A Systems Approach To Depaint Chemistry

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AERO CHEM LLC

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Properties Effecting Coatings Removal

- Type of polymer.
- Tg
- Crosslink density
- Molecular wt. of polymer
- Chain entanglement
- Curing mechanism
- Cohesive and adhesive forces at work.
- DFT
- Age of coating.
- Environmental exposures
- Degree of curing.
- Modulus
- Pigmentation type and CPVC
- Additives
- Polarity
- Tacticity of the polymer
- Morphology
- Backbone and pendant functional groups
- Temperature
- Crosswinds
- Scuff sanding
- Steric effects

THE PROBLEM:

NESHAP changed everything!

- Good by MC, Phenol and the like.
- HAPS List of 189 chemicals.

Production time is wasted on products that work too slow.

Paint removers today are formulated as an afterthought.

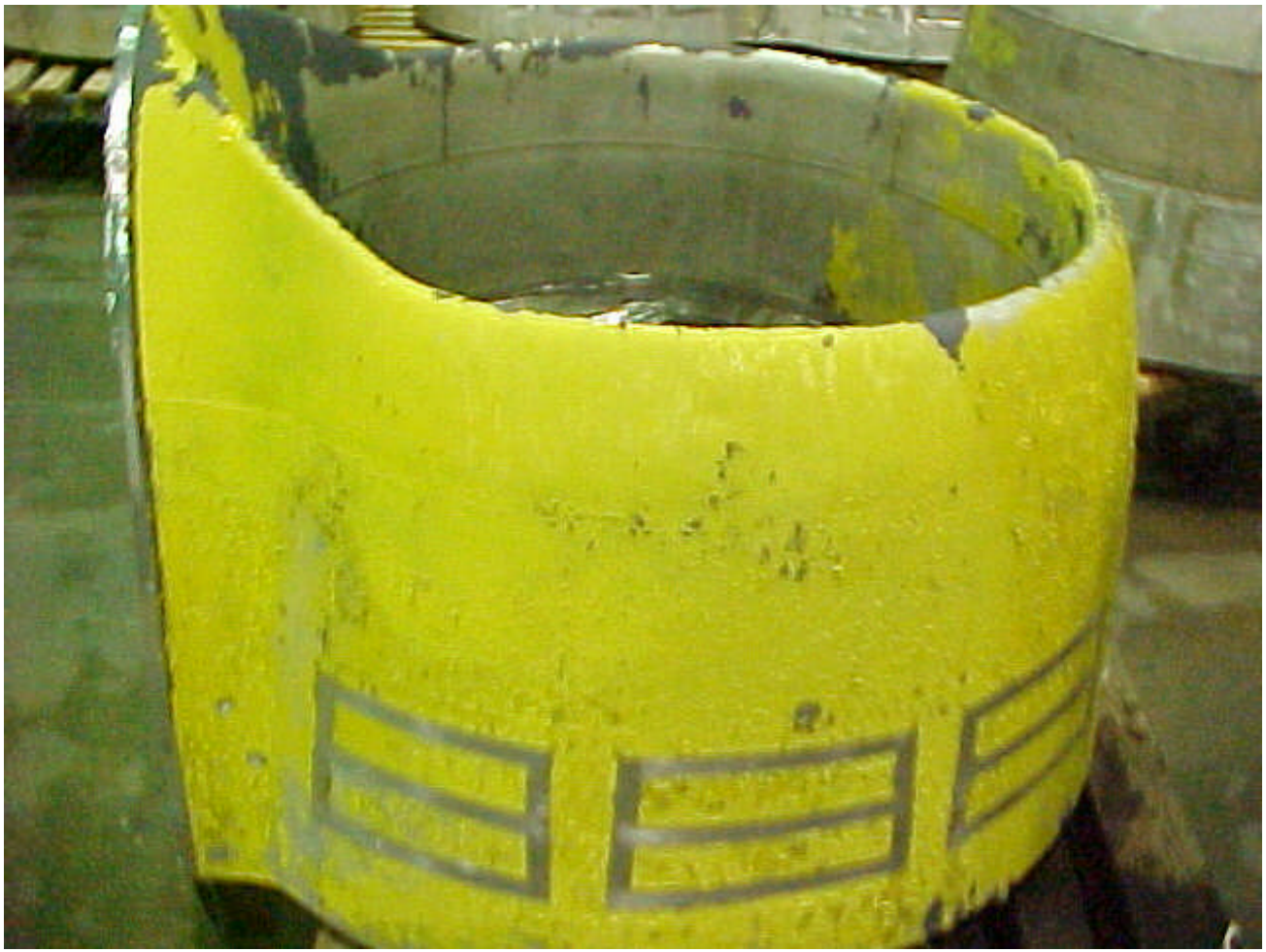
- Over the past 20 years coatings formulation has become a science.

- No such development has taken place with chemical paint removers.

The aircraft industry today requires better paint removal products.

- Coatings companies are making better products.
- The use of adhesion promoters has been added to the mix.
- Application to composite substrates.
- OEM’s and the Military are demanding better coatings i.e. APC.

Coatings have improved resulting in paint remover performance gap.



Science is needed to resolve these performance issues.

THE ANSWER
A SYSTEMS APPROACH

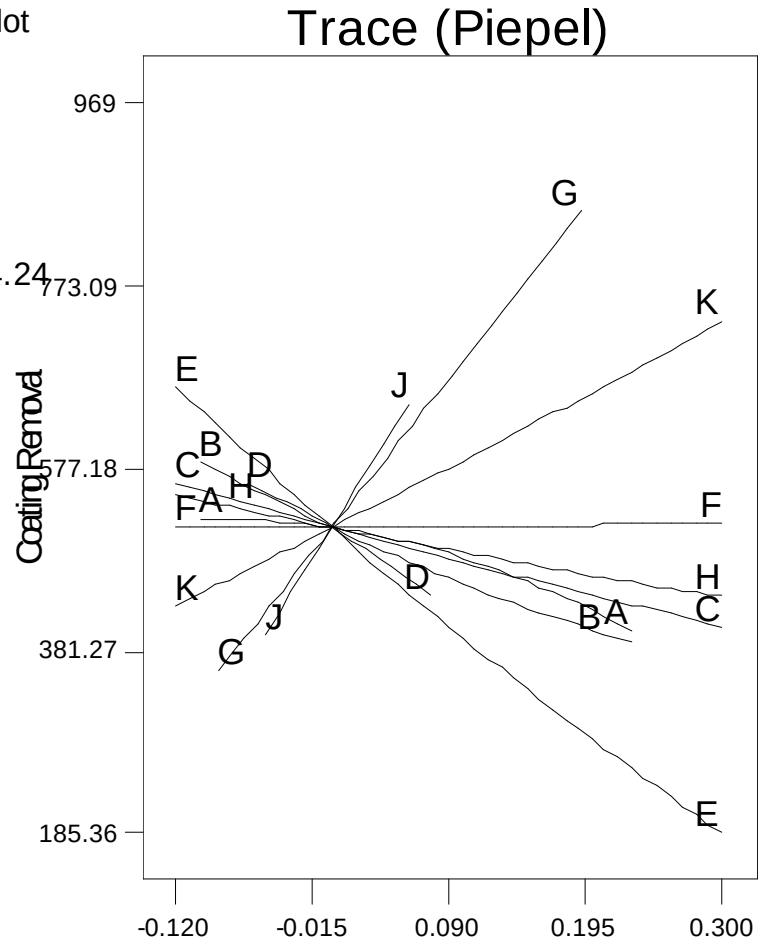
Using DOE, DOM and Aerochem Matrix provides a scientific method.

