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INTRODUCTION TO

THE PROPER SELECTION

AND

APPLICATION OF
PROTECTIVE COATINGS

Stan Osborne
Sr. Industrial Coatings Specialist
ICI Devoe Coatings

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Surface Preparation and Application

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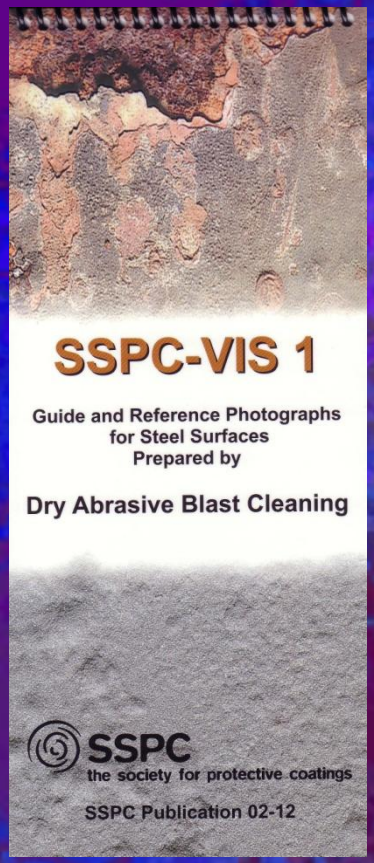
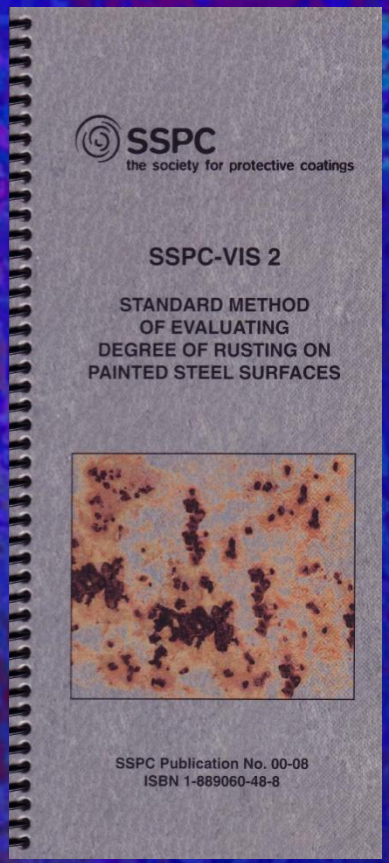
Surface Preparation

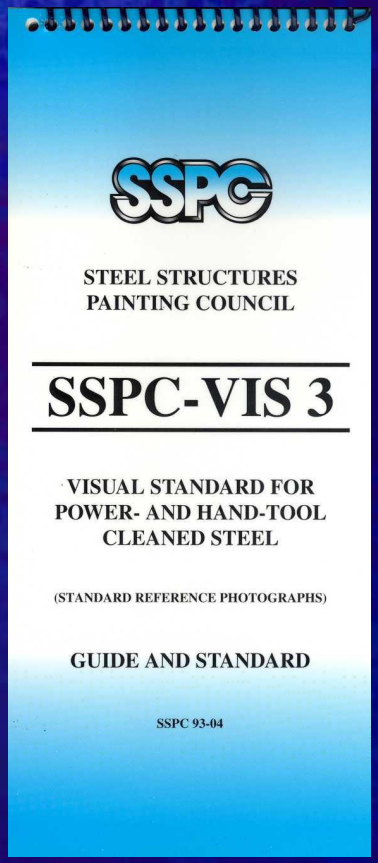
(what you always wanted to know . . . and some stuff you didn't)

Cleaning Standards

The Society for Protective Coatings (SSPC)







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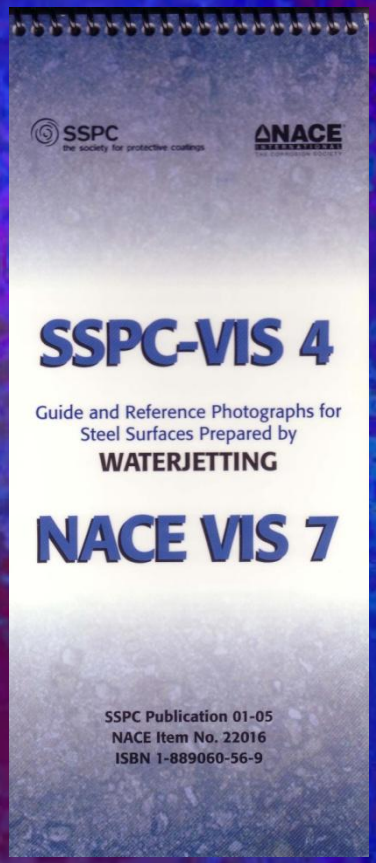
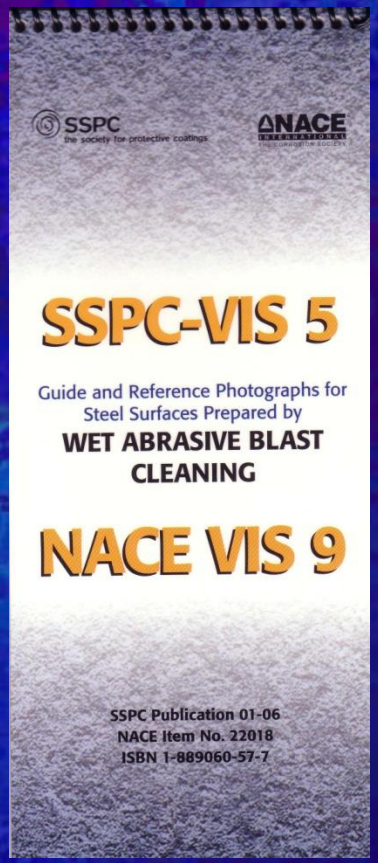


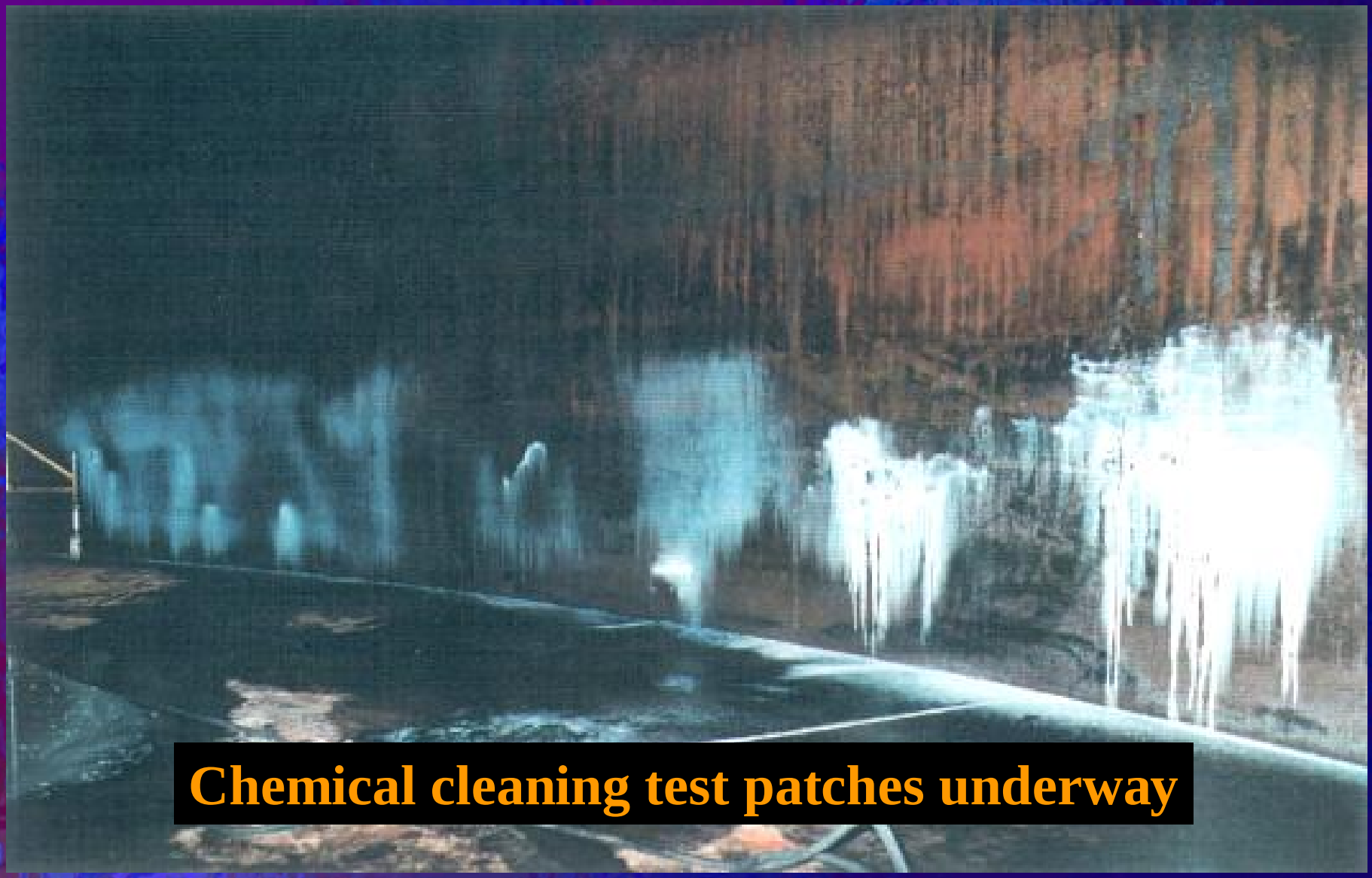


SSPC Cleaning Standards

- SP1 Solvent Cleaning: Removal of oil, grease, dirt, & salts by cleaning with solvent, water, detergent, alkali or steam.
- SP2/SP3 Hand & Power Tool Cleaning: Removes loose paint, loose mill scale and loose paint by chipping, scraping, sanding and wire brushing.
- SP11 Power Tool Cleaning to Bare Metal: Removal of all visible oil, grease, dirt, mill scale, rust, paint, and contaminants and to retain or produce a surface profile.
- SP 15 Commercial Grade Power Tool Cleaning: Similar to SP 11 but allows some staining to remain and mandates minimum 1 mil profile.

