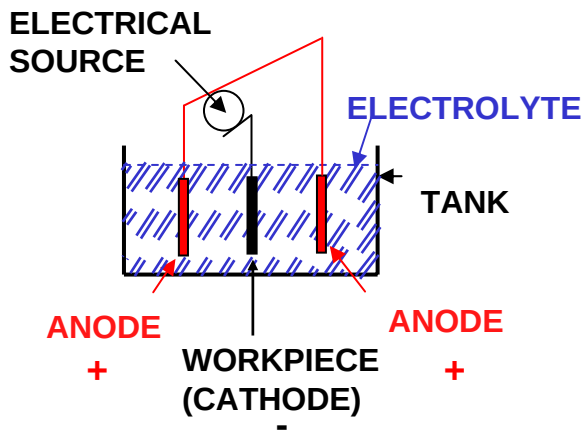
BY METHOD OF APPLICATION



PLATED COATINGS
TANK ELECTRODEPOSITION

- MOST METALS & MANY ALLOYS ELECTRODEPOSITED
  - ON OTHER METALS & ALLOYS
- ELECTRICAL SOURCE
- ELECTROLYTE
- CATHODE: WORKPIECE BEING PLATED
- ANODE: TWO TYPES
  - SOLUBLE ANODE: DISSOLVES TO PROVIDE PLATING ION(S)
    - E.G., Ni, Cd, Cu, Zn, Sn
  - INSOLUBLE ANODE: PLATING IONS COME FROM ELECTROLYTE
    - E.G., Cr, Ag





PLATED COATINGS
TANK ELECTRODEPOSITION

- COMPOSITE ELECTRODEPOSITION POSSIBLE- PROPRIETARY
  - PARTICLES SUSPENDED IN ELECTROLYTE
    - Ni-WC: WC PARTICLES SUSPENDED IN WATTS Ni BATH
    - Cr-GRAPHITE: GRAPHITE PARTICLES SUSPENDED IN CONVENTIONAL Cr BATH
  - ALLOY (Ni-Cr, Ni-Co) PLATING, FOLLOWED BY PTFE INFUSION
    - AKA SYNERGISTIC COATINGS

- LAYERED ELECTRODEPOSITS - DEVELOPMENTAL STAGE
  - FOR ELECTRONIC, MAGNETIC, MECHANICAL & ELEVATED TEMPERATURE APPLICATIONS

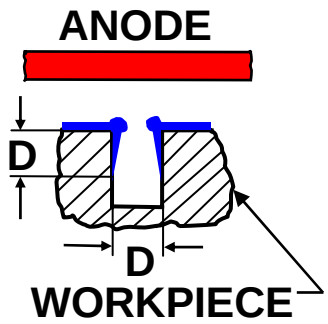
- SURFACE PREPARATION CRUCIAL
  - FOR ADEQUATE ADHESION OF ELECTRODEPOSITS, SURFACES MUST BE PROPERLY CLEANED
    - MECHANICALLY AND/OR CHEMICALLY

TANK ELECTRODEPOSITION NOTES OF CAUTION

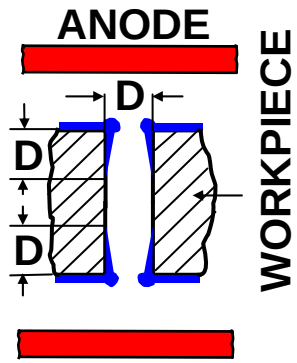
- DIFFICULT TO PLATE ON Al, Ti & STAINLESS ALLOYS
  - SURFACE OXIDE LAYER
  - CLEAN IMMEDIATELY BEFORE PLATING
    - Al: ZINCATE AFTER CLEANING

- DEPOSIT THICKNESS VARIES
  - EDGES: MORE BUILDUP
    - HIGH CURRENT DENSITY
  - THROWING POWER → DEPTH OF COVERAGE LIMITATIONS
    - THICKNESS ↓ WITH DISTANCE FROM ANODE
      - E.G., HOLES, RECESSES
    - BEYOND CERTAIN DISTANCE (DEPTH)-NO COVERAGE

TANK ELECTRODEPOSITION NOTES OF CAUTION



BLIND HOLE



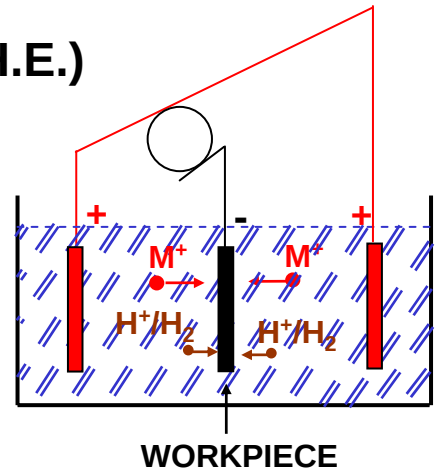
THROUGH HOLE

- THICKNESS VARIATION & DEPTH OF COVERAGE
  - DEPEND ON OPERATING CONDITIONS
  - DEPTH ESTIMATE FOR HOLES: 1 D OR LESS
- USE CONFORMING / SPECIAL ANODES & THIEVES
  - FOR BETTER UNIFORMITY

