# Chương 3. Biến tính bề mặt bằng lớp phủ (T5)

3.1. Lớp phủ hữu cơ

3.2. Lớp phủ vô cơ

4.3. Lớp phủ chức năng

# Coatings

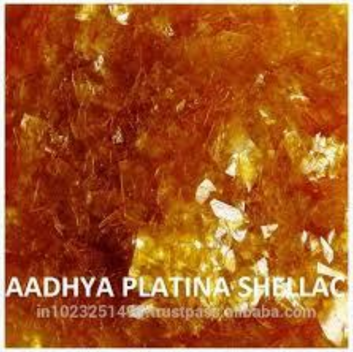
Coatings are materials that are applied to a ***surface*** which form a ***continuous film*** in order to ***beautify*** and/or ***protect*** the surface.


Sealants

Paint


Varnish

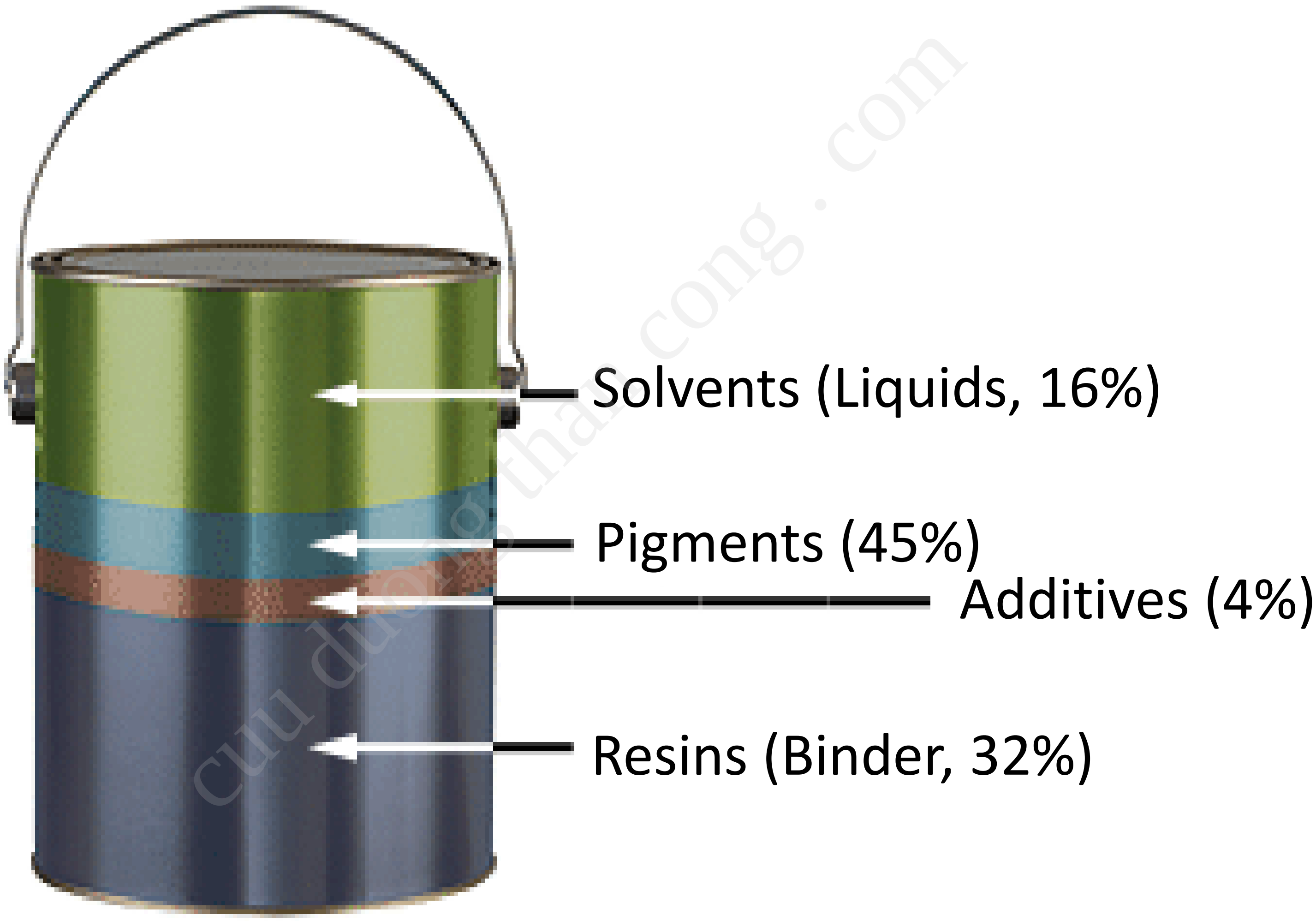
Enamel




Shellacks

Stains

# Basic Composition of Paint




Water based paints may have considerably more liquid carrier

- **Binder (nonvolatile)**
  - Principal ingredient
  - Holds paint together and to the substrate
  - Establishes chemical and physical properties
  - Defines coatings generic type
- **Solvent (volatile)**
  - It carries the pigment and binder (dissolve film former)
  - Reduce viscosity for ease of application
  - Control rate of cure
  - Low molecular weight organic chemicals (aliphatic, aromatic, and chlorinated hydrocarbons; alcohols; ketones; esters; glycol ethers; and water)

## Pigment (nonvolatile)

- Decorate, color, and hide
- Protect
  - ✓Barrier
  - ✓Galvanic
  - ✓Inhibitive
- Provide consistency
- Provide film thickness
- Control vehicle penetration into substrate

## Additives/ extenders

- Anti-fungus
- Anti-skinning
- Plasticizers
- Levelers
- Thixotropic agents
- Accelerators
- Stabilizers
- …