SP-1

SP-1 Emulsion Cleaning



Chemical cleaning test patches underway

SP-2

SP-3

Power Tool Cleaning (Grinding Disk)

Power Tool Cleaning to White Metal (Needle Gun)

SSPC Blasting Standards

- SP5 White Metal Blast: Removal of all oil, grease, rust, mill scale, paint and contaminants by blast cleaning by wheel abrader or abrasive blasting nozzle (dry or wet) using sand, grit or shot.
- SP10 Near White Blast: Same as SP5 but 5% of area allowed residual shadows
- SP6 Commercial Blast: Same as SP5 but 1/3 of area allowed residual shadows

SSPC Blasting Standards

- SP14 Industrial Blast Cleaning: Blasting to remove tightly adhering residues of mill scale, rust and coatings. Traces of residue are permitted on 10% of each unit area if they are evenly distributed.
- SP7 Brush Off Blast: Blasting to remove marginally adhering residues of mill scale, rust and coatings and provide a properly prepared surface condition for application of subsequent coatings.

Commercial Blast

Close Up: Commercial Blast

Near White Metal Blast

Close Up: Near White Blast

Close Up: Near White Blast

SP 10 Wheel Abrader using steel grit / shot

Other SSPC Surface Preparation Standards

- SP12 Surface Preparation and Cleaning of Steel and Other Hard Materials by High- and Ultrahigh-Pressure Water Jetting Prior to Recoating: Covers several cleanliness standards.
- SP13 Surface Preparation Of Concrete: Covers many different techniques - water jetting, abrasive blasting, mechanical tools, etc.

What are the Goals of Surface Preparation?

To provide a surface suitable for painting by:

- Removing contamination
- Providing a surface profile to ensure coatings adhere
- Removing or smoothening irregularities (pits, projections, sharp edges) to allow for uniform film development
- Removing tightly bound mill scale & rust

What Surfaces Require Preparation?

- Iron and Steel
- Galvanized Metal
- Aluminum
- Concrete and Masonry
- Pre-Coated Metal Siding
- Previously Painted

Iron and Steel

Why Clean?

To Remove:

- Mill Scale
- Rust
- Oil/Grease
- Dirt
- Soluble Salts

How to Clean:

- Solvent Cleaning (SP1)
- Hand Tool Cleaning (SP2)
- Power Tool Cleaning (SP3, SP11)
- Abrasive Blast (SP5, SP10, SP6, SP7)
- Water Blast (RP-01-72)

Galvanized Metal

Why Clean?	How to Clean:
To Remove:	◆Weathering (takes up to 1 year)
◆White Rust	◆Can't Wait . . . .
◆Oil/Grease	◆Solvent Cleaning (SP1)
◆Dirt	◆Acid Etching
◆Soluble Salts	◆Hand Tool Cleaning (SP2)
◆No Profile	◆Abrasive Sweep Blast (SP7)

Aluminum

Why Clean?	How to Clean:
To Remove:	◆Solvent Cleaning (SP1)
◆Oil/Grease	◆Acid Etching (minimal profile)
◆Dirt	◆Abrasive Sweep Blast (SP7) *
◆Soluble Salts	

***Sweep blast is often done with softer abrasives such as plastic pellets**

Concrete

Why Clean?

To Remove:

- Efflorescence
- Form Oils
- Laitance
- Air Pockets
- Contaminants
- No Profile

How to Clean:

- Solvent Cleaning (D-4258)
- Brush Off or Sweep Blast(D-4259)
- Acid Etch (Floors) (D-4260)
- Hand Tool Cleaning (SP2)
- Power Tool Cleaning (SP3)
- Water Blast (RP-01-72)

Caution: Test moisture content and for presence of concrete hardeners

Pre-Coated Metal Siding

Why Clean?

To Remove:

- Wax
- Silicone
- Dirt
- Fluropolymer (Hard & glossy surface of low polarity) Kynar Finishes – Marketed as Never Have to Paint Again

How to Clean:

- Solvent Cleaning (SP1)
- Sanding (SP2 or SP3)
- Abrasive Sweep Blast (SP7)

Caution: An adhesion test patch is recommended

Previously Painted

Why Clean?

- Loose Paint
- Oil/Grease
- Dirt
- Soluble Salts
- Rust
- Chalk
- Hard & Glossy

How Clean:

- Solvent Cleaning (SP1)
- Hand Tooling - Scrapers, etc.) (SP2)
- Sanding (SP2)
- Power Tool Cleaning (SP3, SP11)
- Abrasive Blast (SP5, SP10, SP6, SP7)
- Water Blast (RP-01-72)

Test for adhesion and compatibility

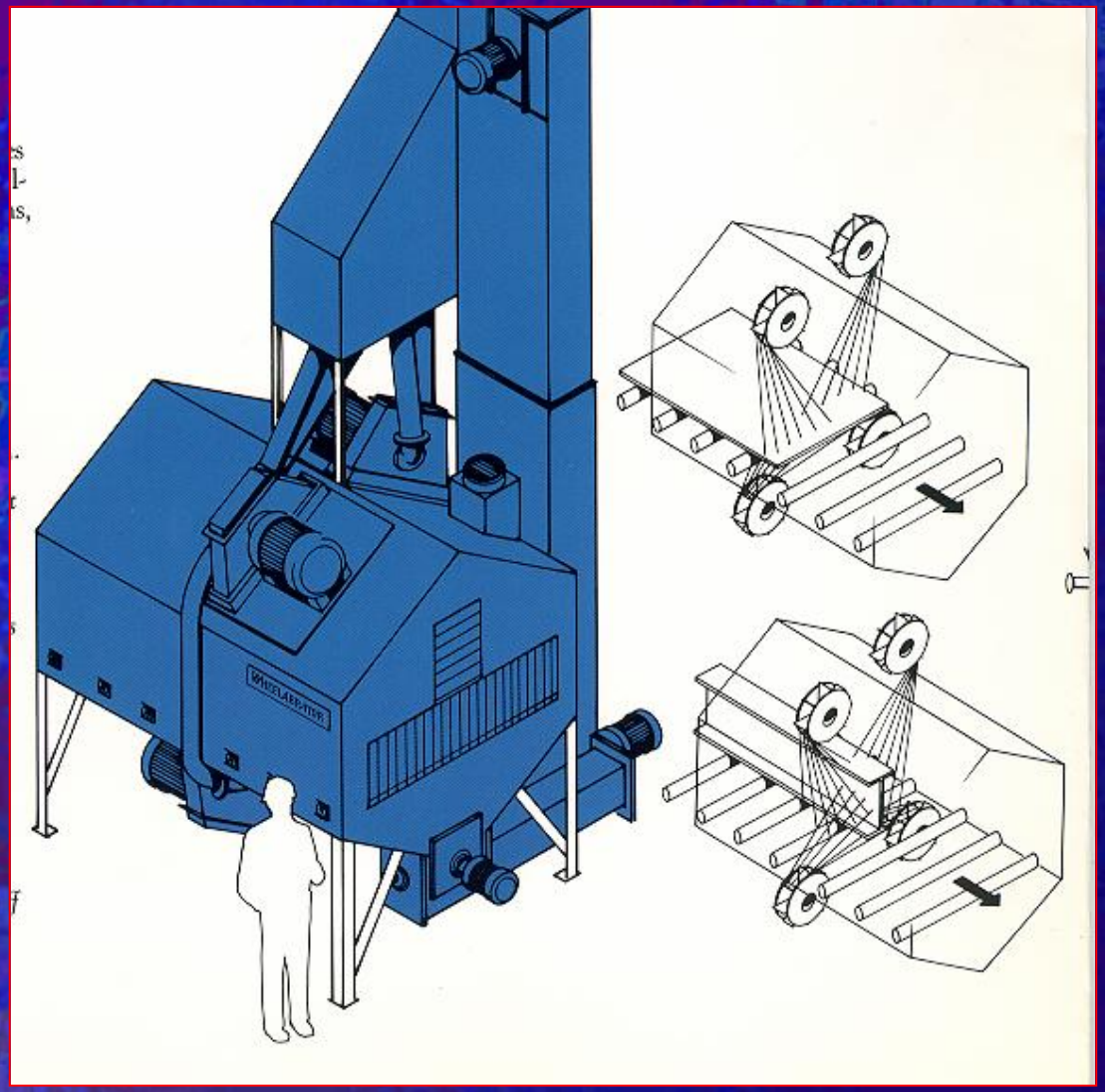
Properties of Abrasives

- Type
  - Metallic, Mineral, Slag, Other (sponge, walnut shell, glass beads, etc.)
- Hardness
- Rate of Breakdown
- Size
- Shape
  - Shot

Grit

Abrasive Blasting Equipment (Field Set-Up)

In-Shop Centrifugal Blasting
(Wheel Abrader)



Relative Surface Preparation Costs

Cleaning Grade	Field	Shop
SP2 Hand Tool	1.8	0.8
SP3 Power Tool	2.3	0.8
SP7 Brush Off Blast	2.1	---
SP6 Commercial Blast	3.1	1.0
SP10 Near White Blast	3.6	1.1
SP5 White Metal Blast	4.4	1.2

Source: G. Brevort, A.H. Roebuck, "Selecting Cost-Effective Protective Coating Systems"