SCREENING DATA

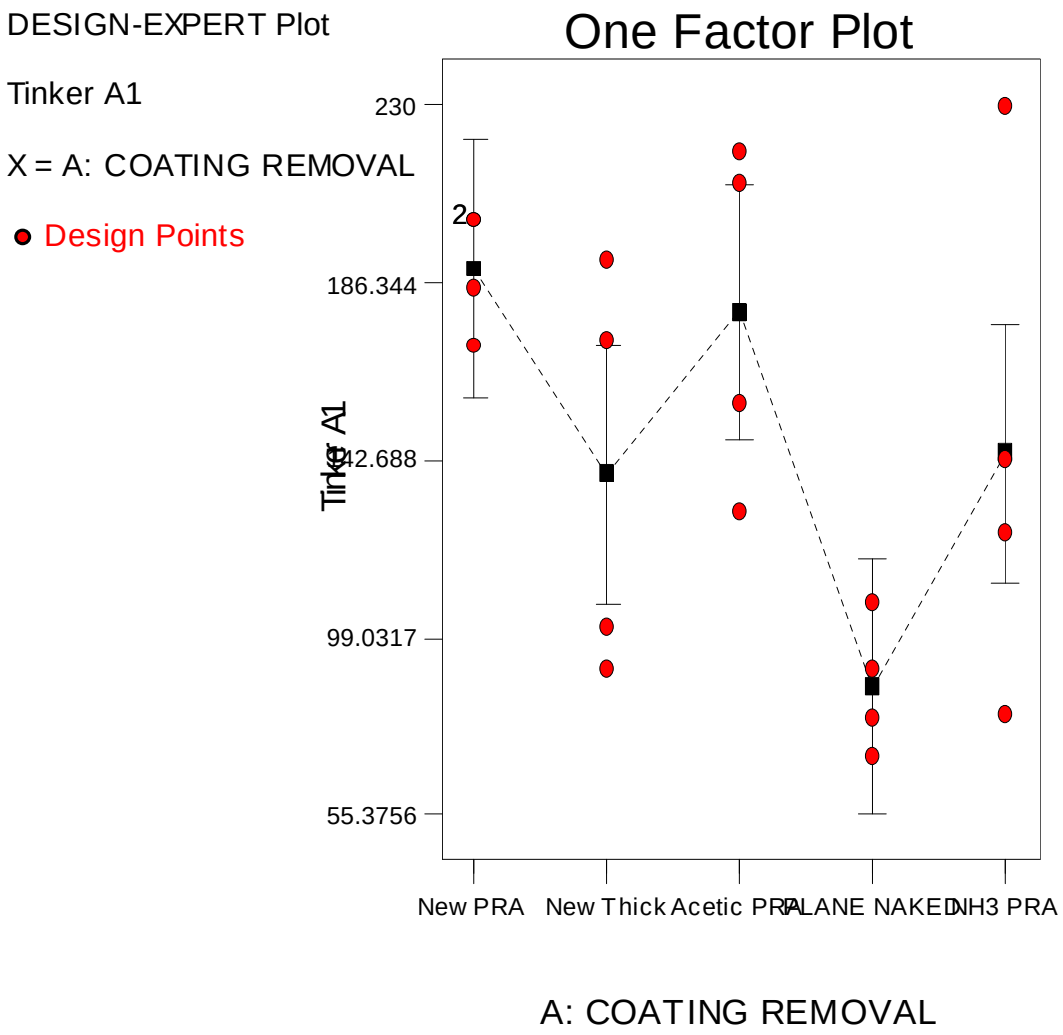
DESIGN-EXPERT Plot

Coating Removal

Actual Components
A: A150ND = 6.54
B: DIOX = 6.54
C: FORMAMIDE = 4.24
D: MEA = 2.27
E: DBM = 4.24
F: TMB = 4.24
G: DMA = 3.12
H: MCT = 4.24
J: TPP = 2.80
K: Water = 24.24



ONE FACTOR PLOT



Aerochem Matrix

Hansen Solubility Parameter Formula X-9 5/31/05

	7 pH				
Solvent	**Percentage**	*Sd*	*Sp*	*Sh*	*MV*
CHEMICAL	0.391	18.2	6.3	6.1	103.6
CHEMICAL	0	15.1	12.3	22.3	40.7
CHEMICAL	0.12	16	5.1	12.3	69.9
CHEMICAL	0.12	17.5	0	3	107
CHEMICAL	0.015	18	0	2	
CHEMICAL	0	17	15.5	21.2	59.8
CHEMICAL	0.28	15.5	16	42.3	18
CHEMICAL	0	17.2	26.2	19	39.8
CHEMICAL	0	17.3	18.7	22.4	60.82
CHEMICAL	0.07	16.1	9.2	15.3	101.1
CHEMICAL	0	17.8	4.1	6.7	119.1
CHEMICAL	0	18	0	0.06	139.8
CHEMICAL	0	17.8	6.3	5.1	104
Percentage Total	**100%**				