# Pigments are selected on the basis of

| | | |
|---|---|---|
| Particle size | Particle shape | Refractive Index |
| Tinting strength | Lightfastness | Hiding Power |
| Thermal Stability | Chemical Reactivity | Density (cost) |

| Property | Preference | Reasons |
|---|---|---|
| (1) Brilliance and clarity of hue | Organic | The most attractive, cleanest colours are obtained with organic pigments. |
| (2) White and black paints | Inorganic | The purest white pigment is $TiO_2$ and the most jet black, carbon. |
| (3) Non-bleeding | Inorganic | Inorganic compounds have negligible solubilities in organic solvents. Some organics are very insoluble. |
| (4) Lightfastness | Inorganic | Inorganic compounds are generally more stable to UV than organics. |
| (5) Heat stability | Inorganic | Very few organic compounds are stable above 300° C. |

- Extenders provide no colour to a film, but their use is an inexpensive method of improving adhesion, ease of sanding, film strength and opacity.
  - Calcium carbonate (whitewash)
  - Aluminum silicate (clay)
  - Magnesium silicate (talc)
  - Barium sulphate (barytes)
  - Silica
- Viscosity Modifiers
  - silicates, clays, poorly soluble resins
- Dispersion Aids
  - aid in pigment dispersion - chosen on a case-by-case basis
- Interfacial Tension Modifiers
  - non-ionic surfactants, soaps
- Biocides
  - insecticides, fungicides

# Solvent Selection Criteria

- Solvating Capacity:

  Miscibility of polymer/solvent systems are dictated by thermodynamics, as approximated by solubility parameters and hydrogen bonding groupings.

- Viscosity:

  Influenced by solvating capacity, but also a function of the viscosity of pure solvent and additives.

- Volatility:

  Rate of solvent evaporation influences drying time as well as film aesthetic qualities. Decisions often based upon boiling point/range.

- Toxicity and smell.
- Cost.

# Type of Curing in Modern Coating Resins

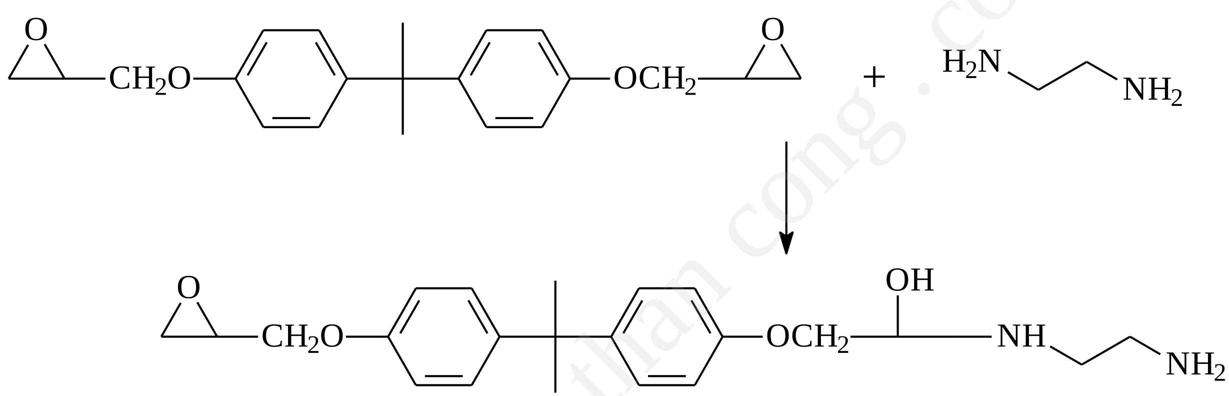
- Solvent evaporation
- Oxidation
- Chemical reaction
- Catalyzed film former
- Thermoplastic
- Thermoset
- Emulsion - water based

# General Coating Formulations

| Method | Polymer M.W. | Solids | Polymer structure | Dry rate (no heat) | Min. dry temp. | Handling/ Storage | Examples |
|---|---|---|---|---|---|---|---|
| Evaporation | high | (i) low, 10-35% solution (ii) medium 40-70% emulsion | linear | fast | no practical limit (solutions) | good | nitrocellulose other lacquers; some emulsion paints |
| Chemical reaction between paint and air | low | medium to high, 35-100% | crosslinked | slow-moderate | very slow in cold weather | cans must be well sealed | decorative paints some stoving enamels; |
| Chemical reaction between paint ingredients | low or very low | medium to high 30-100% | crosslinked | fairly fast | varies; 10-15° C | two-pack or short shelf life, unless stoving or radiation curing type | industrial stoving finishes; acid-catalysed poly-urethane and polyester wood finishes |

# Thermosetting Binders: Epoxy and Polyurethane Resins

- Epoxy resins are two-component paints formulated from epoxide functionalized monomer and (usually) amine hardeners.



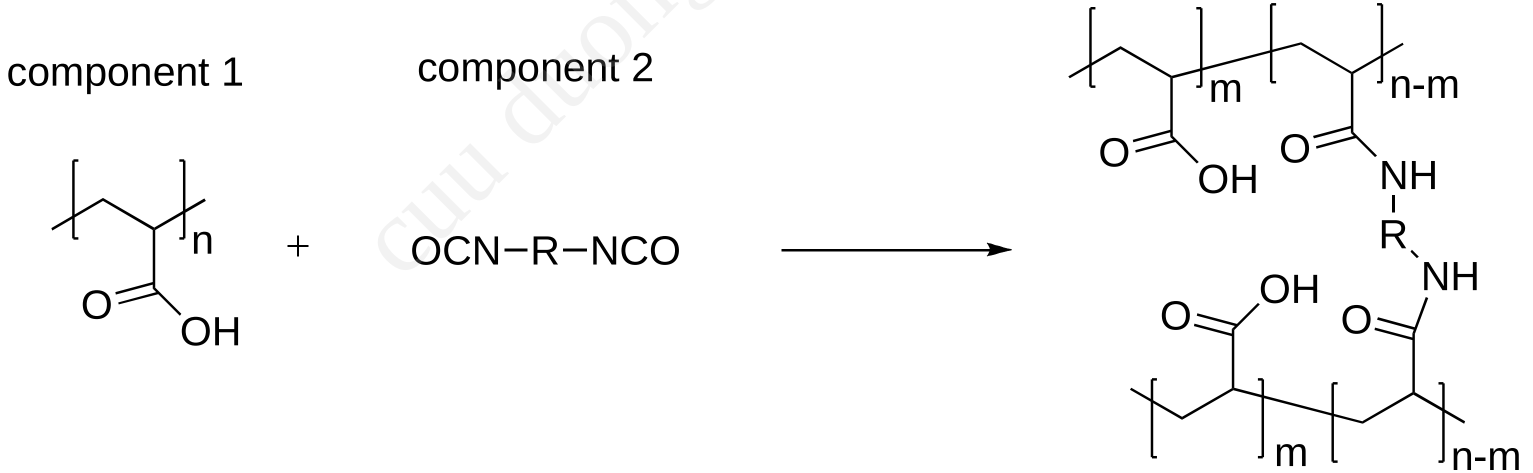
- Reaction of diisocyanates with diols generates polyurethane coatings whose structure/properties can be varied widely.