Data from 2004

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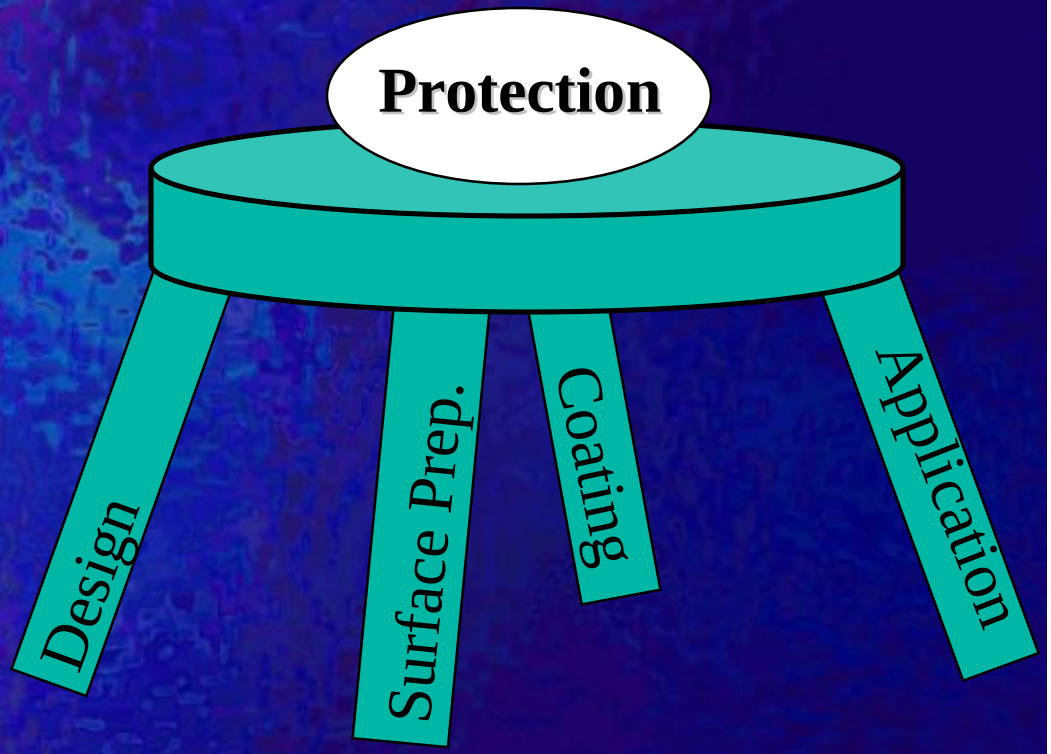
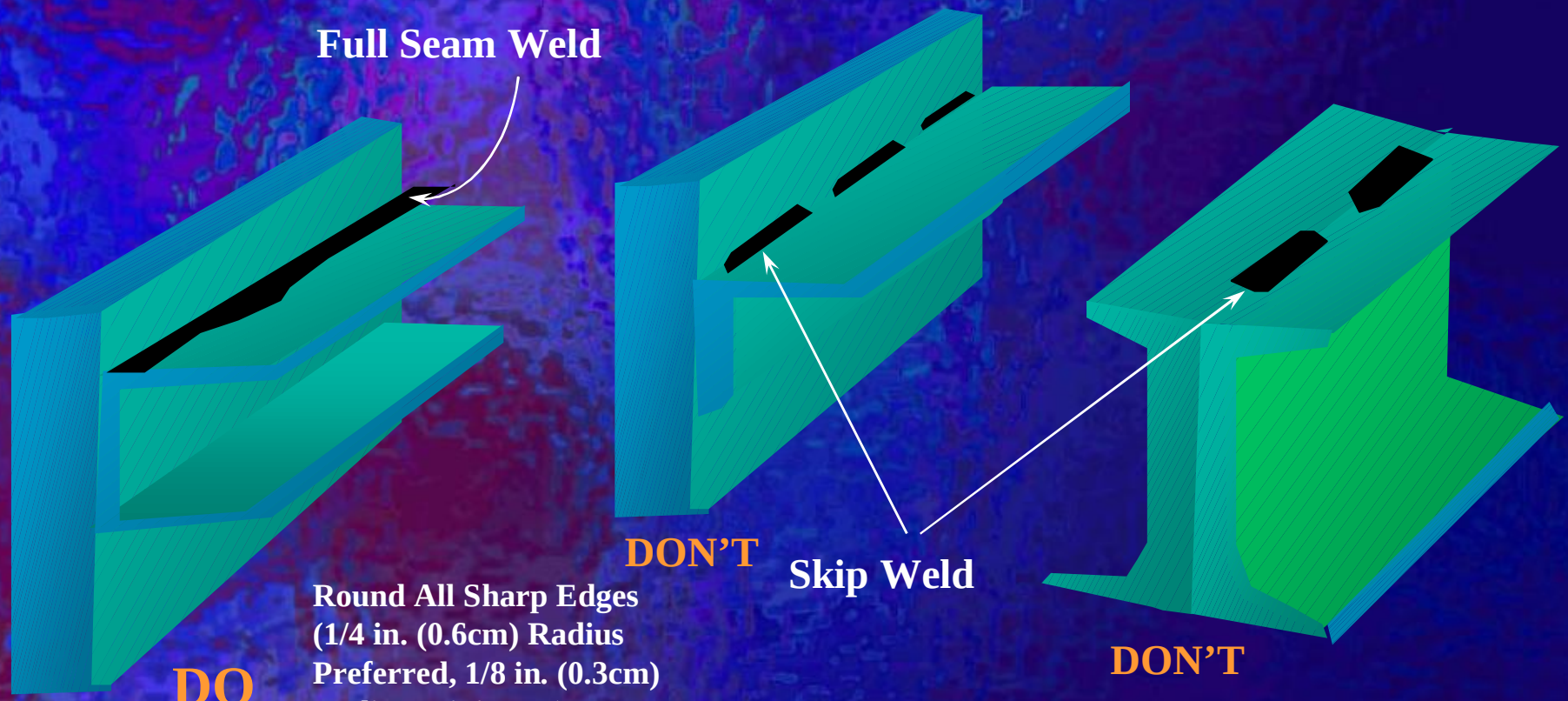
Coating System Selection & Performance Criteria

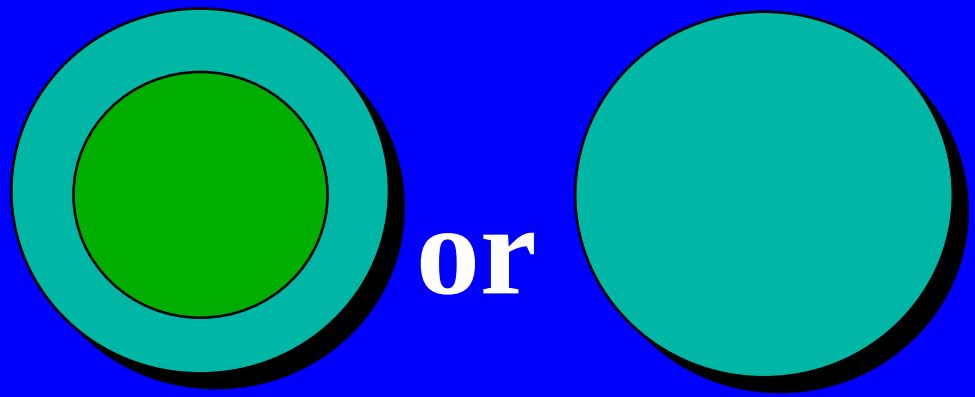
Factors Affecting Coating Performance

- Structural Design
- Coating Selection
- Surface Preparation
- Application

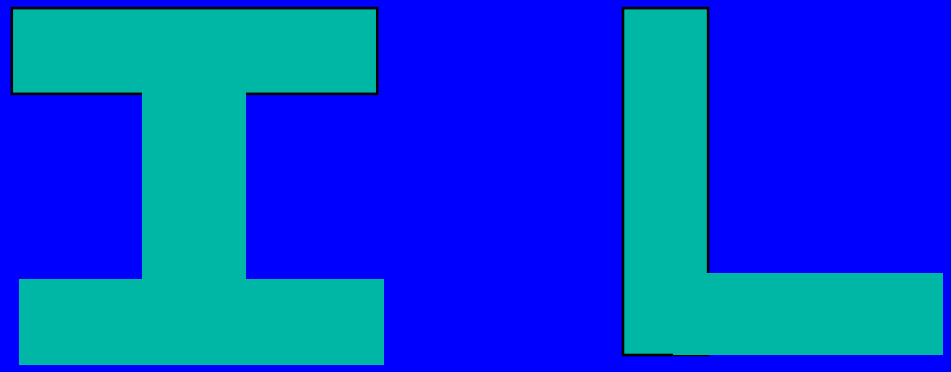


Structural Design for Aggressive Environments





Preferred To



Avoid Angles or Channels

Other Design Considerations

- Surfaces should be smooth (e.g. welds)
- Welding preferred to riveting
- All surfaces should be well drained (ie: weep holes installed to drain pockets/cavities
- Faying surfaces should be avoided
- Stiffening members should be on the outside surface of tank or vessel

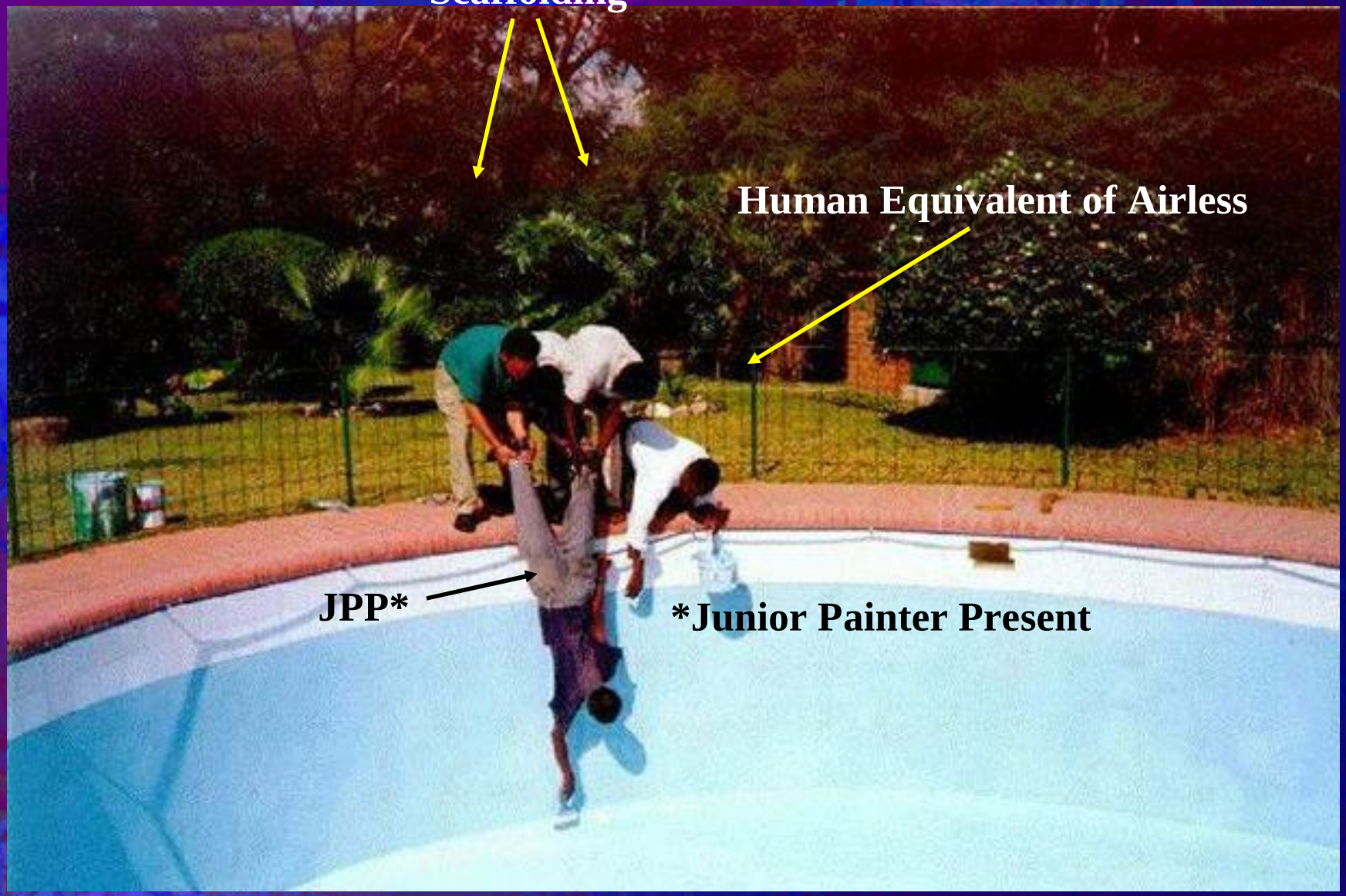
Corrosion at Skip Welds

Corrosion at Rivets

A Poor Design?