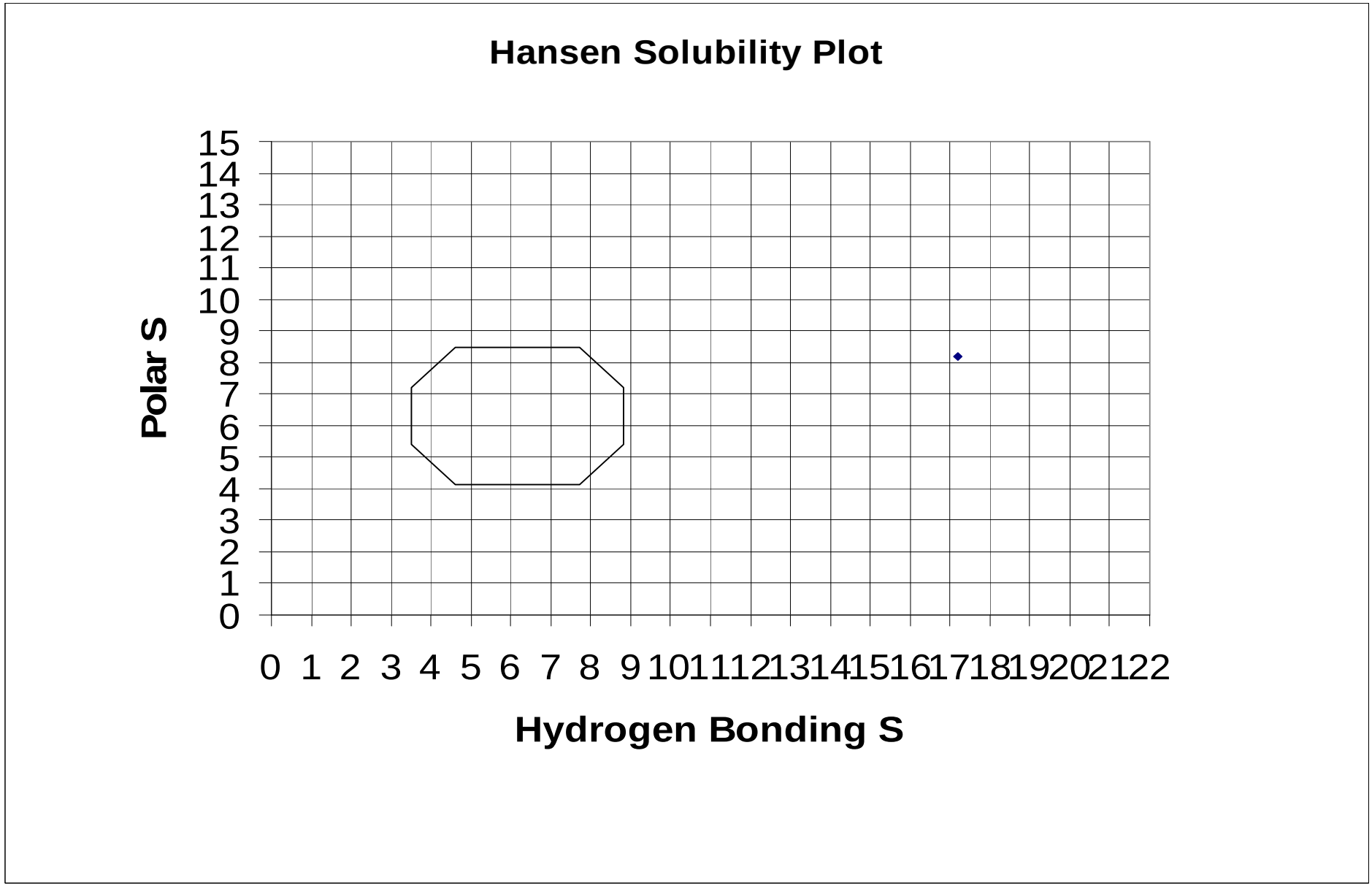
Fractional Parameters	S_d	S_p	S_h	
	7.1162	2.4633	2.3851	
	1.92	0.612	1.476	
	2.1	0	0.36	
	0.27	0	0.03	
	4.34	4.48	11.844	
	1.127	0.644	1.071	
Final Blend Parameters	16.8732	8.1993	17.1661	
	S_d	S_p	S_h	
	16.9	**8.2**	**17.2**	
Fractional Parameters	**39.9%**	**19.4%**	**40.6%**	**100.0%**

Aerochem Matrix Continued

POLYMER SOLUBILITY EQUATION

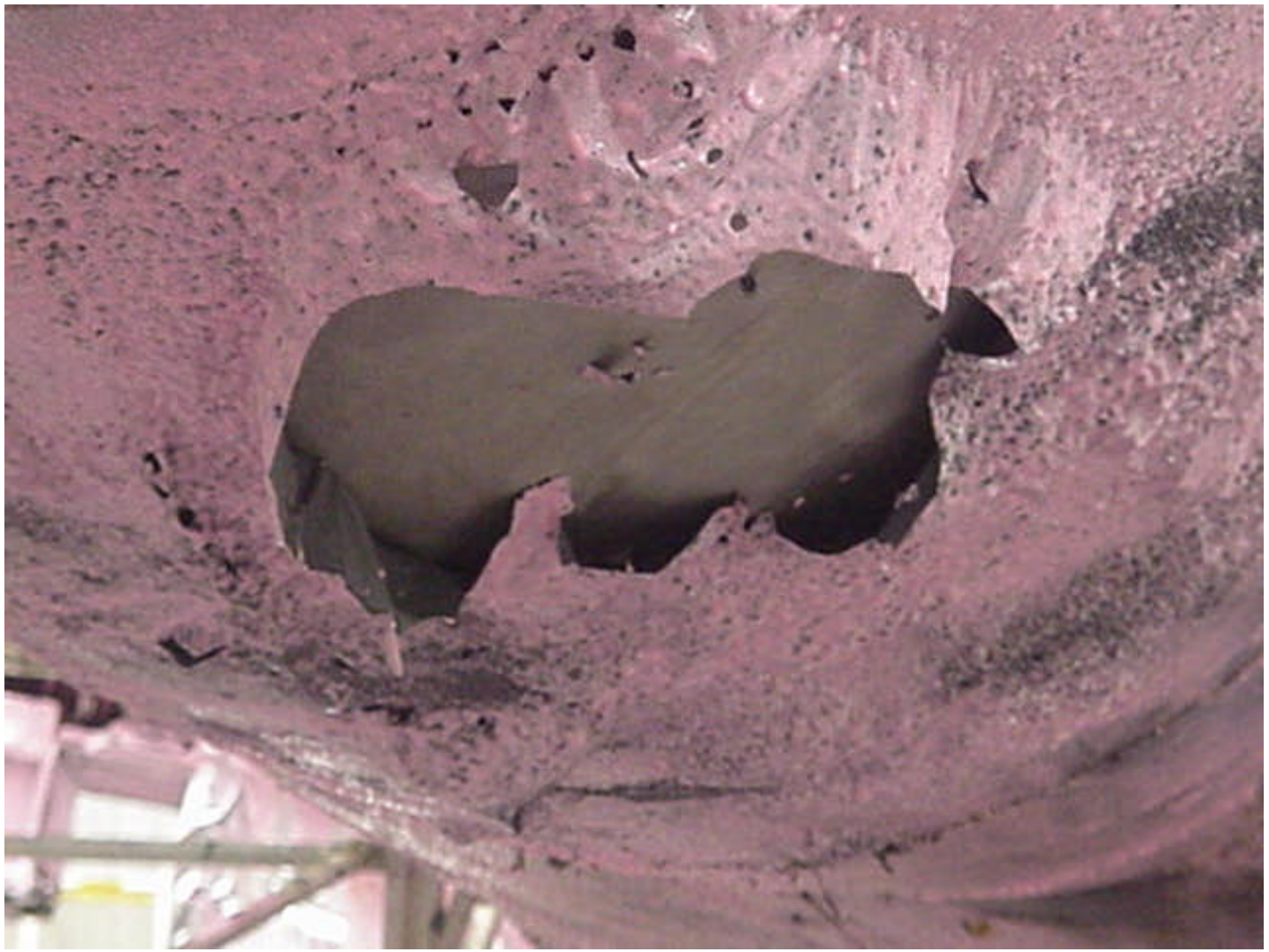
Polymer	δd	δp	δh	***Radius***
Epoxie	16.6	14	2.8	14.9

Aerochem Matrix Continued



Aerochem’s Paint Remover Matrix speeds up the chemical selection.