$$HO-R-OH + OCN-R^1-NCO \longrightarrow HO-R\underbrace{(-O-\overset{\displaystyle O}{\overset{\|}{C}}-NH-)}_{\text{urethane groups.}}R^1-NCO$$

- Polyurethanes afford superiour abrasion and chemical resistance, as well as a fast, low-temperature cure.

# Polyurethanes

- One part polyurethane
- Moisture cured polyurethane
- Acrylic polyols-aliphatic linear isocyanate two part polyurethanes
- Polyester polyols-aliphatic isocyanate two part polyurethane



# Why do we need paints?

Paints are surface coatings generally suitable for site use, marketed in liquid form.

*They may be used for one or more of the following purposes*:

- To protect the underlying surface by exclusion of the atmosphere, moisture and insects.
- To provide a decorative easily maintained surface.
- To provide light- and heat-reflecting properties.
- To give special effects (for example, inhibitive paints for protection of metals; electrically conductive paints as a source of heat; condensation- resisting paints)

# Painting specific materials

***Ferrous metals***

- Steel forms the largest bulk of metals used in building and is one of the most difficult to maintain.

- The best time to paint steel is immediately after production, though mill scale (iron oxide film produced during hot rolling) should be removed because:
  - It behaves cathodically to the bare metal and may lead to local corrosion.
  - It may eventually flake off due to differential movement.

# Non-ferrous metals

- Zinc and aluminium are the non-ferrous metals most likely to require surface coatings and each provides a poor key for paint, unless surface treatment is first carried out.
- Zinc, in particular, reacts with most oil-based paints, forming soluble salts which reduce adhesion.
- Zinc should be degreased with white spirit, followed by roughening of un-weathered surfaces with emery paper.
- Primers containing phosphoric acid are available for this; they often also contain an inhibitor, such as zinc chromate.
- Other suitable primers contain *calcium plumbate, zinc dust or zinc oxide.*

# Wood

- Protect as soon as possible after the manufacturing process is completed since the surface is quite rapidly affected by weathering/ultraviolet light, as a result of which the paint adhesion properties significantly deteriorate.

- A primer is essential to penetrate and yet block the pore structure.

- Undercoats are unsatisfactory here, since they often do not penetrate the wood and may flake off later.

# Plastics

- Most plastics do not require painting, and paint coats, once applied, cannot be removed by normal techniques.

- Paints, on the other hand, will reduce the rate of degradation of plastics such as polyethylene.

- Adhesion is poor unless the surface is first roughened to give a mechanical key.

- The impact strength of some plastics, such as PVC, may be adversely affected, if painted, by migration of solvent into the paint.

# Painting systems


Provides aesthetic and 1st defence protective properties from the environment

Builds film thickness to provide extra protection

Inhibits corrosion and creates good adhension propeties

Appropriate surface preparation should always be carried out to ensure the success of the project

# Aesthetic Properties of Dried Film Coatings

- Opacity
  - ✓Extent of substrate coverage, as determined by pigments, extenders and other occlusions in the film.
  - ✓Dependent on refractive index of fillers relative to the polymeric binder.
- Surface Finish: Gloss is a function of surface irregularity, as determined by the film formation process and dispersion of pigments/fillers.
- Color: Inorganic and organic colourants that are soluble or dispersed in the film (may or may not provide opacity).

# Engineering Properties of Dried Film Coatings

- **Properties**:
- Hardness
- Impact (& Chip) Resistance
- Flexibility
- Abrasion Resistance
- Solvent Resistance
- Adhesion

- **Tests**:
- Indentation, Scratch (Pencil)
- Drop tests, Gravelometer
- Elongation, Bend
- Falling sand test
- MEK (methylethylketone) double rub
- Scraping, Crosscut Adhesion