TANK ELECTRODEPOSITION NOTES OF CAUTION-HYDROGEN

- H_2 GENERATED DURING ELECTRODEPOSITION
  - AT WORKPIECE (-)
  - CAN CAUSE "HYDROGEN EMBRITTLEMENT" (H.E.)
- FOR STEELS
  - SUSCEPTIBILITY TO H.E. ↑ AS
    - HARDNESS / STRENGTH ↑
    - RESIDUAL TENSILE STRESS ↑
- H.E. RELIEF PROVISIONS
  - STRESS RELIEVE BEFORE PLATING
    - TO REDUCE RESIDUAL STRESSES

    AND
  - BAKE AFTER PLATING
    - WITHIN A SPECIFIED TIME AFTER PLATING
      - TYPICALLY 4 Hrs
    - TO REDISTRIBUTE / REDUCE H_2 LEVEL



TANK ELECTRODEPOSITION NOTES OF CAUTION-HYDROGEN

- STRESS RELIEF & BAKE (CARBON, ALLOY, TOOL & PH STEELS)
  - REQUIRED WHEN HARDNESS / STRENGTH > SET VALUE
    - SET VALUE: DEPENDS ON SPECIFICATION
      - MOST IN HRC 35-40 (F_{tu} 150-180 KSI) RANGE
  - TEMPERATURE: LOWER THAN FINAL TEMPERING / AGING
    - INDUSTRY PRACTICE: 375 F
    - 800 F & HIGHER POSSIBLE FOR PH STAINLESS STEELS
  - TIMES: STRESS RELIEF, 3-8 HRS; BAKE, 3-23 HRS
    - DEPENDING ON
      - PLATING SPECIFICATION
      - REVISION OF PARTICULAR SPECIFICATION

- STRESS RELIEF REQUIRED ONLY IF PARTS WERE MACHINED OR FORMED AFTER TEMPERING / AGING
  - SOME SPECIFICATIONS FOLLOW THE SET VALUE APPROACH
  - OTHERS MANDATE IT FOR FOR ALL PARTS

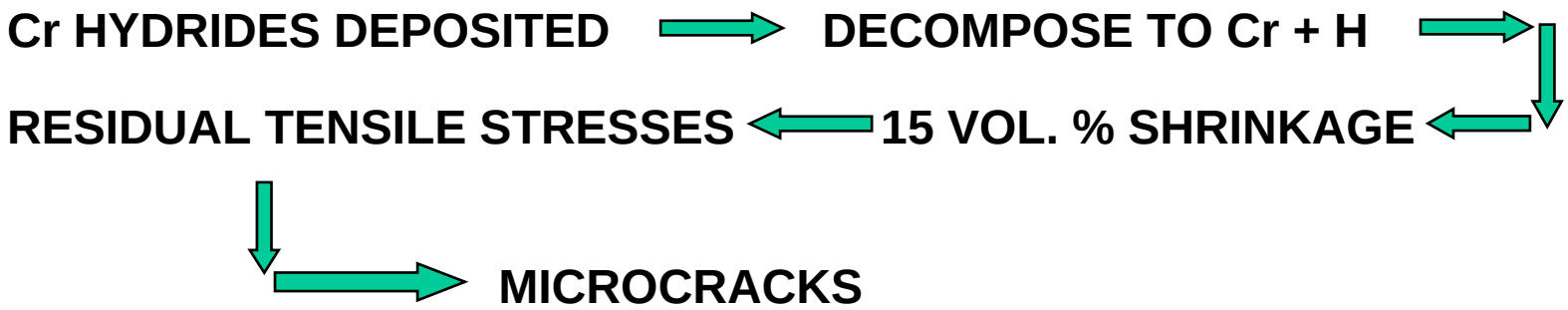
TANK ELECTRODEPOSITION NOTES OF CAUTION-HYDROGEN

WARNING: H.E. RELIEF PROVISIONS NOT BASED ON SOLID, REPRODUCIBLE DATA

- THE SMART WAY IS TO FOLLOW THE CONTROLLING SPECIFICATION
- IF YOU DO NOT STRESS RELIEVE BEFORE PLATING
  - IT IS OF NO USE TO DO IT AFTER PLATING
  - THE HARDWARE IS SUSPECT
- IF YOU DO NOT BAKE WITHIN SET TIME AFTER PLATING
  - IT IS NO HELP TO DO IT LATER
  - THE HARDWARE IS SUSPECT
- IF YOU USE LOWER TEMPERATURES AND / OR SHORTER TIMES
  - THE HARDWARE IS SUSPECT
  - DIFFICULT TO SHOW OTHERWISE
- WHEN THE HARDWARE IS SUSPECT
  - THERE REALLY IS NO CORRECTIVE ACTION