DOE and DOM provides statistical data that clearly provides answers.



1) Training and experience in coatings and corrosion chemistry is a must.

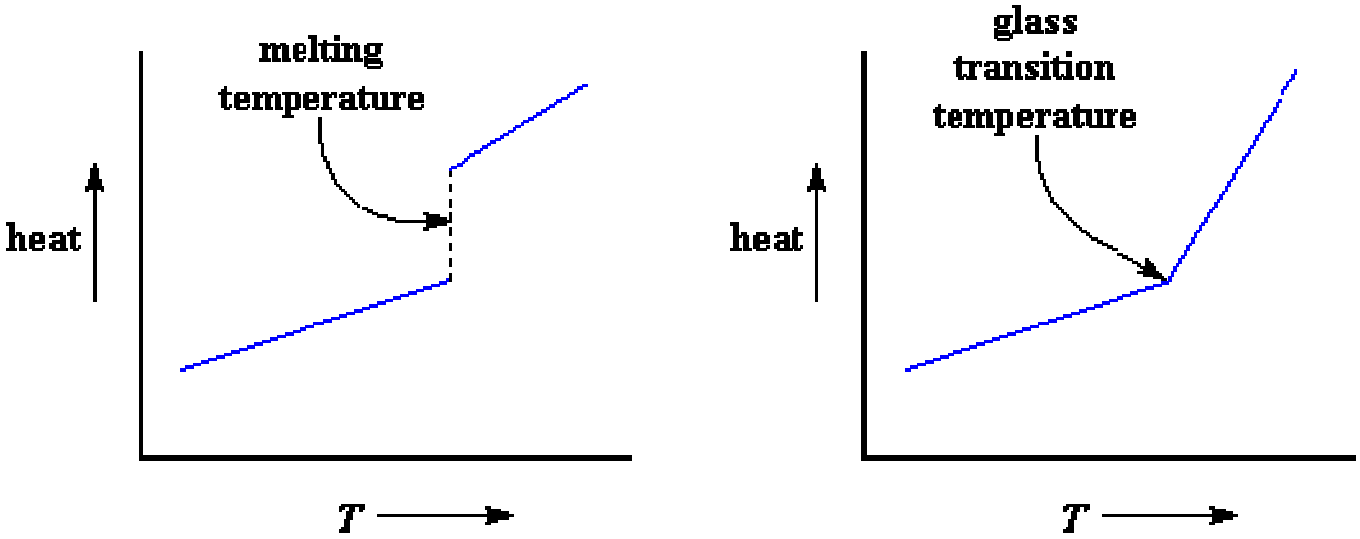
2) All the tools in the world cannot replace subject matter knowledge!

THE SCIENCE OF PAINT

What is Paint

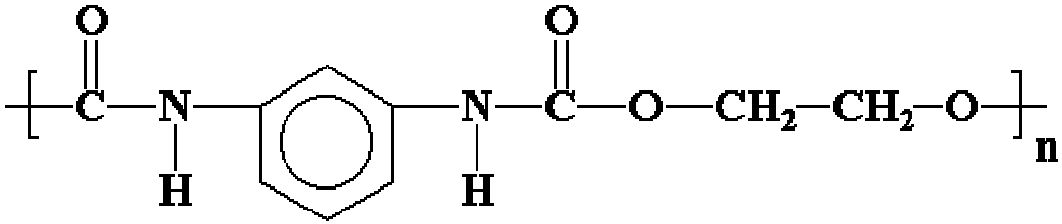
- Dispersion of pigments in a vehicle and solvents. Cast into a continuous colored film by curing through solvent evaporation, oxidation, catylization or other means.
  - Vehicle: Film former, binder, resin or polymer. Imparts properties of toughness, durability, dry time, etc..,.
  - Solvent: Carrier for the binder. Allows for sparyability of the coating. Two types are True and Diluent Solvents.
  - Pigment: Provides hide, color, barrier, and corrosion inhibition.
  - Extender Pigments: Do not impart hide or color, but control gloss and reduce cost (Clays, talcs, calcium carbonates.)

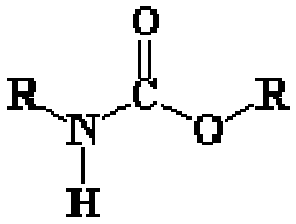
Glass Transition (Tg)



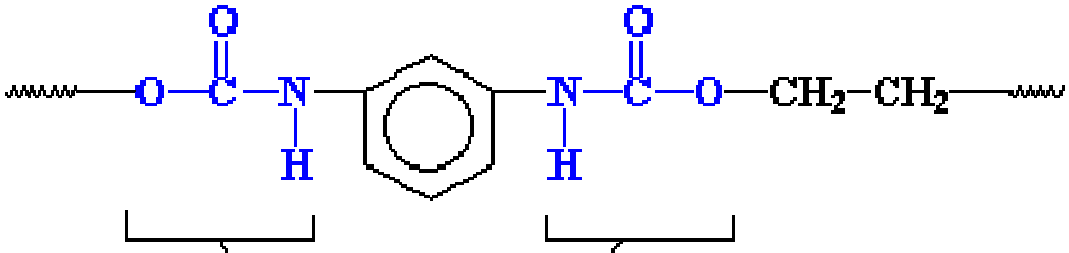
A heat vs. temperature plot for an crystalline polymer, on the left; and a amorphous polymer on the right.