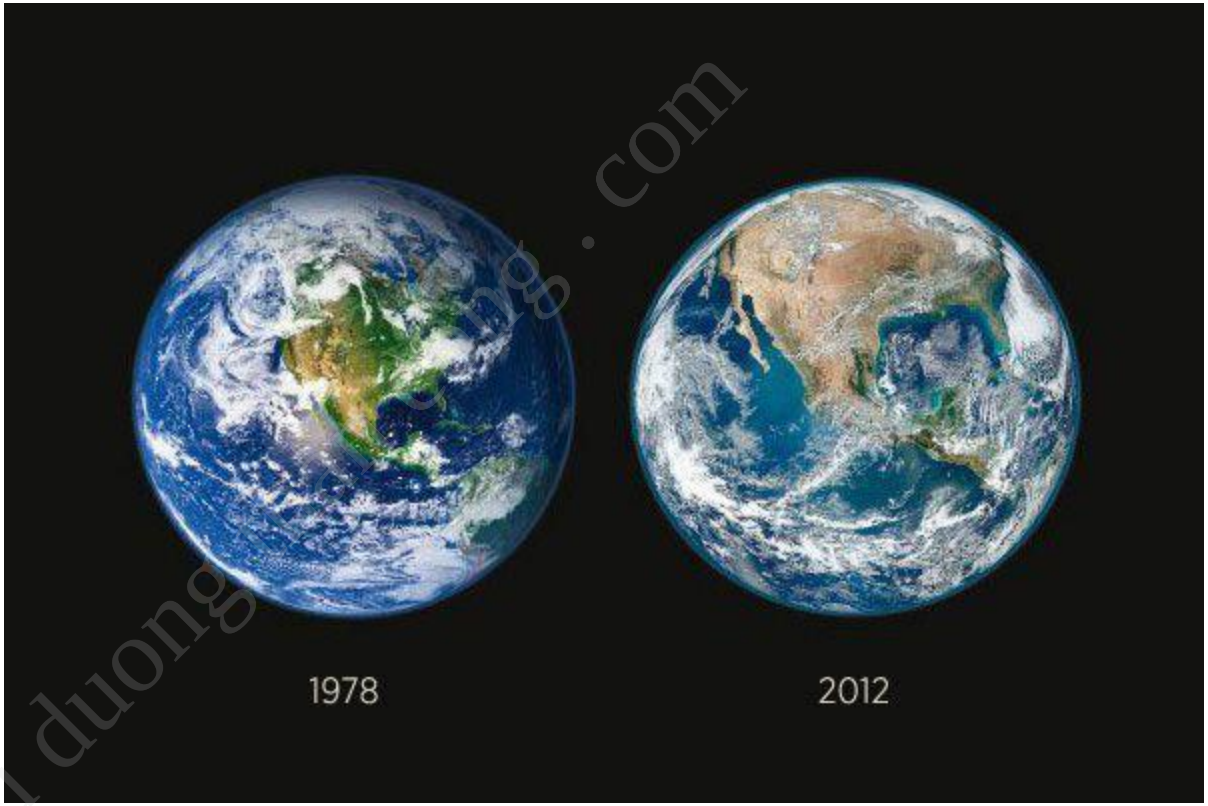
**Issues:**

- Properties are a complex function of many factors: Tg, MW, crosslink density, pigmentation, static stress-strain behaviour, transient (creep) behavior
- What do you test? Free films? Coating with substrate?
- Weatherability and UV resistance – How does it hold up over time?

# Solvent Emissions From the Organic Coating Process ?

Climate Change

Carbon Footprint



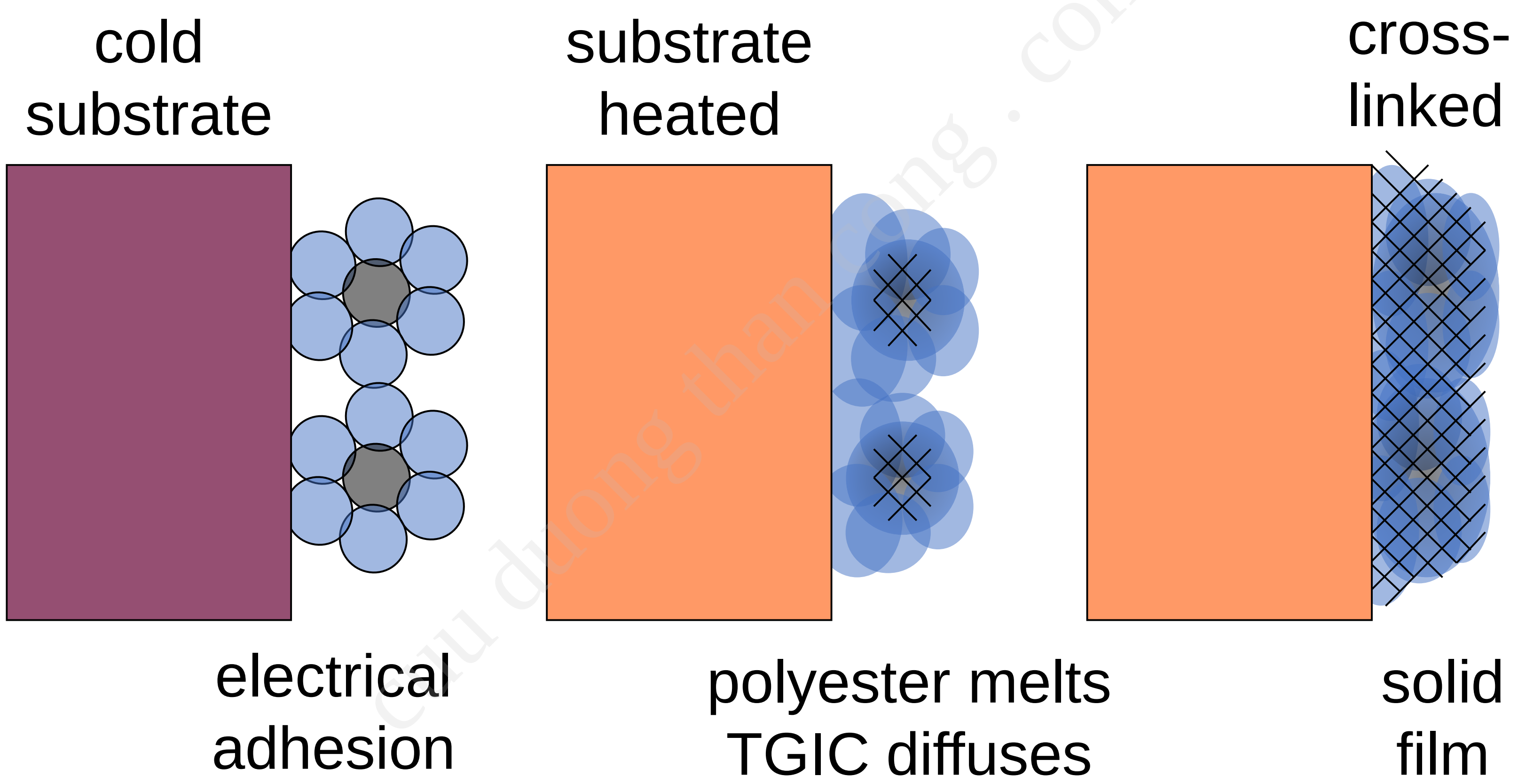

- ✓ Paints based on organic solvents
- ✓ Carbon derived from fossil sources
- ✓ Used as a carrier in paints, evaporates and adds to the environmental carbon compound concentration