TANK ELECTRODEPOSITION
HARD Cr PLATING

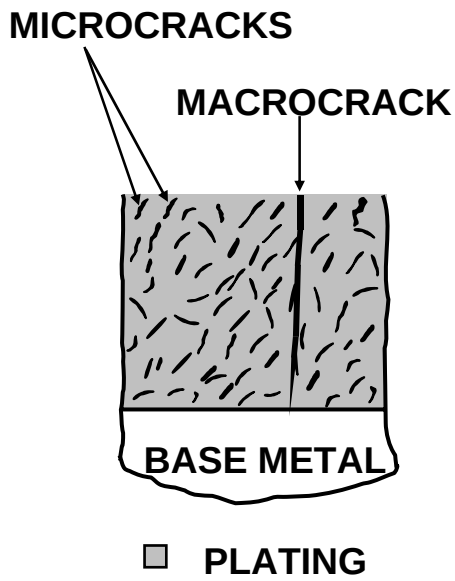
- AKA ENGINEERING / FUNCTIONAL Cr
  - SAME BATH AS FOR DECORATIVE Cr
    - ELECTROLYTE: CHROMIC ACID + VARIOUS SALTS
    - INSOLUBLE ANODES
- FOR WEAR APPLICATIONS & SALVAGE / REPAIR
  - THICKNESS: 0.001-0.020 IN (1-20 MILS) OR THICKER
  - AS DEPOSITED HARDNESS: HRC 67 OR HIGHER
  - LOW FRICTION
- DEPOSIT ORDINARILY CONTAINS MICROCRACKS
  - BELIEVED DUE TO COATING VOLUME SHRINKAGE:



TANK ELECTRODEPOSITION
HARD Cr PLATING

- MICROCRACKS
  - NO ADVERSE EFFECT ON CORROSION PROTECTION
    - DO NOT LINE UP
    - NO PATH FROM TOP TO INTERFACE
  - RESIDUAL TENSILE STRESSES
    - NOT FULLY RELIVED
    - ∴ FATIGUE DEBIT

- MACROCRACKS
  - ADVERSELY AFFECT CORROSION RESISTANCE
    - FROM TOP TO INTERFACE, LONGER, WIDER
  - RESULT FROM
    - PLATING CONDITIONS
    - PRECOATING RESIDUAL STRESSES
    - THERMAL SHOCK AFTER PLATING

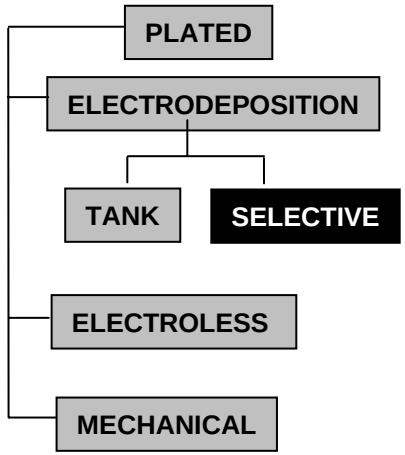


TANK ELECTRODEPOSITION
HARD Cr PLATING

- PROBLEMS WITH Cr PLATING
  - ❶ NOT ENVIRONMENTALLY FRIENDLY
  - ❷ LONG PROCESSING TIMES
    - ☹ SLOW DEPOSITION RATES (ABOUT 0.001 IN / HR)
    - 😐 H.E. PROVISIONS FOR STEELS
      - ☺ NOT JUST Cr BUT ALL OTHER PLATES
  - ❸ FATIGUE DEBIT
  - ❹ INCONSISTENT CORROSION PROTECTION
    - 😐 DUE TO MACROCRACKS
      - ☺ CAN BE AVOIDED
- Cr REPLACEMENT EFFORTS UNDERWAY GLOBALLY
  - ⌦ COMPOSITE Co-WC, Co-Cr-WC COATINGS
    - ✱ THERMALLY SPRAYED
      - ➲ BY HVOF (HIGH VELOCITY OXY-FUEL)
- Cr WILL NOT GO AWAY
  - ◘ THERMAL SPRAY LIMITATIONS

PLATED COATINGS
SELECTIVE ELECTRODEPOSITION

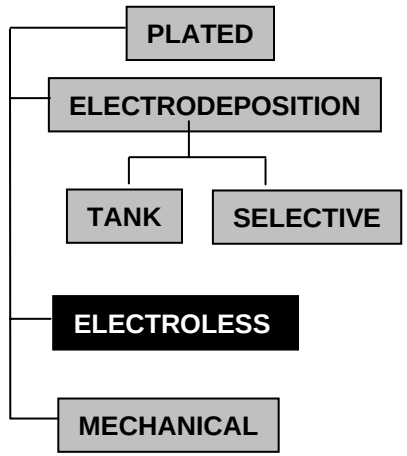
- LOCALIZED ELECTRODEPOSITION
  - AKA STYLUS / BRUSH PLATING
- NO DIPPING IN TANK
  - ELECTROLYTE BROUGHT TO STYLUS (ANODE)
  - STYLUS HAS ABSORBENT WRAPPING
- USED FOR Cr, Ni, Cd, Cu & OTHER METALS
  - CLEAN SURFACES CRUCIAL FOR ADHESION
- ATTRACTIVE WHEN PLATED AREA IS SMALL
  - MINIMUM MASKING REQUIRED
- MAY BE USED FOR SALVAGE & REPAIR