Polyurethanes



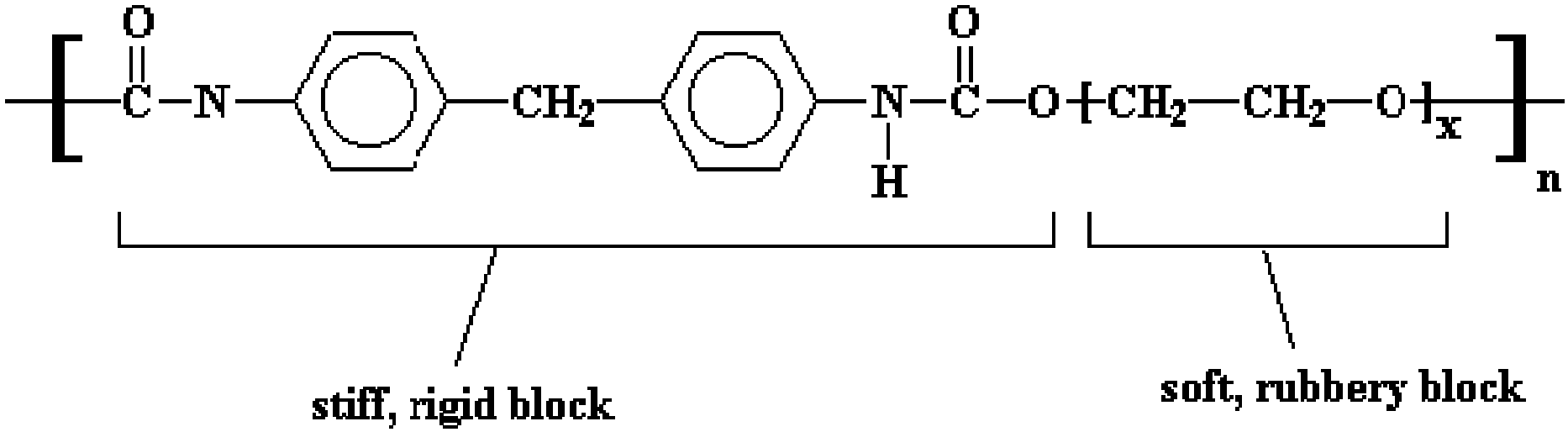


a urethane



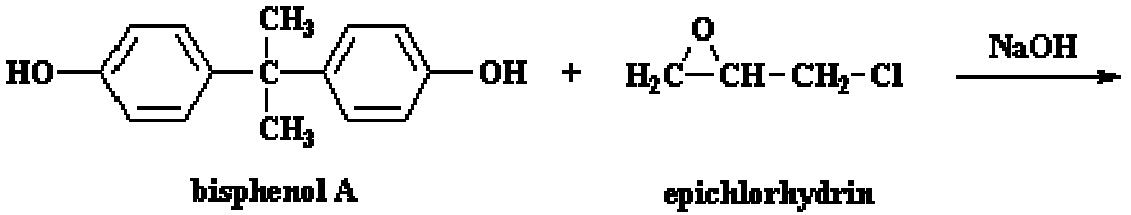
the urethane linkages
in a polyurethane

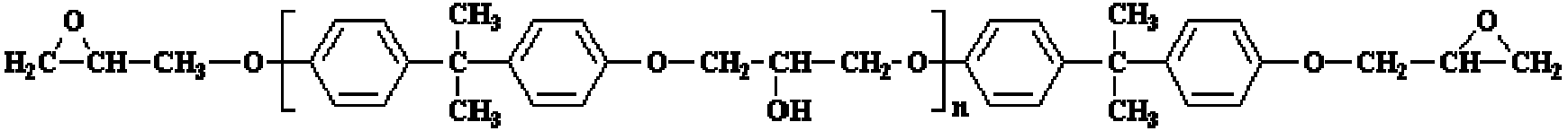
Modulus of Polyurethane



a polyurethane made from a polyglycol

Epoxies


HO
CH3
C
CH3
OH
+
O
H2C
CH
CH2
Cl
NaOH
bisphenol A
epichlorhydrin


O
H2C
CH
CH3
O
CH3
C
CH3
O
CH2
CH
CH2
O
OH
n
CH3
C
CH3
O
CH2
CH
CH2
O

EPOXY PROFILE

- Bisphenol A is a ridged moiety that provide toughness, chemical and heat resistance
- There are no ester groups in the epoxy molecule, only ether and carbon-carbon linkages. This composition leads to excellent chemical resistance.
- Pendant hydroxyls and terminal oxirane groups provide good wetting and adhesion, as well as reactivity with other resin species

Coatings Adhesion

- Wetting properties.
- Mechanical adhesion.
- Chemical adhesion (primary forces).
- Physiochemical adhesion (secondary forces).
- Adhesion promoting additives.
- Surface and polymer moieties.

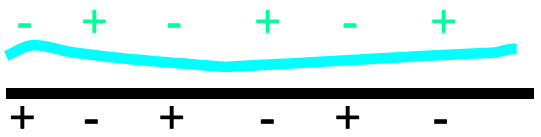
Adhesion Defined

- Presenting Paint Adhesion
- The problem of complex and multiple adhesion forces between the material to be removed and the underlying substrate, along with cohesive forces in the material itself.
- ASTM D 907 adhesion definition: “The state in which two surfaces are held together by interfacial forces which may consist of valence forces or interlocking action or both”.
- A more technical definition: adhesive forces are the sum of all interatomic and intermolecular interactions, and it’s these interactions that must be speedily and effectively overcome in chemical stripping.