# Powder Coating

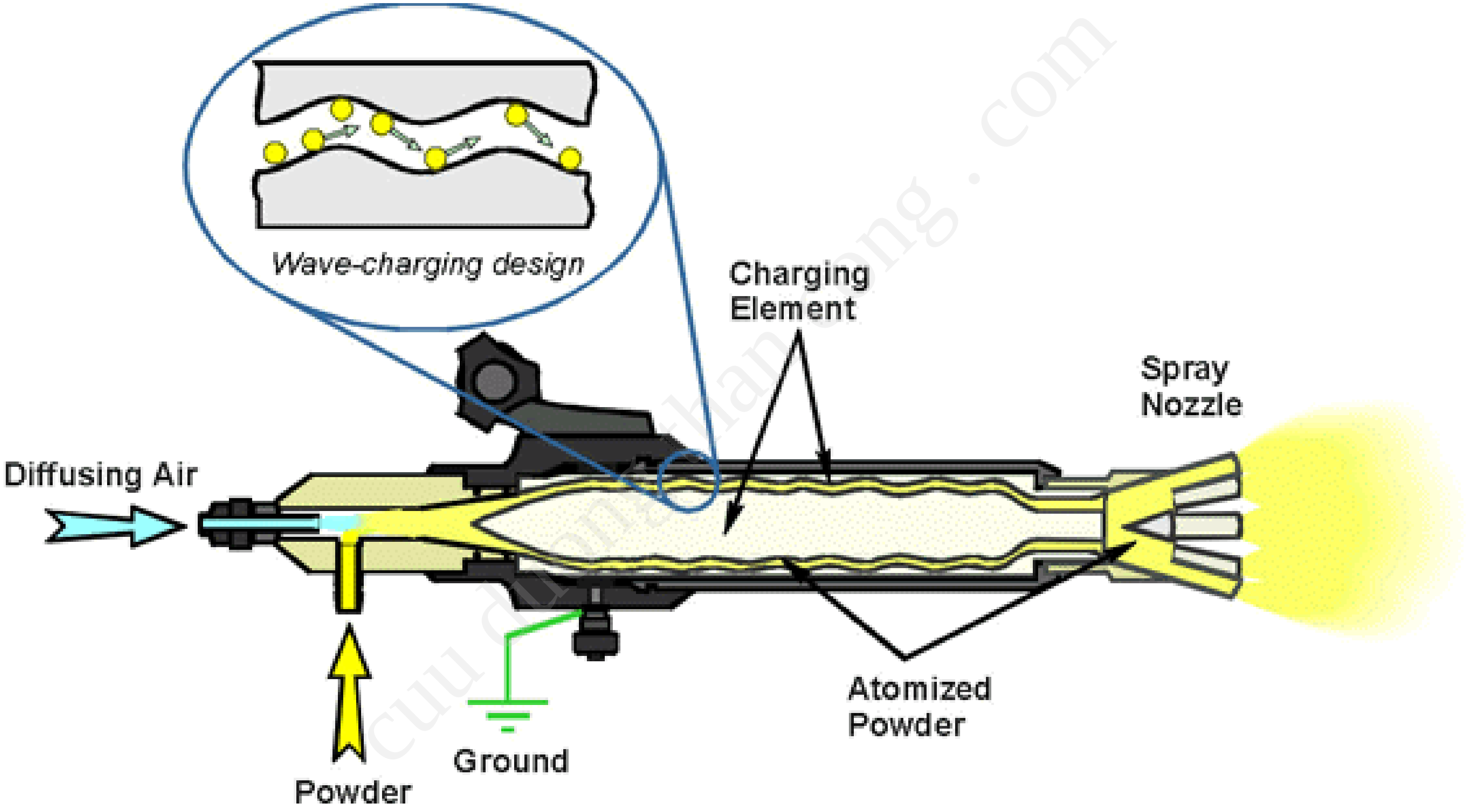
- Powder coating is a dry finishing process, using fine particles of paint, which are electrostatically charged and sprayed onto a workpiece.
- Once the powder is applied, the part is cured, causing the powder to adhere to the surface.

# Painting Process

- Fine particles are fluidized in a feed hopper
- Powder is vacuumed into the spray gun
- A second burst of air increases the particle velocity
- Particles are then charged by high velocity friction
- Spray gun applies powder to the grounded workpiece
- Coated part is then oven cured
    - Oven temperature: 300 °F
    - Time for complete cure: 20 minutes
    - Curing causes a chemical reaction that bonds the powder coating to the workpiece.


cold
substrate
substrate
heated
cross-
linked
electrical
adhesion
polyester melts
TGIC diffuses
solid
film

# Tribostatic Gun Layout



# Higher Quality, Extremely Durable, Environmentally Friendly, Cost Efficient

**Advantages**

- No solvents are used
- Over-spray (up to 98%) can be reused
- More resistant to chipping, cracking, and fading
- Corrosion and chemical resistant
- Coating does not run, drip, or sag
- Thick coatings are easily done
- Simple clean-up and maintenance