- H.E. PROVISIONS APPLY FOR STEELS
  - EXCEPT FOR SPECIFIC PLATING SOLUTIONS: LHE Cd (Cd-Ni), Ni-W
- SELECTIVE PROCESSES ALSO USED FOR ANODIZING, ELECTRO- STRIPPING / MILLING / POLISHING / ETCHING
  - STYLUS ANODE OR CATHODE, AS REQUIRED

PLATED COATINGS
ELECTROLESS PLATING

- BY CATALYTIC REDUCTION REACTION
  - NO ELECTRIC SOURCE REQUIRED
  - DIPPING IN TANK REQUIRED
- CAN PLATE ON METALS AND NONMETALS (E.G., PLASTICS)
- COATING IS UNIFORM
  - NO EDGE BUILDUP OR DEPTH OF COVERAGE LIMITATIONS
- CLEAN SURFACES CRUCIAL FOR ADHESION
  - FOR ALUMINUM
    - BEST TO ZINCATE AFTER CLEANING
    - NOT MANDATORY IN SOME SPECIFICATIONS ☹
- H_2 GENERATED
  - NOT AS MUCH AS IN ELECTRODEPOSTION
  - STILL A PROBLEM
  - FOR STEELS: H.E. RELIEF PROVISIONS APPLY



ELECTROLESS PLATING TYPES

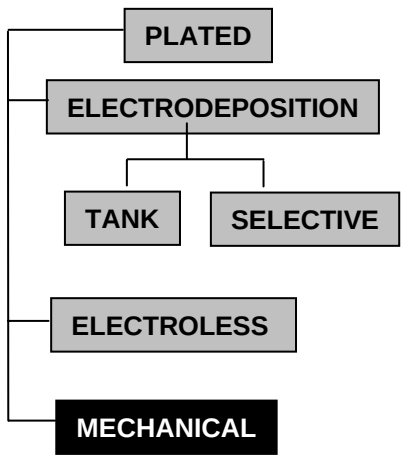
- SINGLE METAL PLATING
  - Cu, Au, Pd FOR ELECTRONIC APPLICATIONS
- ALLOY PLATING
  - Ni-P (CONVENTIONAL ELECTROLESS Ni), Ni-B, Co-B, Ni-Mo-P, Co-Mo-P, OTHERS
- COMPOSITE PLATING- PROPRIETARY
  - PARTICLES SUSPENDED IN ELECTROLYTE
    - SOFT PARTICLES (LUBRICANTS)
      - E.G., PTFE- AKA SYNERGISTIC COATINGS
    - HARD PARTICLES
      - CARBIDES, CERAMICS OR DIAMOND
  - ELECTROLESS PLATING FOLLOWED BY PTFE INFUSION
    - AKA SYNERGISTIC COATINGS
- NOT AS MANY CHOICES AS IN ELECTRODEPOSITION

ELECTROLESS PLATING
CONVENTIONAL ELECTROLESS NICKEL

- MOST WIDELY USED ELECTROLESS PLATING
  - SODIUM HYPOPHOSPHITE SOLUTION
  - FOR STEEL & ALUMINUM
- ALLOY OF Ni & P
  - HIGH HARDNESS-LOW FRICTION
    - GOOD FOR WEAR APPLICATIONS
  - GENERALLY POROUS
    - FOR ADEQUATE CORROSION PROTECTION, NEED 0.0015 IN. MIN.
- P CONTENT DETERMINES PROPERTIES
  - LOW P: HIGH HARDNESS, LOW CORROSION RESISTANCE, HIGH RESIDUAL TENSILE STRESSES (FATIGUE DEBIT)
  - HIGH P: LOW HARDNESS, HIGH CORROSION RESISTANCE, LOW RESIDUAL TENSILE STRESSES (COMPRESSIVE ABOVE 11% P)
- AGING: HIGHER HARNESS& LOWER CORROSION RESISTANCE
  - E.G., HIGH P (8-10%) ELECTROLESS Ni
    - AS DEPOSITED HRC 46-52
    - HARDNESS OVER 70 HRC AFTER 750 F / 1 HR AGE

PLATED COATINGS
MECHANICAL PLATING

- AKA PEEN / IMPACT / BARREL PLATING, MECHANICAL GALVANIZING
- FOR APPLYING
  - MALLEABLE (SOFT) METAL OR ALLOY COATINGS
    - Pb, Zn, Cd, Sn, Cu, Al, COMBINATIONS
      - IN POWDER FORM
  - ONTO STEEL AND Cu ALLOY PARTS
    - APPLIED @ ROOM TEMPERATURE
    - NO ELECTRICAL CURRENT
- PARTS TUMBLED IN BARREL WITH
  - PEENING MEDIUM
    - GLASS BEADS, METAL SHOT
  - CHEMICALS
    - TO PROMOTE ADHESION
  - COATING POWDER(S)
  - WATER
    - CARRIER