Current Application Techniques

We always adhere to regulatory requirements?



Brushing (working into and around rivet heads)

Painters Mitt (for pipes & tubing)

Roller (for flat surfaces)

Why isn’t this man spraying?

Airless Spray – High Transfer Efficiency

Some thick floor coatings must be toweled . . . .

Application benefits of 100% solids coatings: Little or no odor, no solvent emissions

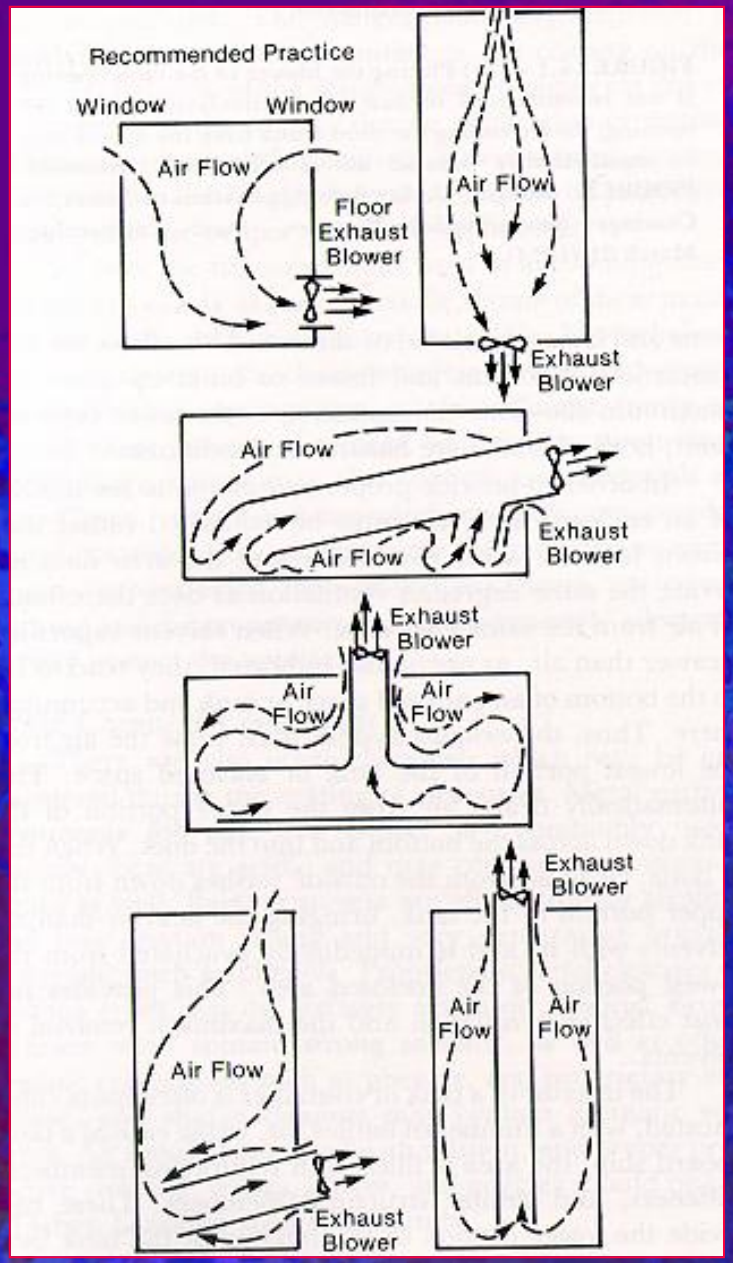
Note: Applicators are wearing paper filter masks, not organic vapor masks for PPE

Airless Pumps

Air Driven Pneumatic Airless Units

Plural Component Spray Pump (Fixed Ratio)

For Elastomer Urethanes or Polyurea Ctgs



Proper Ventilation: Use tubing to suck air out from bottom corners. All coatings require ventilation during cure.

Dehumidification and Ventilation:
Improves Quality of Blasting & Painting

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Basic Coatings Technology & Proper Selection of Coatings

Stan Osborne
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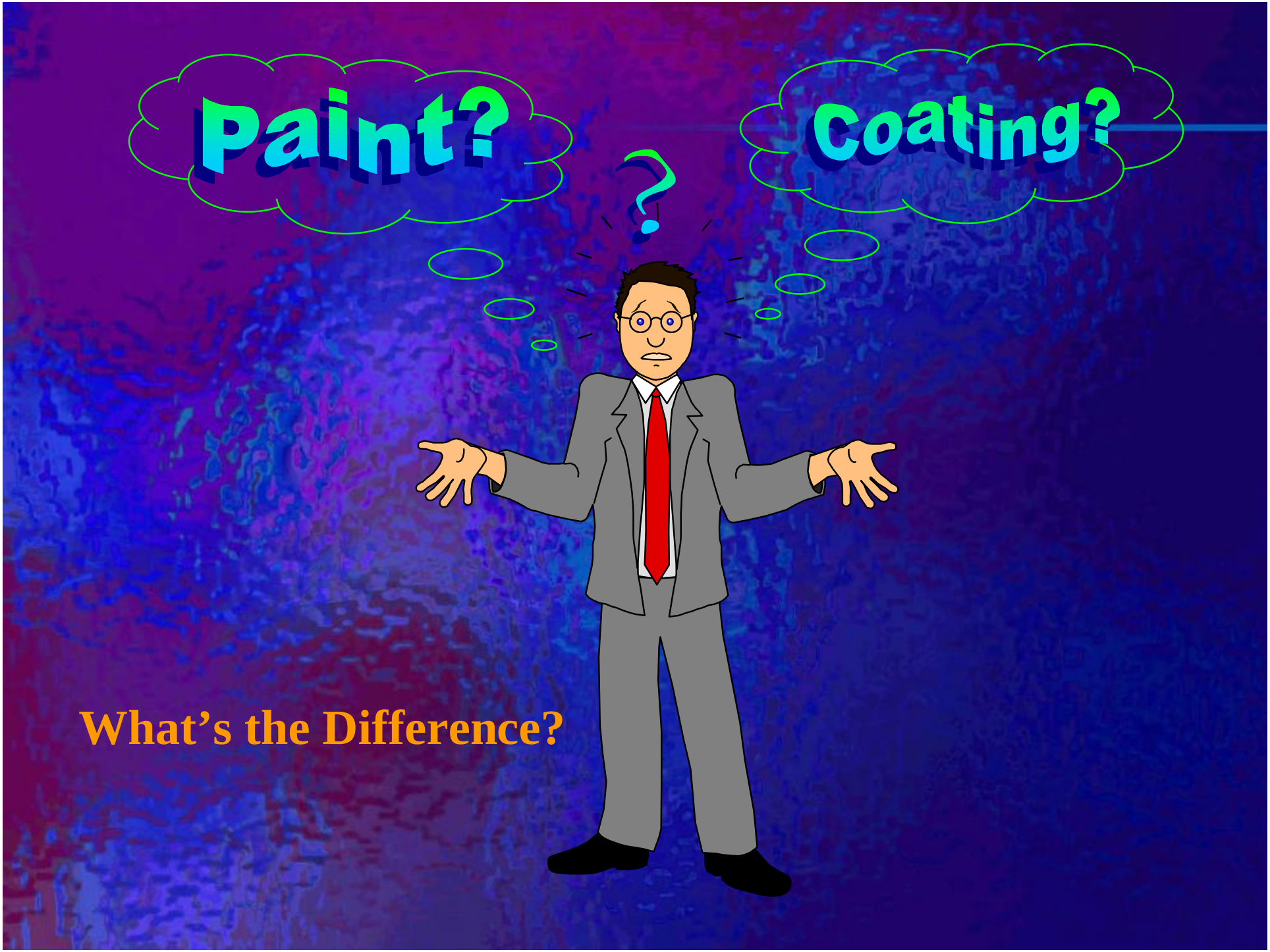
Coating Fundamentals



What's the Difference?

What's the Difference????

- "Paint" - usually associated with decorative or aesthetic uses.
- "Coating" - usually associated with protective or functional uses.

What goes into a Can of Paint?

- Resin
- Pigment
- Solvent
- Additives

What Do Resins Do?

- Binds pigmentation.
- Provides film forming material.
- Provides adhesion to substrate.
- Generally defines generic coating type

What Do Pigments Do?

- Provide :Opacity or hiding
- Provide Color – TiO_2 Titanium Dioxide (White), organic & inorganic liquid colorants
- Barrier Pigments (dry) - platy talcs, MIO, aluminum, mica, etc. applied at factory
- Anti-corrosive properties
  - Phosphates, borates, zinc pigment
- Extender Pigments (talc) – Cost reduction

What Do Solvents Do?

- Dissolve the resin system and allow the liquid material to be applied to a substrate
- Provide fluidity and flow
- Control “rate of dry” of the coating
- Modify cure rate of some two pack coatings

Additives

- Correct deficiencies in the coating formulation
- Improve application performance
- Improve sag resistance of applied film
- Perform “miracles” as needed . . . .