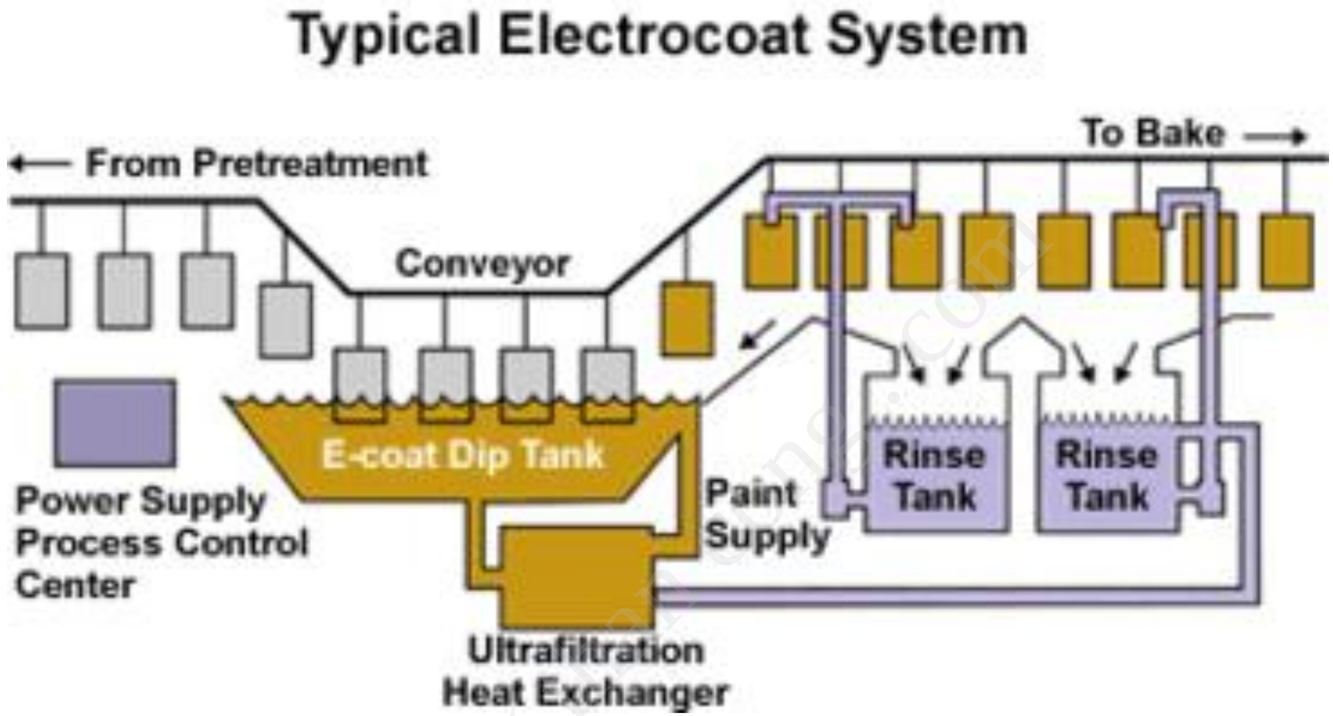
**Disadvantages**

- ❑ Thin coatings are difficult to produce
- ❑ Storage and handling of the powder requires special climate controls
- ❑ Color matching is somewhat more difficult
- ❑ Cure temperatures may be too high
- ❑ Difficult to coat sharp corners

# Methods for applying organic Coatings

- Powder Spray coatings
- Electrocoating
- Fluidized Bed
- Dip coating
- Spray coating
- Spin coating

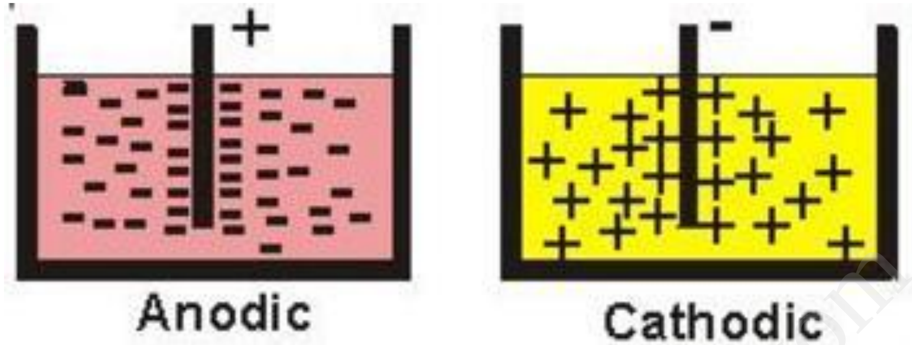
# Powder Spray coatings




The basic principle of electro coat is that materials with opposite electrical charges are attracted to each other. In an electro coat bath a specific charge is applied to the part that is immersed in paint particles that have an opposite charge.

The paint particles are attracted to the part and are deposited on the part to form an even, continuous film over every surface until the coating reaches the desired thickness. Electro coating is complete when attraction stops.

Electro coating is classified as either anodic or cathodic depending on the polarity of the charge.




**Anodic**

In anodic electro coating, the part to be coated is made the anode (a positive electrical charge) and attracts the negatively charged paint particles in the paint bath.

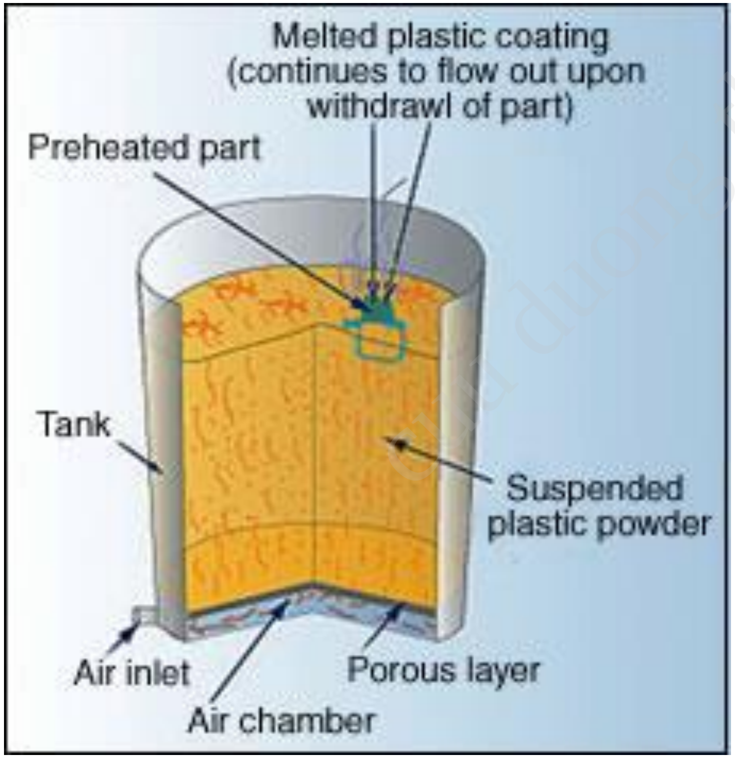
**Cathodic**

In cathodic electro coating, the workpiece is made the cathode (a negative charge) and attracts the positively charged paint particlesType your paragraph here.