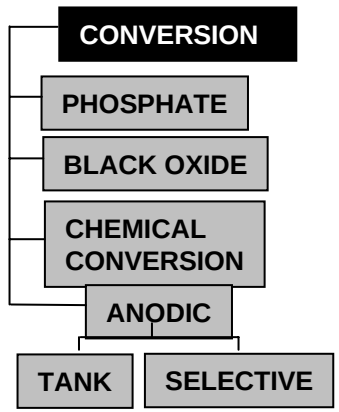


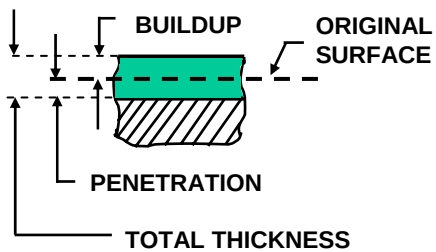
PLATED COATINGS
MECHANICAL PLATING

- BEADS / SHOT PROVIDE HAMMERING ENERGY
  - POUND COATING MATERIAL AGAINST PART SURFACES
    - ADHESION BY COLD WELDING
- CLEAN SURFACES ESSENTIAL
  - JUST LIKE ALL PLATING PROCESSES
- THIN Cu LAYER BARREL PLATED BEFORE DESIRED COATING
  - TO PROMOTE ADHESION
- SOME H_2 GENERATED BUT NOT TRAPPED
  - H.E. NOT A PROBLEM
- HOLES PLATED IF BEADS OR SHOT CAN GET IN
- FOR SMALL PARTS & MASS PRODUCTION
  - FASTENERS, COIL SPRINGS, TORSION BARS
- GENERALLY NOT FOR PRECISION PARTS
- VARIANT WITH MESH
  - ELECTROMECHANICAL
    - H.E. PROVISIONS APPLY FOR STEELS

CONVERSION COATINGS

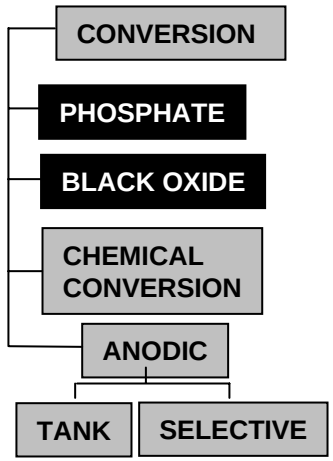
- FORMED BY DISSOLVING METAL & DEPOSITING LAYER
  - LAYER INTEGRAL
    - PENETRATION + BUILD UP
- TWO MAJOR CLASSES OF COATINGS
  - CHEMICALLY APPLIED
    - DIP, SPRAY AND / OR BRUSH
    - PHOSPHATE, BLACK OXIDE, CHEMICAL CONVERSION COATINGS
  - ELECTROCHEMICALLY APPLIED
    - ANODIC COATINGS (ANODIZING)
      - ELECTRICAL SOURCE NEEDED
- GOOD AS PAINT BASE





- COATINGS GENERALLY POROUS TO VARIOUS DEGREES
- OFFER VARIOUS DEGREES OF CORROSION PROTECTION

CONVERSION COATINGS
BLACK OXIDE & PHOSPHATE COATINGS



BLACK OXIDE

- FOR STEELS, STAINLESS STEELS, Al, Cu, Zn, Cd
- DIP IN HOT OXIDIZING SALTS
  - FORM THIN OXIDE LAYER
- THIN: < 0.0001IN. (< 0.1MIL)

PHOSPHATE

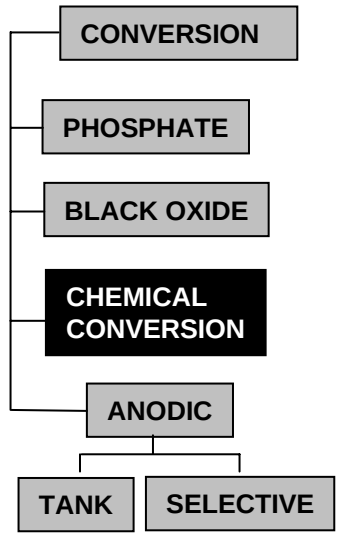
- FOR STEELS, Al, Zn, Cd
- DIP, SPRAY
  - PHOSPHORIC ACID + SALTS
  - FORM PHOSPHATE LAYER
- STEELS: H.E. RELIEF PROVISIONS APPLY (BECAUSE OF THE ACID)
- THIN 0.0001-0.002 IN. (0.1-2.0 MIL)

CONVERSION COATINGS
BLACK OXIDE & PHOSPHATE COATINGS

- NOT ADEQUATE FOR LONG TERM CORROSION PROTECTION
  - PHOSPHATE GENERALLY BETTER-THICKER PHOSPHATE BEST
- IMPROVE PROTECTION BY
  - SUPPLEMENTARY OIL OR LUBRICANTS
- PHOSPHATE + SOLID FILM LUBRICANT / OIL ON STEELS
  - COMMON IN WEAR APPLICATIONS
  - GOOD CORROSION PROTECTION