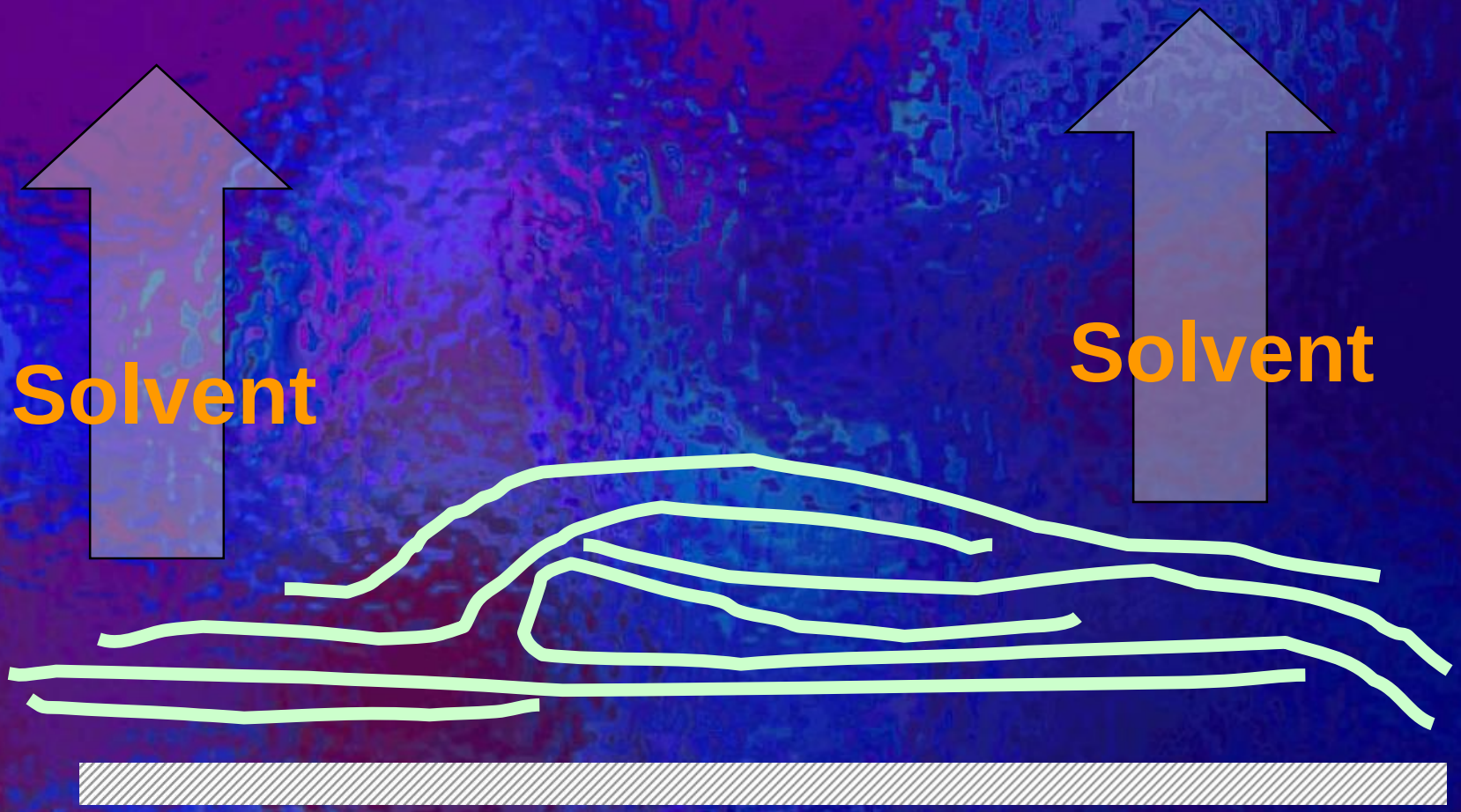
To Be Useful, Paint or Coatings Must...

- Be able to be applied to a substrate
- Convert from a liquid to a solid film
- Perform some desired function

How do Coatings Cure?

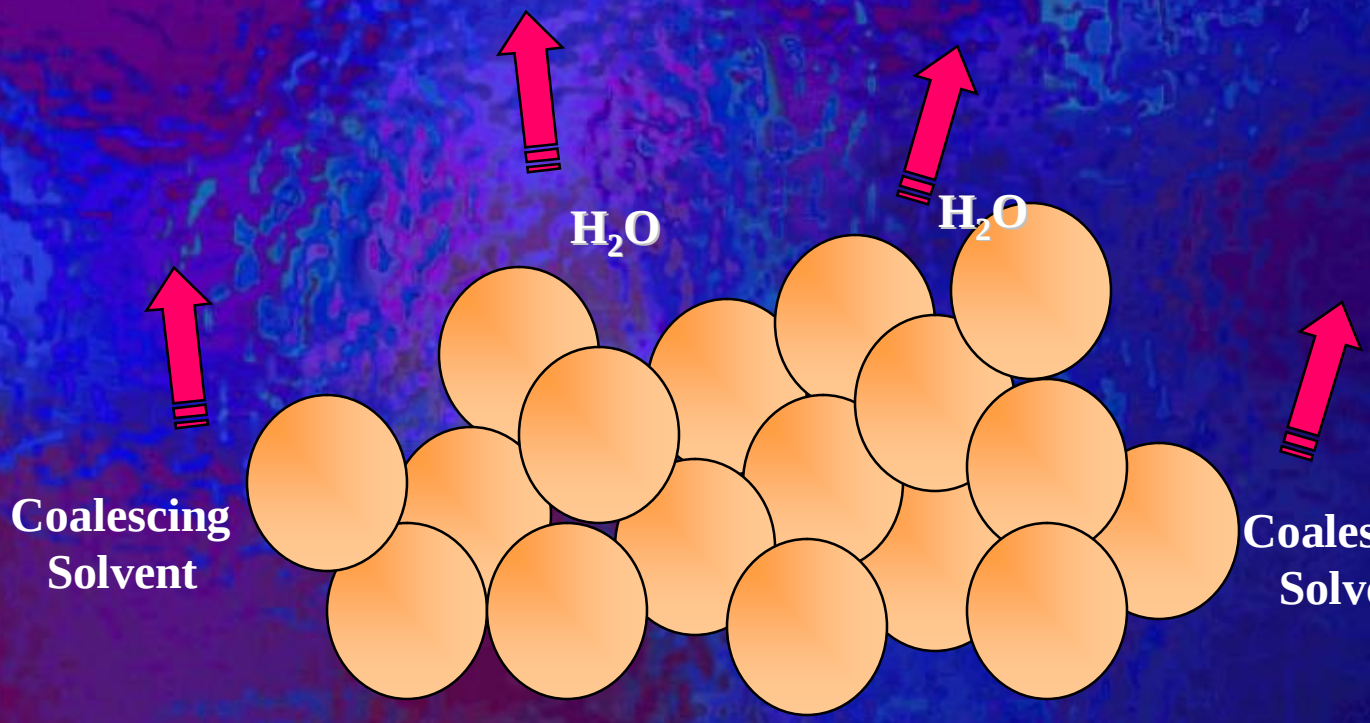
- Solvent Evaporation
- Coalescence (water base)
- Reaction with Atmosphere (solvent base)
  - Oxidation
  - Moisture Cure
- Reaction of Two Components (chemical crosslink)