ADHESION

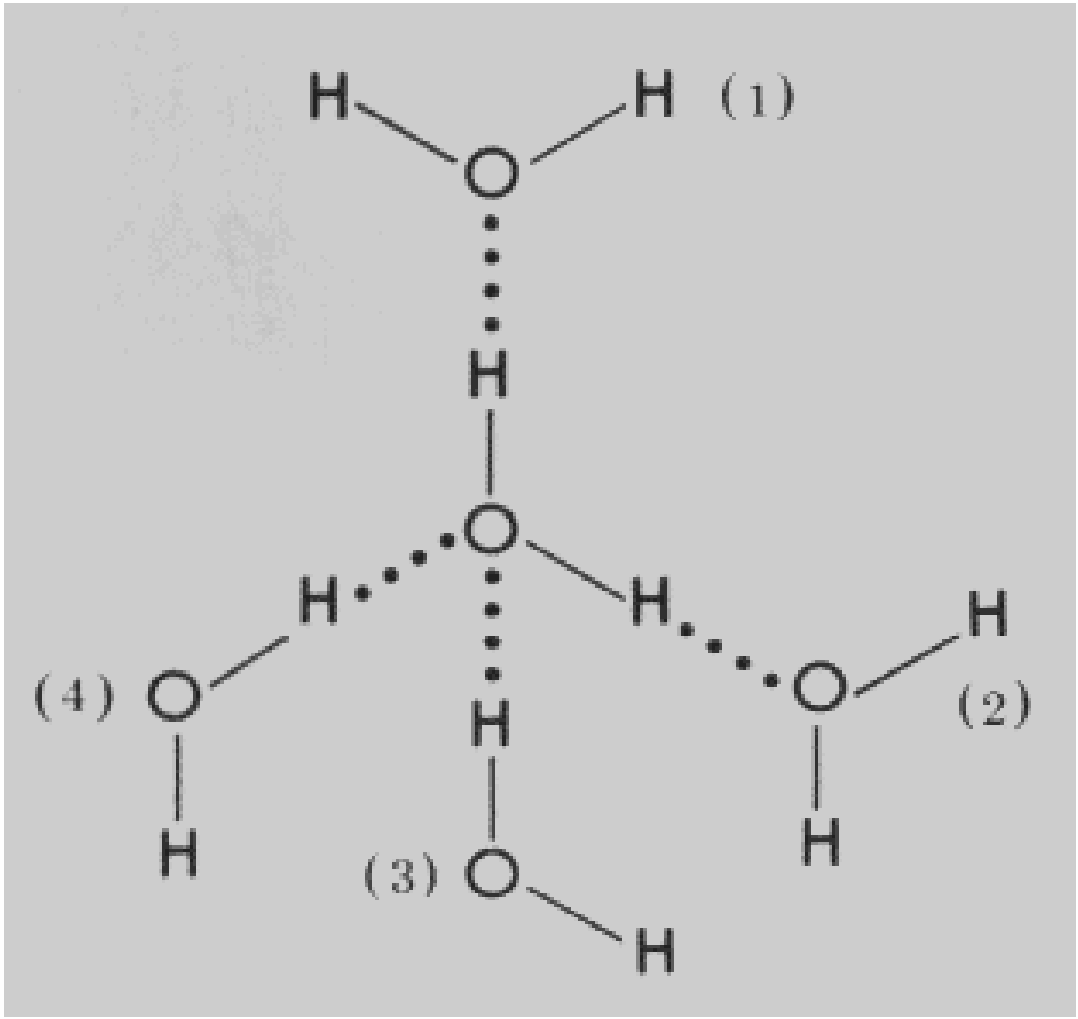
- Chemical Adhesion

- Polar Adhesion

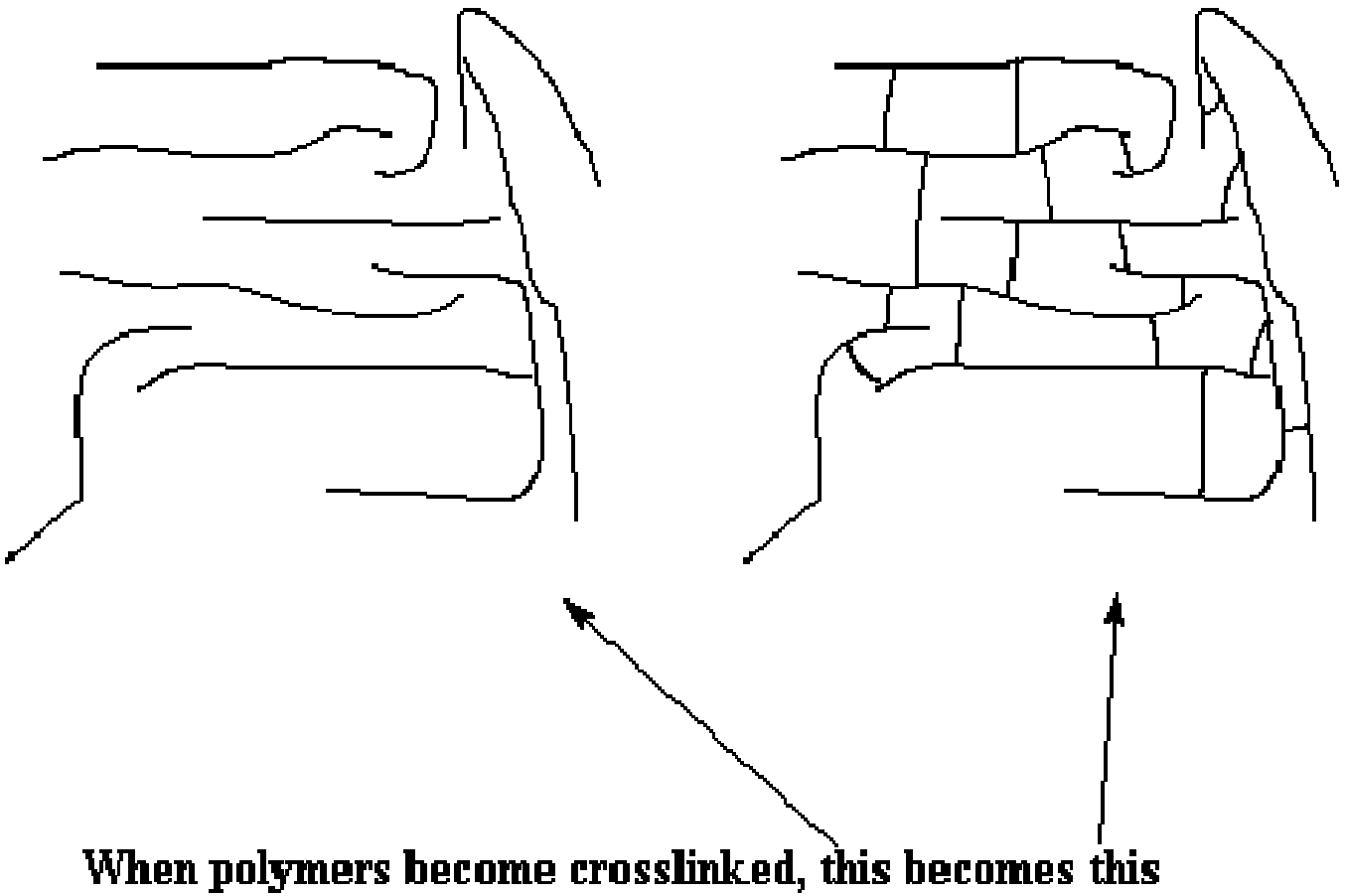


- Mechanical Adhesion

Hydrogen Bonding



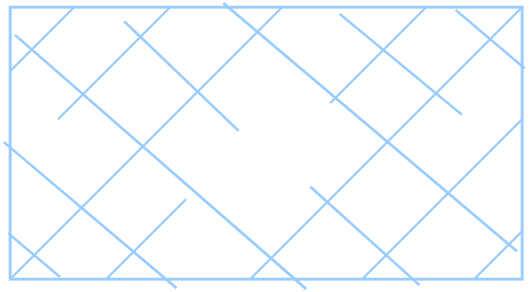
Crosslinking



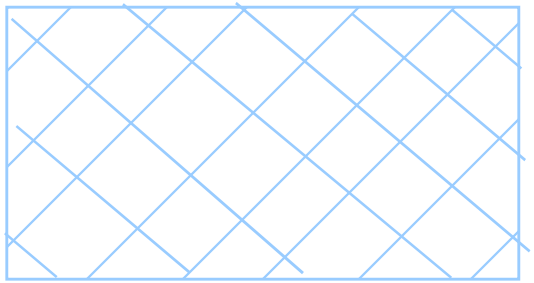
When polymers become crosslinked, this becomes this

The Challenge-Epoxy Crosslink Density

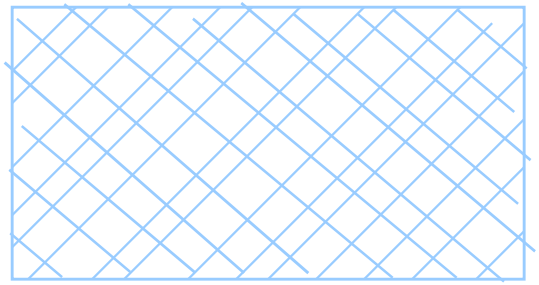
Traditional Bis A Epoxy



Low viscosity Bis F Epoxy



Higher Viscosity Novolac Epoxy (Higher Tg, Higher Elastic Mod.)