CONVERSION COATINGS
CHEMICAL CONVERSION COATINGS

- FOR Al, Mg, Be, Cd, Zn, Sn, Cu
  - YELLOW COLOR ON Al-ALLOYS & Cd PLATED HARDWARE
- APPLY BY BRUSH, SPAY OR DIP
  - CHROMIC ACID + Cr SALTS OR ACIDS
  - FORM CHROMATE LAYER
- TOO THIN 0.000005-0.00001 IN. (0.005-0.010 MIL)
- WATER SOLUBLE – REMOVED BY ERASER
- NOT ADEQUATE FOR LONG TERM CORROSION PROTECTION
- CHROMATE NOT ENVIRONMENTALLY FRIENDLY

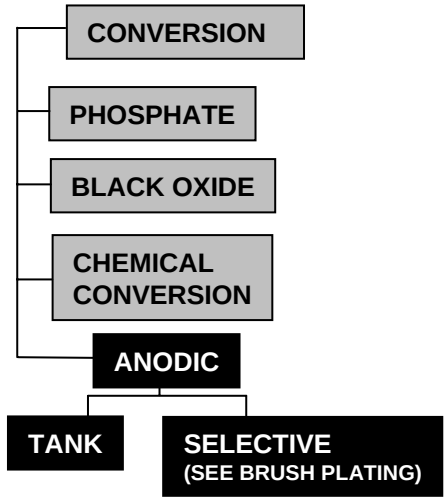


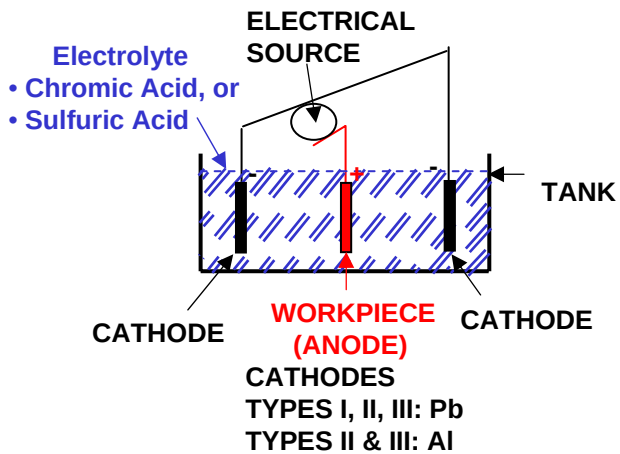
CONVERSION COATINGS
ANODIC COATINGS

- ELECTROCHEMICAL CONVERSION
  - FORM OXIDE LAYER
  - FOR Al, Be, Ti, Zn

ALUMINUM ANODIZING

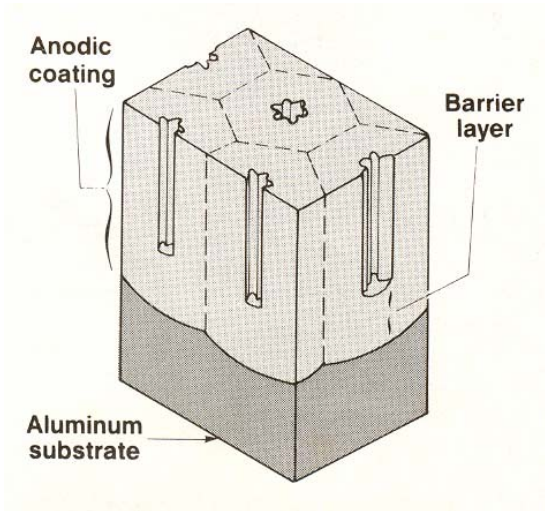
- THREE MAIN TYPES
  - TYPES I, II
    - FOR CORROSION PROTECTION
  - TYPE III
    - FOR WEAR APPLICATIONS
- SUPERIOR TO CHROMATE CONVERSION COATINGS
  - IN PROTECTION & DURABILITY
- EASIER THAN PLATING
  - NO ZINCATE





CONVERSION COATINGS
ANODIC COATINGS - ALUMINUM

- DYING & SEALING POSSIBLE
- SEQUENCE
  - ① ANODIZE
  - ② DYE FOR COLOR
    - IF POSSIBLE, REQUIRED
  - ③ SEAL
    - IN BOILING DI WATER OR ACIDIFIED HOT WATER
    - ONLY IF PERMITTED
- SEALING CAUSES COATING TO EXPAND & CLOSE PORES
  - IMPROVES CORROSION PROTECTION
  - ADVERSELY AFFECTS
    - PAINT ADHESION
    - WEAR PERFORMANCE