Solvent Evaporation



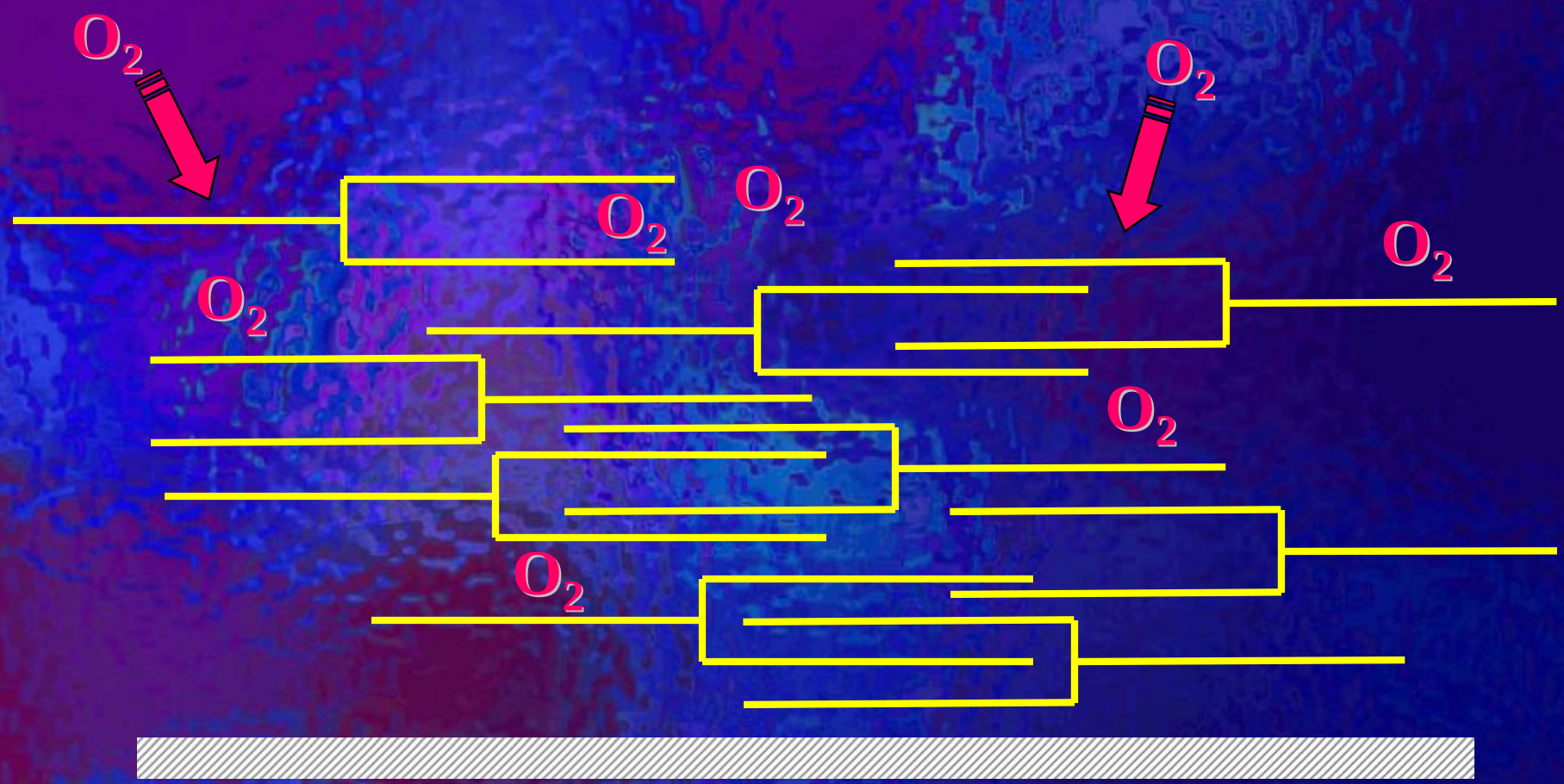
Types: Lacquer, Vinyl

Coalescence



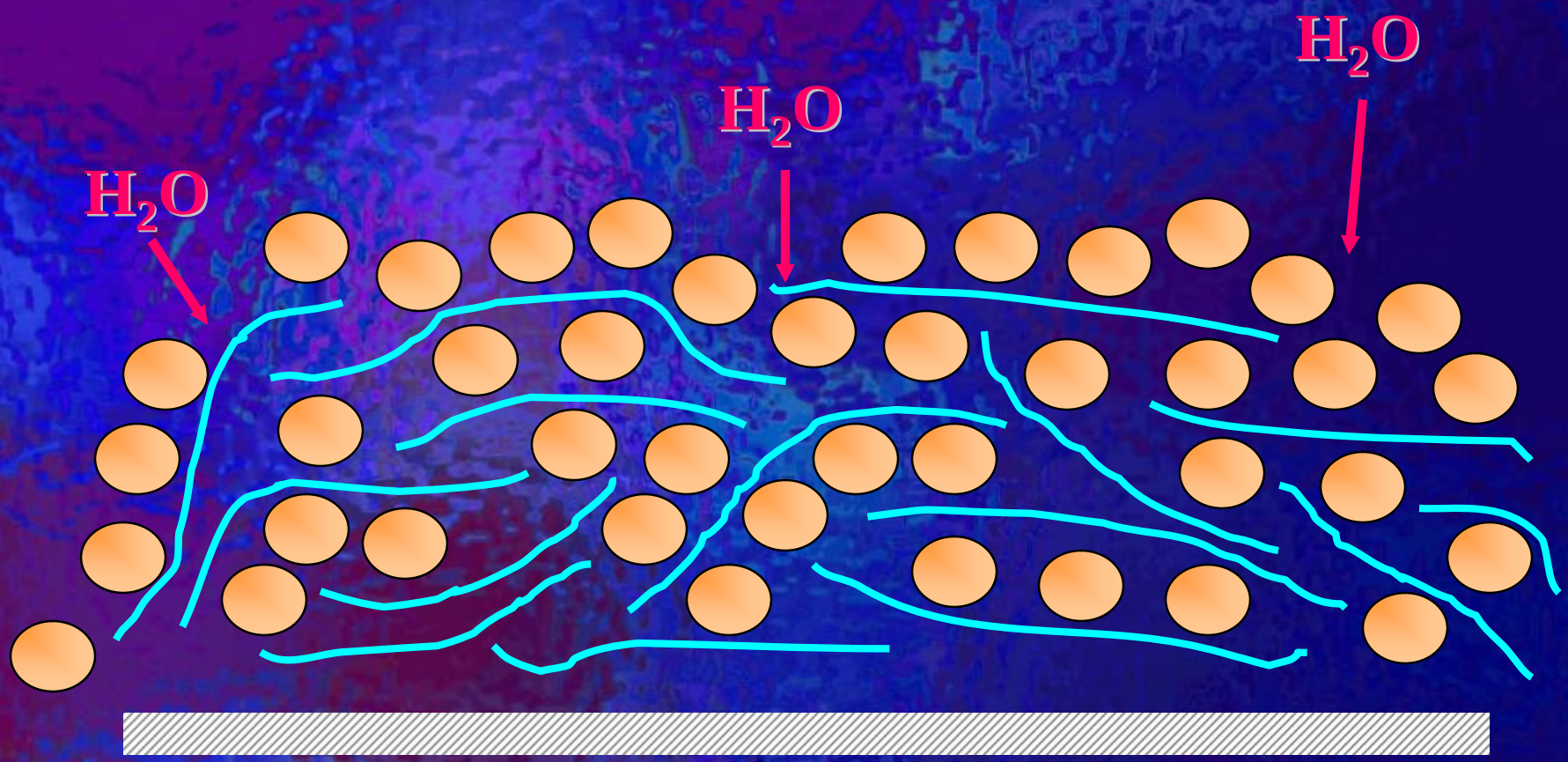
Types: Latex (Acrylic, PVA)

Atmospheric Reaction: Oxidation



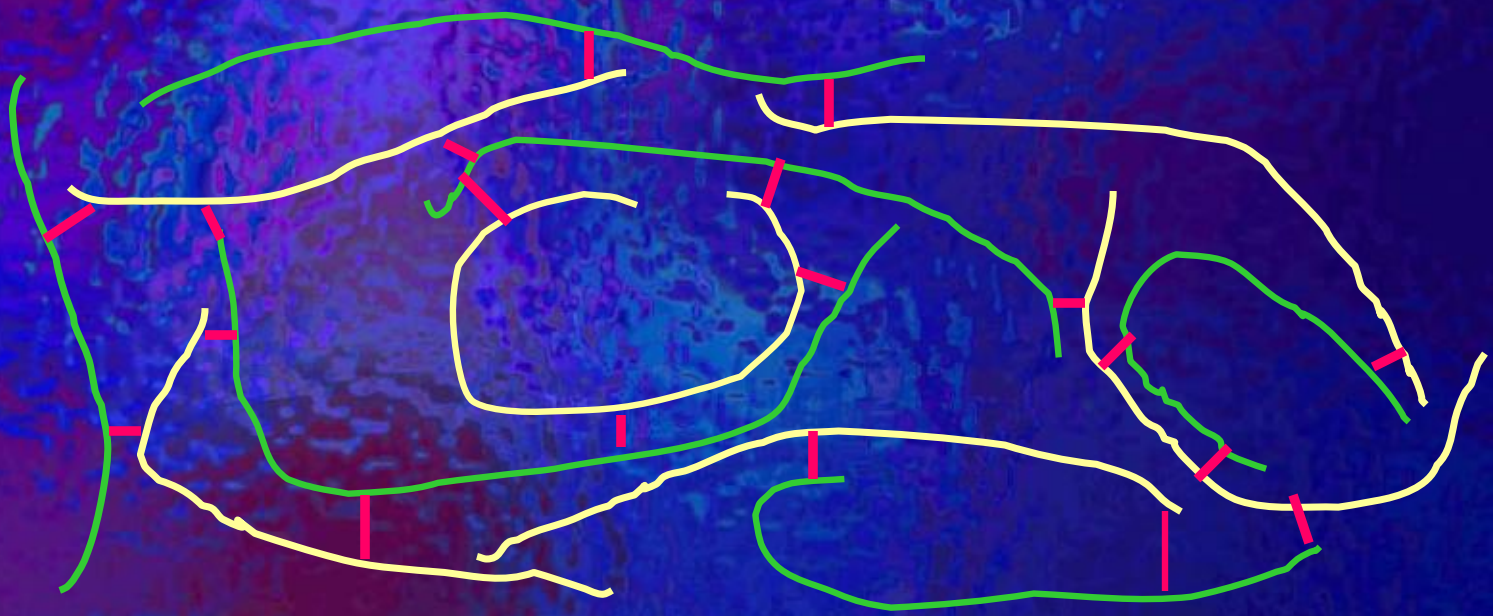
Types: Oil, Alkyd, Epoxy Ester, Urethane Alkyd

Atmospheric Reaction: Moisture Cure



Ethyl Silicate Zinc Primer, Moisture Cured Urethane

Reaction of Two Components (chemical crosslink)



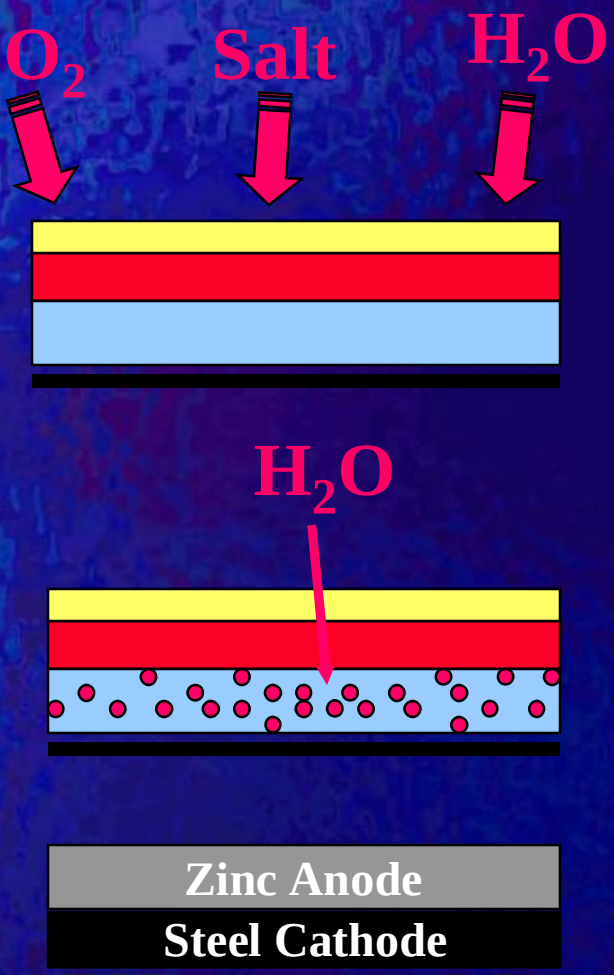
Polyurethane, Epoxy (Polyamide, Novolac, Amine)

How do Coatings Protect?

Barrier Protection

Rust Inhibitive Pigment

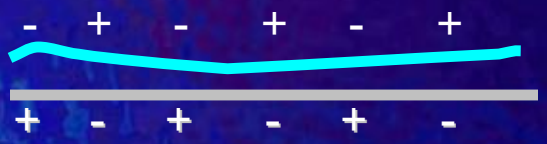
Galvanic Protection



How do Coatings Adhere?

- Chemical Adhesion

- Polar Adhesion



- Mechanical Adhesion

Generic Coatings Types

Generic Types

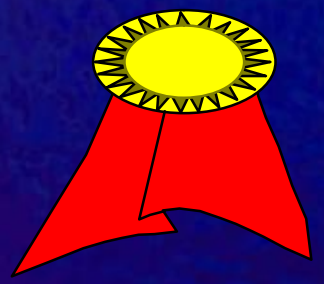
- Zinc
- Epoxy
- Polyurethanes
- Alkyds (oil base)
- Acrylics (water base)
- Specialties

Zincs

Zinc-Rich Coatings

A Major Advantage

“Only zinc-rich coatings can eliminate pitting corrosion at voids, pinholes, scratches and abrasions. This protective capability makes zinc-rich coatings so unique.”