ADDITIVES

- Make up a small percentage of the coating but impart large changes in properties.
  - Suspending agents
  - Driers
  - Anti-Skinning Agents
  - Wetting Agents
  - Anti-Foaming Agents
  - Coalescing Agents
  - Thickners
  - Thixotropes
  - Other additives: mar resistance, antifreeze, non-sagging etc….

Paint Pigments

- Types
- PVC and CPVC
- Functional and non-functional

Polymers Applied in Coatings

- What is a polymer and what is their significance in paint coatings?
- Step Growth Polymerization.
- Different polymer configurations.
- Morphology.
- Molecular wt. vs Molecular wt. distribution.
- Chain entanglement.
- Glass transition temperature (Tg).
- Crosslink density.

Cohesive Forces

- Intermolecular forces.
- Carbon backbone.
- Backbone and pendant functional groups.
- Importance of multi-coat compatibility.
- Curing and internal stress.
- External stresses.

Film Formation Basics

- Thermoplastic (non-convertible) coatings.
- Thermoset (convertible) coatings.
- Modulus.
- Curing mechanisms.
- Aging and weathering considerations of coatings.

How a Paint Remover Works

- Wetting and Diffusion into the coating
- Swelling of the crosslink network
- Geometric changes in the coating
- Induced stresses
- Polymer chain cission (bond breaking)
- Breaking adhesive forces

Conditions Effecting Strip Rate

- Rate of stripper diffusion and the solubility of the stripper once inside.
- Spatial configuration, crosslink density, free volume, and molecular motion.
- Emulsion type, molecular size and shape, and polarity (Solvents of low molecular weight and high polarity tend to be more aggressive.)

Stress Induced Strippers

- Most common are based on low molecular weight hydrocarbon solvents such as Methylene chloride, oxygenated solvents like acetone, methanol, and MEK.
- A lower carboxylic acid such as Formic Acid because of it’s high reactivity and powerful solvent characteristics.
- Earliest and still most common is MC.

Problems with These Stress Induced Strippers

- Along came NESHAP.
- Highly Toxic and heavily regulated by OSHA and EPA.
- Highly volatile; dries out too quickly.
- Requires multiple applications.
- Create a hazardous waste slurry $$$$.
- Excessive manhours and cleanup.

“Paint Release Agents”
A new category of Strippers

1. Full aircraft stripping of all coating types.
2. Spot stripping in a convenient aerosol package.
3. Environmentally acceptable & Safe to Use.
4. Non-Corrosive to Aerospace metals.
5. Composite compatibility (Raydome stripping) no delamination.

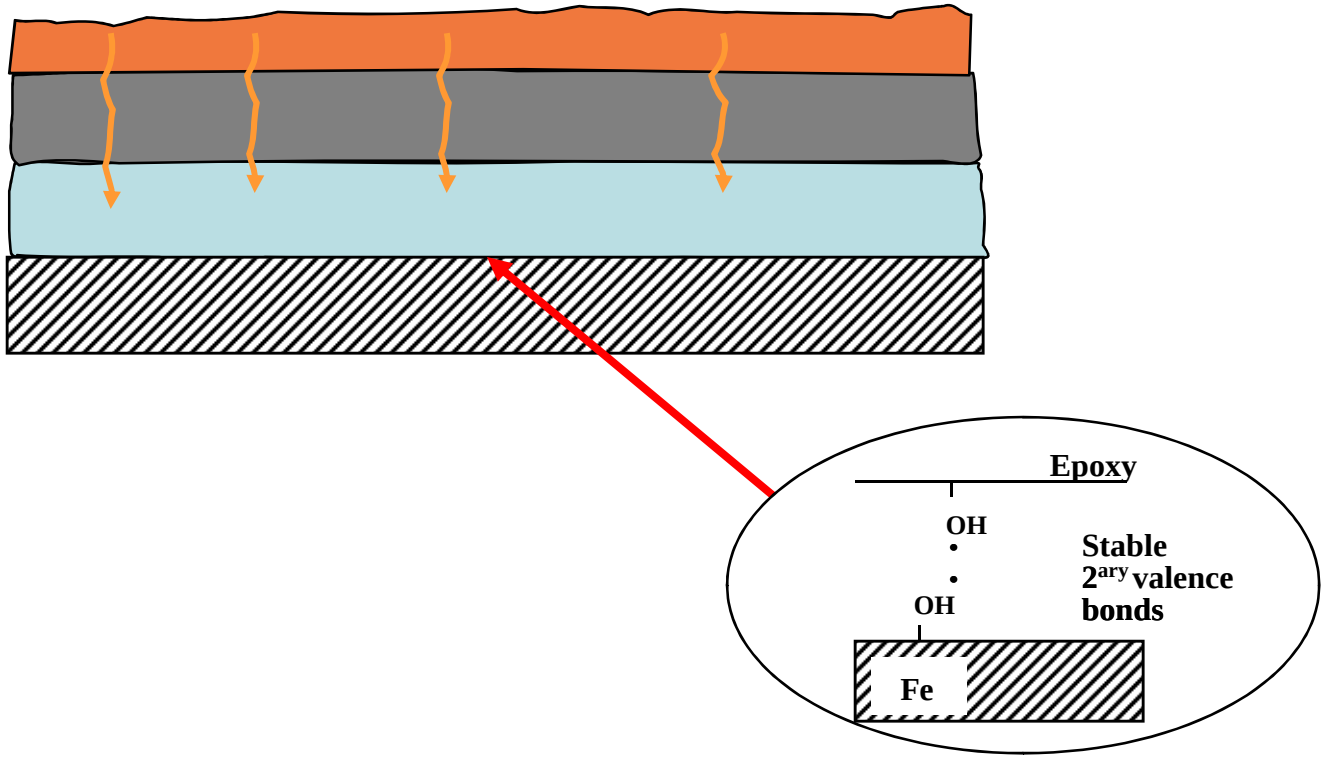
Paint Remover Components

- Active solvents (True solvents)
- Wettings agents.
- Thickening agents.
- Evaporation retardants.
- Activating agents.
- Corrosion inhibitors.