CONVERSION COATINGS
ANODIC COATINGS - ALUMINUM

TYPE I: CHROMIC ACID

- THICKNESS: 0.00002-0.0007 IN.
  - 0.02-0.7 MIL
- NOT SUITABLE FOR ALLOYS
  - WITH Cu > 5 %
    OR
  - WITH TOTAL ALLOYING ELEMENTS > 7.5 %
- NOT ENVIRONMENTALLY FRIENDLY
- DIFFICULT / IMPOSSIBLE TO DYE
- MAY BE SEALED

TYPE II: SULFURIC ACID

- THICKNESS: 0.00007-0.0010 IN.
  - 0.07-1.0 MIL
- PORES
  - LARGER THAN TYPE I
- MAY BE DYED
  - MANY COLORS
- BRIGHT ANODIZE POSSIBLE
  - GET Cr-LIKE FINISH
    - SOME ALLOYS
    - ONLY IF POLISHED
- MAY BE SEALED

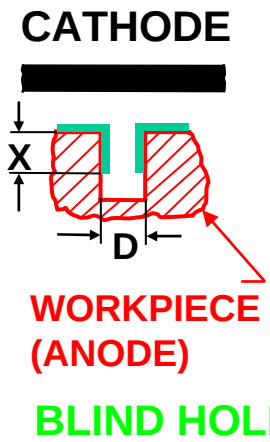
CONVERSION COATINGS
ANODIC COATINGS - ALUMINUM

TYPE III: HARD ANODIZE

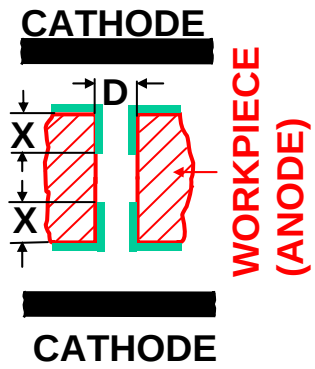
- SULFURIC ACID @ TEMPERATURES < TYPE II
- NOT SUITABLE FOR ALLOYS
  - WITH Cu > 5 %
    OR
  - WITH Si > 7 %
- THICKNESS: 0.0005-0.0050 IN. (0.5-5.0 MIL)
- FILE HARD- HRC > 60
  - MAY LAP TO DIMENSIONS
- NOT NORMALLY DYED
- NOT SEALED UNLESS OTHERWISE SPECIFIED
  - SMALL PORES
  - SEALING NOT GOOD FOR WEAR PERFORMANCE

CONVERSION COATINGS
ANODIC COATINGS - ALUMINUM

- THICKNESS OF ANODIC COATINGS
  - GENERALLY UNIFORM
  - MAYBE LITTLE THIN ON EDGES
- DEEP HOLES MAY NOT BE FULLY COATED
  - X = 1.25 D (FOR D < 0.50 IN)
  - X = 1.75 D (D ≥ 0.50 IN)
- PENETRATION & BUILDUP
  - AS SHOWN IN BOX



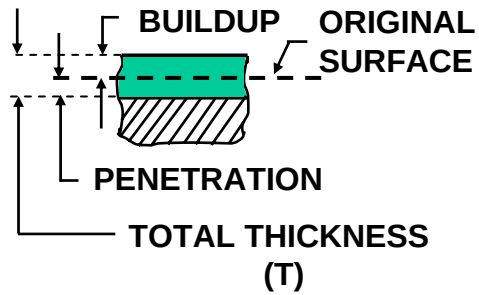
BLIND HOLE



THROUGH HOLE

	TYPES I & II *			TYPE III
BUILDUP	1/3 T	2/3 T	1/2 T	1/2 T
PENETRATION	2/3 T	1/3 T	1/2 T	1/2 T

** REFERENCES VARY AS TO PENETRATION AND BUILDUP IN TYPES I & II*



CONVERSION COATINGS
MISCELLANEOUS ANODIC COATINGS

- OTHER ANODIC PROCESSES USED FOR ALUMINUM
  - PHOSPHORIC
    - TO PROMOTE PLATING OR ADHESIVE BONDING
  - SULFURIC-OXALIC
    - FOR COATING THICKNESS BETWEEN TYPE II & TYPE III
  - SYNERGISTIC (COMPOSITE) : HARD ANODIZE + TEFLON (PTFE)
    - FOR IMPROVED WEAR PERFORMANCE
    - PTFE INFUSED OR CODEPOSITED
  - SELECTIVE (BRUSH) ANODIZING POSSIBLE
- ANODIZING TITANIUM (E.G., TIODIZING)
  - FOR WEAR APPLICATIONS
  - 10 % PENETRATION & 90 %BUILDUP-CAN BE BURNISHED
  - DECORATIVE COLORING POSSIBLE
- ANODIZING MAGNESIUM
  - FOR CORROSION PROTECTION OR FOR COLOR (BLACK)