Why do we use Zincs?

- Superior Corrosion Protection

Where do we use Zincs?

- Where best corrosion protection is required
  - IOZ and RIOZ & OZ are all effective
- New construction – IOZ Shop Applied
- Marine Environments – Severe Service
- Maintenance - RIOZ & OZ
  - More tolerance to lesser surface prep
  - Easier to apply in field

(Tanks, piping, structural steel that might experience coating system damage (scratching or chipping) are typical applications)

Types of Zinc Rich Coatings?

- Inorganic (IOZ)
  - Ethyl Silicate(solvent)
  - Lithium, sodium silicate (water)
- Organic (OZ)
  - Epoxy (solvent or water)
  - Moisture Cure Urethane (solvent)
- Reinforced Inorganic (RIOZ)
  - Hybrid with IOZ and OZ characteristics (solvent)

  (Proprietary Mfr's – Limited Availability)

Limitations

- IOZ
  - IOZ requires moisture to cure – no good in desert climates or low humidity regions
  - Mudcracking if over applied – 5mils max dft
  - High Potential for bubbles in film when topcoating
- OZ & RIOZ
  - Less heat resistance - 400°F v. 750°F
  - less solvent resistance - immersion

Organic vs Inorganic Zinc

Organic Resin

Carbon backbone

- C-C-C-C

Easier to Apply

Inorganic Resin

Silicate backbone

- Si-O-Si-O-Si

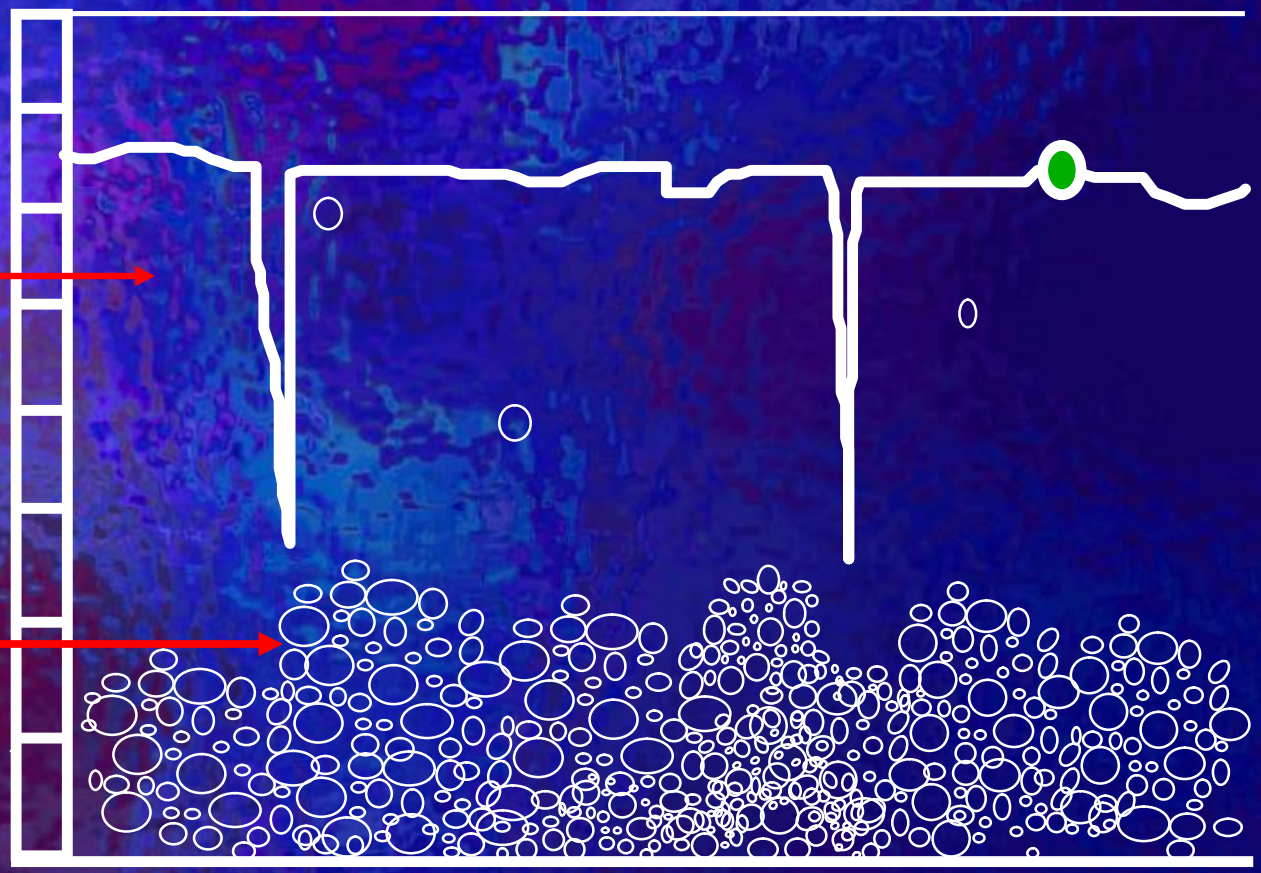
Stronger bonds: higher heat resistance

Better Corrosion Resistance

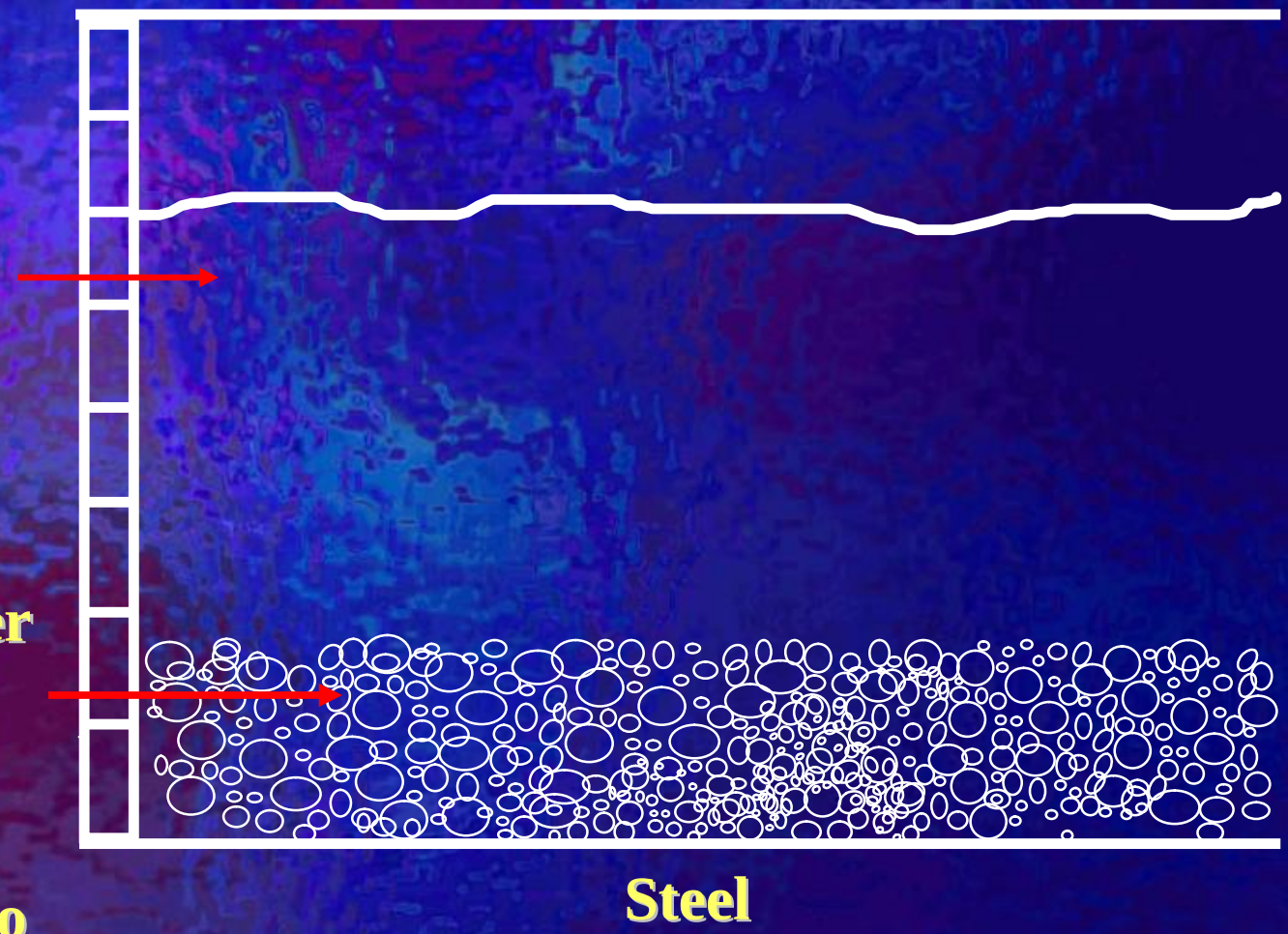
Ethyl Silicate Inorganic Zinc Primer: Bubbling Problems

High Build Protective Coating

Zinc Primer (many voids – air pockets between zinc particles)



Reinforced Inorganic Zinc Primer: No Voids - No Bubbles



Reinforced Inorganic Zincs vs Traditional Inorganic Zincs (cont.)

- Film is essentially void free
  - Eliminates topcoat bubbling - No Mist/Tie coat of epoxy required
  - Does Not require humidity to proper cure (fast recoating)
- Improved adhesion and flexibility
  - Tolerates less surface preparation (SP-6)
  - Can be recoated over itself
  - No cracking on 90^{o} bend
  - High resistance to mud cracking
- Lower heat & solvent resistance
  - Resists 400F dry heat (vs 750F of traditional IOZ)
  - Cannot be used as a tank lining for solvents

Reinforced Inorganic Zinc Benefit Summary

- Improves Compatibility with many topcoats
- Speeds up Recoat Time (30 Min. @ 75 ^{0}F)
- Resists Splitting - excellent flexibility
- Resists Mud Cracking – Less Rework
- Reduces Salting (recoat months later)
- Reduces Bubbling when topcoated - No Epoxy Mist/Tie Coat required - A HUGE BENEFIT
- Not Humidity Dependent – Use in Arid Climates

Epoxies

Why do we use Epoxies?