Major advantage of electro coat over most other systems is its covering ability. Thickness is easily controlled using simple voltage adjustment. Electro coating lines can be highly automated, closed-loop systems with excellent productivity and low operating costs so no direct labour is required.

# Fluidized Bed Coating

- Polymer powder in air generated fluidized bed
- Normal or electrostatic FB coater
- PVC, polyethylene copolymers
- Protective, decorative coatings
- Safety glass bottles




*Heat part, then dip into FB coater*

100 $^{O}$C for PE copolymer

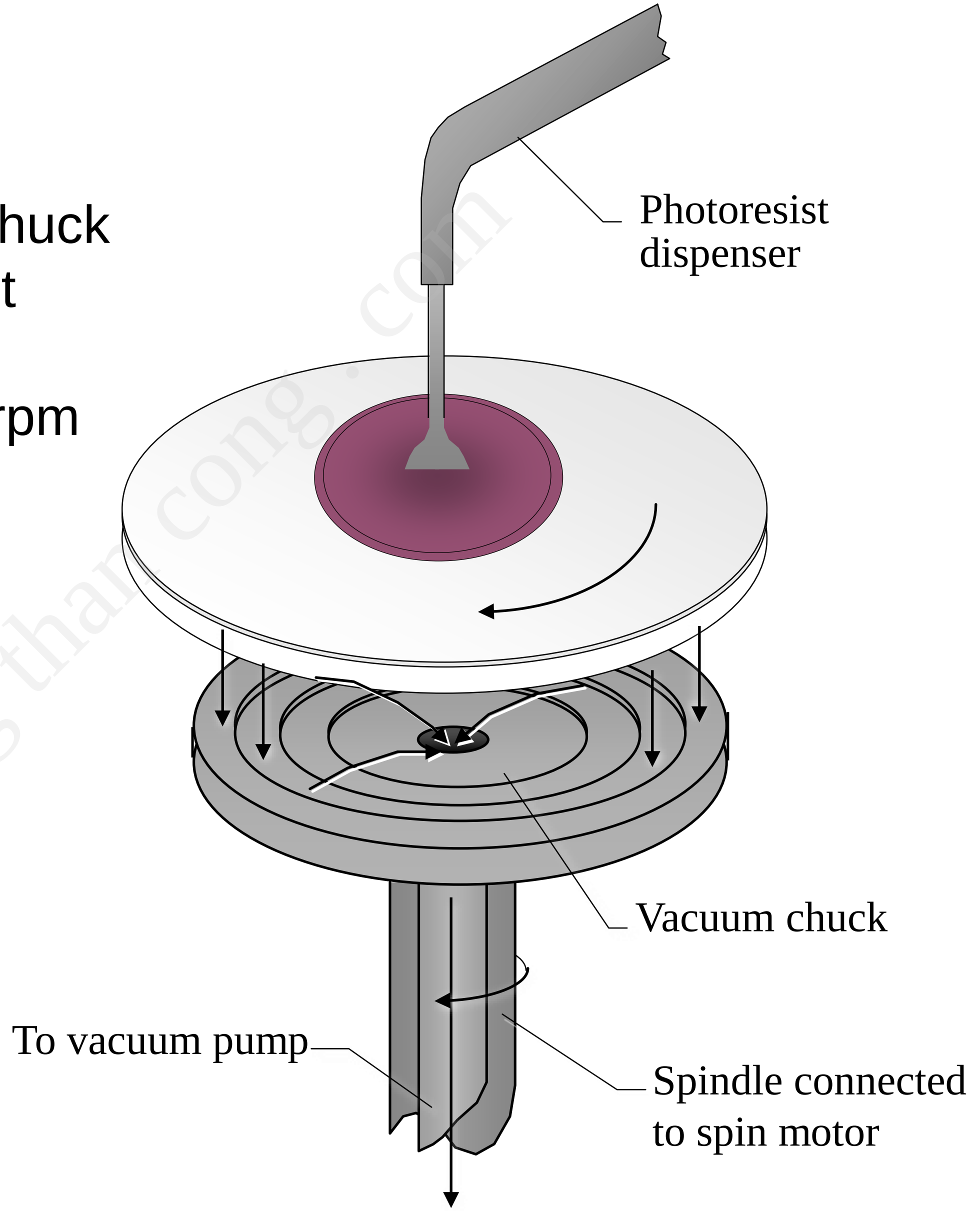
# Dip Coating

PVC

# Spin Coat

Process Summary:

- Wafer is held onto vacuum chuck
- Dispense ~5ml of photoresist
- Slow spin ~ 500 rpm
- Ramp up to ~ 3000 to 5000 rpm
- Quality measures:
  - time
  - speed
  - thickness
  - uniformity
  - particles and defects