PLATED & CONVERSION COATINGS DIMENSIONS

- DRAWING DIMENSIONS TYPICALLY APPLY BEFORE COATING
- USUALLY, ONLY MINIMUM COATING THICKNESS SPECIFIED
  - DIMENSIONS BEFORE COATING CONTROLLED BY DRAWING
  - DIMENSIONS AFTER COATING NOT CONTROLLED
- TO CONTROL DIMENSIONS AFTER COATING
  - ❶ ADD MAXIMUM COATING THICKNESS
    - ⌦ TO DRAWING OR SPECIFICATION REQUIREMENTS
  - ❷ ADD AN AFTER COATING SET OF DIMENSIONS
    - ⌦ TO DRAWING
      - ⇨ ONLY ONE SET DEPICTED?: IT IS BEFORE COATING
- PLATED COATINGS CAN BE SO CONTROLLED
  - ❶ PRECISE THICKNESS CONTROL DURING PLATING
  - ❷ HARD PLATES: GROUND, HONED OR LAPPED TO DIMENSIONS

PLATED & CONVERSION COATINGS DIMENSIONS

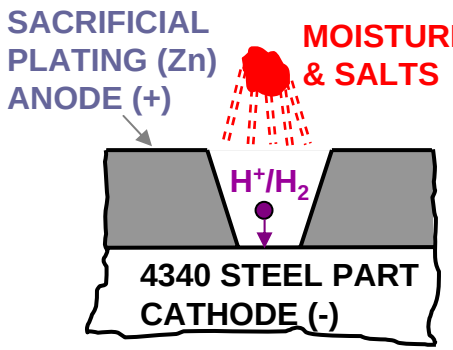
- CONVERSION COATINGS CAN NOT BE SO CONTROLLED
  - DUE TO PENETRATION & BUILDUP
- AFTER COATING CONTROL
  - ❶ BLACK OXIDE, CHEMICAL CONVERSION COATINGS
    - ⌦ TOO THIN TO WORRY ABOUT
  - ❷ ANODIC ALUMINUM COATINGS
    - ⌦ TYPE III (HARD) COATINGS
      - ⇨ HONE OR LAP TO DIMENSIONS
    - ⌦ TYPES I & II
      - ⇨ TOO THIN FOR “SAFE” LAPPING OR HONING
      - ⇨ MAY WISH TO EXPERIMENT
  - ❸ PHOSPHATE COATINGS
    - ⌦ HEAVY (2 MIL)- HONE OR LAP TO DIMENSIONS
    - ⌦ THIN: MAY WISH TO EXPERIMENT
  - ❹ ANODIC COATINGS ON OTHER METALS
    - ⌦ DEALT WITH ON CASE BY CASE BASIS
      - ⇨ E.G., FOR TITANIUM: BURNISH TO DIMENSIONS

PLATED & CONVERSION COATINGS
HYDROGEN-AGAIN

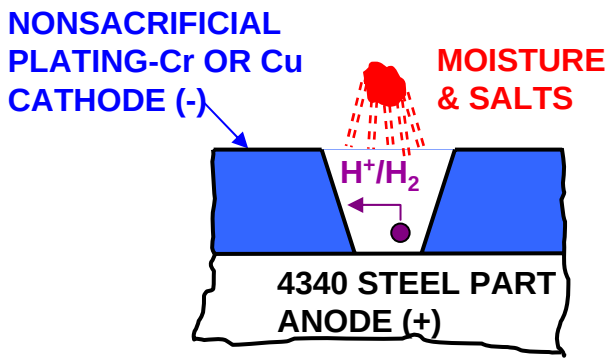
- HYDROGEN EMBRITTLEMENT (H.E.) A CONCERN IN
  - ELECTRO & ELECTROLESS PLATING
  - PHOSPHATE COATINGS
- H.E. ALSO A CONCERN IN
  - NONELECTROLYTIC OPERATIONS IN ACIDS
    - CLEANING, DESCALING, PICKLING, STRIPPING, ETCHING, CHEMICAL-MILLING, ETC.
  - ELECTROLYTIC SURFACE PREPARATION METHODS
    - ELECTROPOLISHING, ELECTROCHEMICAL MACHINING, ETC.
      - ONLY IF WORKPIECE IS CATHODE (TYPICALLY, WORKPIECE IS ANODE)
        OR
      - IF AC IS USED
- H.E. RELIEF PROVISIONS MUST ADDRESS <u>ALL</u> CONCERNS
  - E.G., STRESS RELIEF, PICKLE, BAKE, PLATE, BAKE

PLATED & CONVERSION COATINGS
SOME MORE HYDROGEN

- APART FROM STEELS
  - H.E. IN ALLOYS OTHER THAN STEEL
    - E.G., Ti & Ni ALLOYS
  - RELIEF PROCEDURES NOT READILY AVAILABLE
    - FOR Ti & ALLOYS
      - 4-6 HRS VACUUM BAKE (10^{-4} TORR OR BETTER) @ 1200-1400 F
      - 375 F NOT ADEQUATE
- H.E. ALSO
  - FROM GALVANIC COUPLING
    - BREAK IN SACRIFICIAL PLATING
- IF H IS PROBLEM, USE ORGANIC, VACUUM, THERMAL OR MECHANICAL COATINGS



Zn CORRODES
H_2 INTO PART



STEEL CORRODES
H_2 AWAY FROM PART