(and what do they provide)

- Excellent Adhesion
- Superior Barrier Protection
- Superior Corrosion Resistance
- Excellent Chemical Resistance

Where do we use Epoxies?

- When good barrier properties needed
- New construction
- Maintenance painting in the field
- Tank Linings
- Floor Coatings – Secondary Containment
- Marine Environments

Types of Epoxy Coatings?

- Designated by curing agent type
  - polyamines
  - polyamides
  - alkylated phenolic polyamines
- Solvent and water based

“Polyamine Epoxy” Advantages

- Water Immersion
- Good Chemical Resistance
- Good Acid Resistance
- Fast Cure
- Alkali Resistance

“Polyamine Epoxy” Limitations

- Short pot life
- Amine Sweat or Blush
  - CO_2 and Water
- Chalking, Fading, Yellowing, Etc.

“Polyamide Epoxy” Advantages

- Surface Tolerance
- Decent Recoatability
- Adhesion and Wetting
- More Tolerant of Surface Moisture

“Polyamide Epoxy” Limitations

- Poor Exterior Exposure Resistance
- Application Above 50°F
- Limited Chemical Resistance
- Chalking, Fading, Yellowing, Etc.

“Waterborne Epoxy” Advantages

- Low Odor
- Waterborne - Safety
- Good Chemical Resistance

“Waterborne Epoxy” Limitations

- Usually Not For Water Immersion
- Application Above 50°F
- Working Life versus Pot Life
- No Surface Tolerance For Oil
- Chalking, Fading, Yellowing, Etc.

Modified Epoxies

Why Modify Epoxies?

To improve some particular characteristic

- water resistance
- weather resistance
- flexibility
- recoatability
- reduce viscosity

“Coal Tar Epoxy” Advantages

- Excellent Water Resistance
- Good Acid Resistance
- High Film Build Possible
- “Historical Old School Coating Standard” In Waste Water Treatment

“Coal Tar Epoxy” Limitations

- Safety
  - Skin Burns
  - Carcinogenic
- Bleeding of Light Topcoat Colors
- Difficult to Recoat
- Stability In Container is Poor

"Hydrocarbon Modified Epoxy - Coal Tar Offset" Advantages

- Formulated with synthetic hydrocarbon resin
  - Will not cause coal-tar burns
  - Improved water resistance
  - Improved can stability (1 year vs coal tar @ 6 months)
  - Improved recoatability (30 days vs coal tar @ 20 hrs)

“Synthetic” Tar Technology

- Lower Material Cost
- Coal Tar Performance Without Coal Tar Associated problems
- No Coal Tar Burns – Worker Safe
- Not Carcinogenic Like Coal Tar
- Superior Performance
- Superior Application Elements

“Hydrocarbon Modified Epoxy-Coal Tar Offset” Limitations

- Like Coal Tar, Available Only In Black
- Aromatic Backbone, Chalks And Turns Gray On Exterior Exposure

“Hydrocarbon Modified Epoxy” Light Color Base Advantages

- Hydrocarbon Resin Improves water resistance
- Non-bleeding so may be overcoated
- Multiple Uses
- Effective cost

“Hydrocarbon Modified Epoxy”
Light Color Base
Limitations

- Reduced Solvent And Chemical Resistance
- Not able to provide long term Cosmetic Appeal
- Aromatic backbone not UV resistant

"Alkylated Phenolic Polyamine Modified Epoxy" Advantages

- True low temperature cure to 0°F, without use of deleterious cure additives for temps below 50F
- Excellent surface tolerance (power tool cleaning) even for water immersion
- High Solids = High Build film build capability

"Alkylated Phenolic Polyamine Modified Epoxy" Limitations

- Color changes (yellowing) more than polyamides
- shorter recoat window due to low temp cure built into formulation
- Not UV resistant

Please, Remember That...

Based on the Aromatic backbone, All Epoxy Coatings On Exterior UV Exposure will:

Chalk

Fade

Color Drift

This does not negatively affect corrosion protective performance

Urethanes

Why do we use Urethanes?

- To Provide Excellent Color and Gloss Retention
- When a structure needs to look good (cosmetics)
- To provide abrasion resistance in the finish coat for specific applications (ie: Floor Coatings)

Where do we use Urethanes?

- Exterior applications for appearance and cosmetic appeal
- New construction (shop & field)
- Maintenance painting in the field
- Interior applications for chemical resistance properties
- Can be used as finish coat for Flooring Installations

Types of Urethanes Coatings?

- Two Component Aliphatic Urethanes
- Two Component Polyaspartic Polyurethane
- Single Component Moisture Cure Urethanes
- 100% Solids Elastomer Polyurethane Fast Set Coatings – Two Component

“Aliphatic Acrylic Polyurethane” Advantages

- Maximum color and gloss retention
- Excellent Ultraviolet Light (UV) resistance
- Hard, mar & graffiti resistant finish
- The “Ultimate” finish coat for cosmetic appeal and appearance

“Aliphatic Acrylic Polyurethane” Disadvantages

- Poor Recoatability after maximum recoat window is exhausted (requires abrading)
- Sensitive to surface moisture at time of application
- Relatively expensive (due to aliphatic backbone UV resistance properties)

“Polyaspartic Polyurethane” Advantages

- Excellent color and gloss retention
- Excellent Ultraviolet Light (UV) resistance
- Very fast cure and return to service (much quicker than Aliphatic Acrylic Polyurethanes) 5hrs dry hard @ 70F
- Atmospheric Humidity aides in fast cure and quick weather resistance
- Suitable for floor finish with fast turnaround

“Polyaspartic Urethane” Disadvantages

- Poor Recoatability after maximum recoat window is exhausted (requires abrading)
- Sensitive to moisture on surfaces at time of application
- Relatively expensive (due to aliphatic backbone UV resistance properties)

“Single Component Moisture Cured Urethane” Advantages

- Single Package
- Perceived as simple to apply under all conditions – (sometimes oversold)
- Utilizes atmospheric humidity to dry

“Single Component Moisture Cured Urethane” Disadvantages

- Poor Recoatability – Inter-coat sensitivity
- Requires atmospheric humidity to dry – trouble in low humidity climate zones
- Critical Re-Coat windows (ie: MC Tar)
- Overbuilding can create solvent entrapment / micro blistering
- Very Expensive Coating System when compared to convention two pack systems

“Elastomer Polyurethane Fast Set Coatings” Advantages

- Very Fast dry time (ie: 15 seconds to handle)
- Fast Return to Service
- Extremely High Film Build Capabilities via multiple pass of spray gun
- Elastomeric properties
- 100% Volume Solids – Very Low VOC
- Relatively expensive – due to high films

“Elastomer Polyurethane Fast Set Coatings” Disadvantages

- Primers recommended to wet out substrate and provide high adhesion
- High dry film thickness required to provide chemical resistance – can delam in sheets
- Very Sophisticated Plural Spray Equipment Required for Installation
- Most manufacturer’s only have aromatic formulation (chalk, fade & lose gloss in UV)

Single Component

Conventional Paints & Coatings

"Alkyd" (Oil/Solvent Base) Advantages

- Moderate Cost
- Good color and gloss retention (3-4 yrs.)
- Ease of application-brushing/rolling
- Less critical surface preparation-good wetting
- Historical workhorse for Light Duty Industrial installations

“Alkyd” (Oil/Solvent Base) Limitations

- Slow drying - skinning over - long oil
- Poor chemical resistance
- Relatively poor water resistance
- Poor flexibility and impact resistance - short oil
- High Humidity can negatively affect gloss during application/cure
- Yellows and chalks in UV exposure

" Silicone Modified Alkyd" (Oil/Solvent Base) Advantages

- Higher Cost than Alkyd Enamel (silicone additive 30%)
- Good color and gloss retention (6+ yrs.)
- Ease of application-brushing/rolling
- Less critical surface preparation-good wetting
- Silicone Modification improves resistance to Yellowing and chalking in UV exposure
- Historical workhorse for Military/Marine Exterior UV installation

“Silicone Modified Alkyd” (Oil/Solvent Base) Limitations

- Slow drying - skinning over - long oil
- Poor chemical resistance
- Relatively poor water resistance
- Poor flexibility and impact resistance - short oil
- High Humidity can negatively affect gloss during application/cure

“Epoxy Ester” Advantages

- Abrasion Resistance
- Chemical Resistance Better Than Alkyd
- Ease of application-brushing/rolling
- Less critical surface preparation-wetting – tolerates rusty surfaces
- Single package for ease of use

“Epoxy Ester” Limitations

- Poor Color And Gloss Retention On Exterior
- More Expensive Than Alkyd
- Color will drift in UV Exterior Exposure

“Waterborne Acrylics” Advantages

- Safety - Waterbased - Low Odor
- Excellent Color and Gloss Retention
- Wide Range of Colors Via Tint Bases
- Fast Dry
- Usually Rather Flexible

“Waterborne Acrylics” Limitations

- Usually Require Temperatures Above 50°F
- Not Abrasion Resistant
- Temperature Resistance 200°F max.
- Not Much Chemical Or Water Resistance
- High Humidity retards drying and cure
- Does Not provide Equivalent Performance of an Aliphatic Polyurethane Two Pack Product

UV Resistance of Topcoats
(Gloss and Color Retention)

	UV Resistance	Aesthetic Life (Years)
Alkyd	Fair	3 – 4
Latex	Good	6 - 8
Modified Silicone[1]	Good	6 - 9
Epoxy	Poor	1 - 2
Polyurethane	Excellent	9 - 12
Vinyl/Chlor Rub	Good	6 - 8
Pure Silicone	Excellent	9 - 12

1. Modified Silicone = Silicone Alkyd or Silicone Acrylic

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THANK YOU
FOR YOUR INTEREST & ALLOWING DEVOE COATINGS TO ASSIST WITH PROTECTING YOUR FACILITIES ASSETS

Stan Osborne
Sr. Industrial Coatings Specialist
ICI Devoe Coatings

ICI PAINTS
DEVOE COATINGS

Contact Information:

Washington/Alaska/Idaho/MT/WY

Stan Osborne

Phone: (253) 209-3120

Email: stan_osborne@ici.com

Fax: (253) 471-9130

Contact Information:

Oregon State

Ron Watts

Phone: (541) 673-0019

Email: ron_watts@ici.com

Fax: (541)673-0019