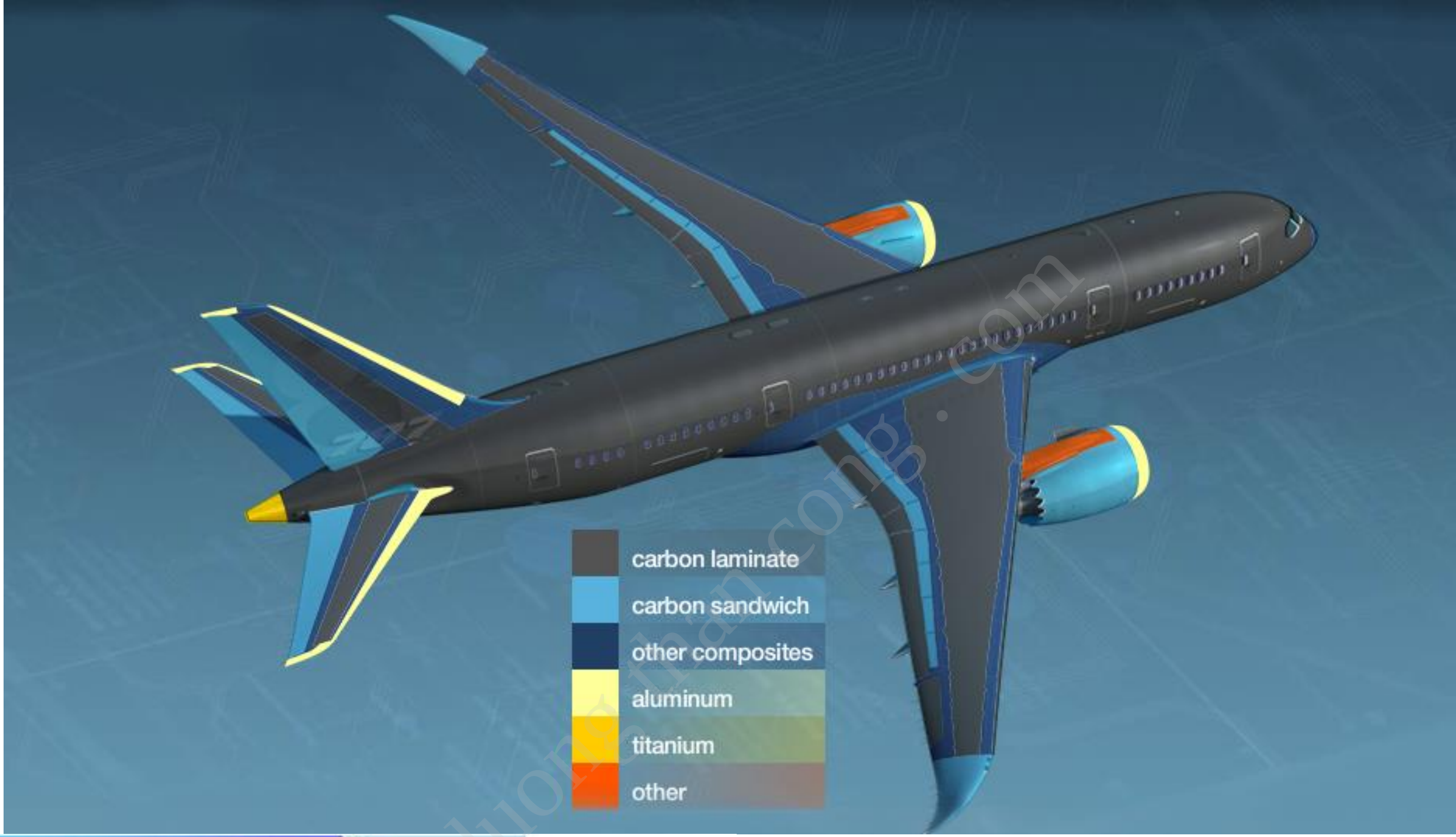
# Spray coating

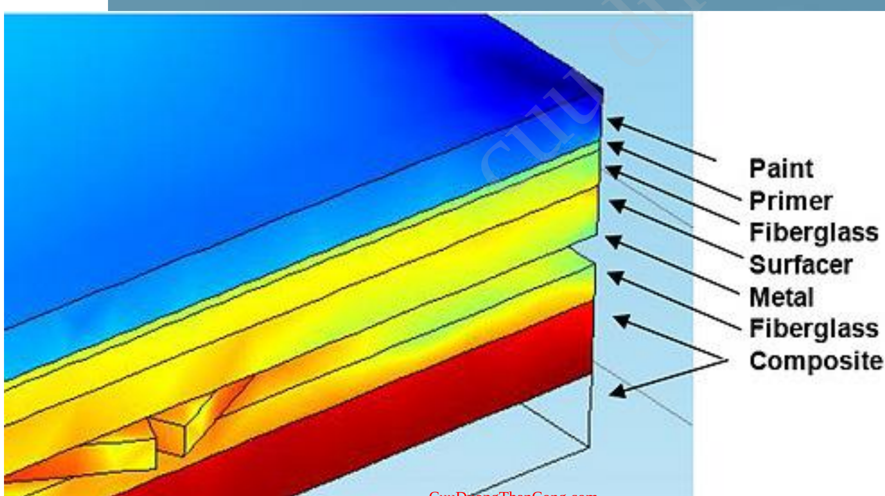
# Quality Control of Industrial Painting Operations

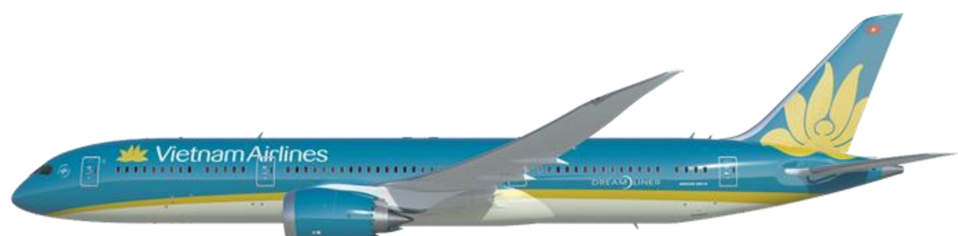
- Industry standards for coating application QC
- Developing a quality control plan for painting
- Navigating a Technical (Product) Data Sheet
- Measuring ambient conditions and surface temperature
- Witnessing mixing, thinning and application procedures
- Calculation and measurement of wet film thickness
- Dry film thickness measurement
- Post-application testing
    - ➢Cure/hardness
    - ➢Holiday/pinhole detection
    - ➢Adhesion
    - ➢Identifying application defects

# Industry Standards for Coating Application

- SSPC-PA 1 *Shop, Field and Maintenance Painting of Steel*
- SSPC-PA 2 (frequency and tolerance of coating thickness measurements on steel)
- SSPC-PA 9 (frequency and tolerance of coating thickness measurements on concrete)
- ASTM E337 (use of whirling/aspirating psychrometers)
- ASTM D4414 (wet film thickness measurement)
- ASTM D7091/D6132 (dry film thickness measurement)
- ASTM D5402/D4752/D3363/D1640 (drying, curing, hardness)
- ASTM D5162/D4787 (holiday/pinhole detection)
- ASTM D3359/D6677/D4541/D7234 (adhesion)


carbon laminate
carbon sandwich
other composites
aluminum
titanium
other


Paint
Primer
Fiberglass
Surfacer
Metal
Fiberglass
Composite


Vietnam Airlines