PRA Strippers

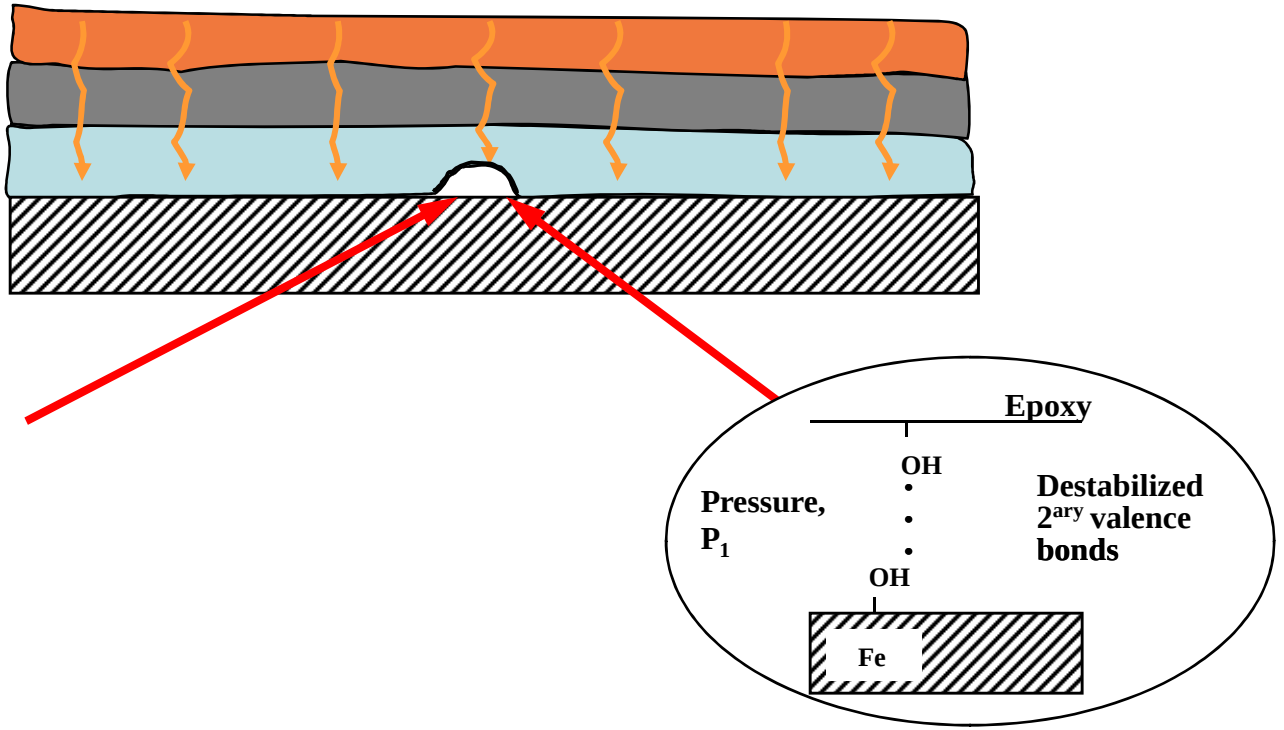
- How it works.
  - Phase 1- Stripper penetrates and diffuses into the free volume holes of the coating, progressively moving towards the underlying substrate and inducing stress and physical changes in the coating. Simultaneously, a paraffinic phase migrates to, and stabilizes at the external surface of the stripper. This process increases the residence time of the low volatile stripper inside the coating.

Paint Release Agent
Coating Removal Mechanism



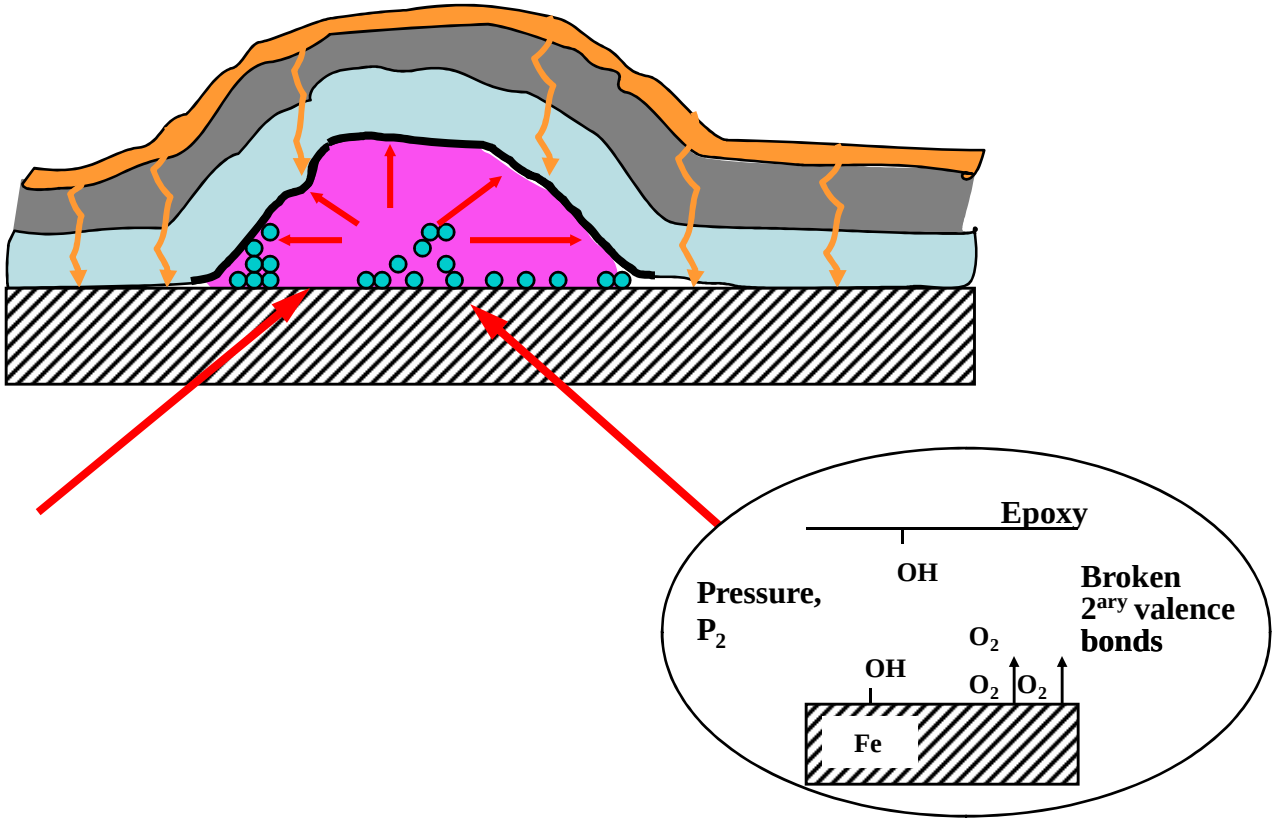
- Phase 2- Stripper has virtually permeated through the entire coating and has closely approached the coating-substrate interface. Bonds at the substrate are dramatically destabilized from the swelling and deformation in the compressively stressed coating system, developing a negative pressure at the interface between the primer coating and substrate. This is significant in the context of the stripping step that follows. Specific ingredients in stripping formulation selectively recognize the substrate and use that substrate as a catalyst to speed up the stripping process.Phase 1 & 2 make up the stripper diffusion-coating stress step.

Paint Release Agent
Coating Removal Mechanism



- Phase 3- The stripper has completely permeated the coating and contacted the substrate, whereupon immediate decomposition of a select compound in the stripper releases oxygen and sets up a positive pressure between the substrate and primer coating. Hence, a negative pressure vs positive pressure differential causes de-adhesion and popping of the the coating from the substrate. This pressure inversion causes the onset of lateral and vertical coating detachment from the substrate.

Paint Release Agent
Coating Removal Mechanism

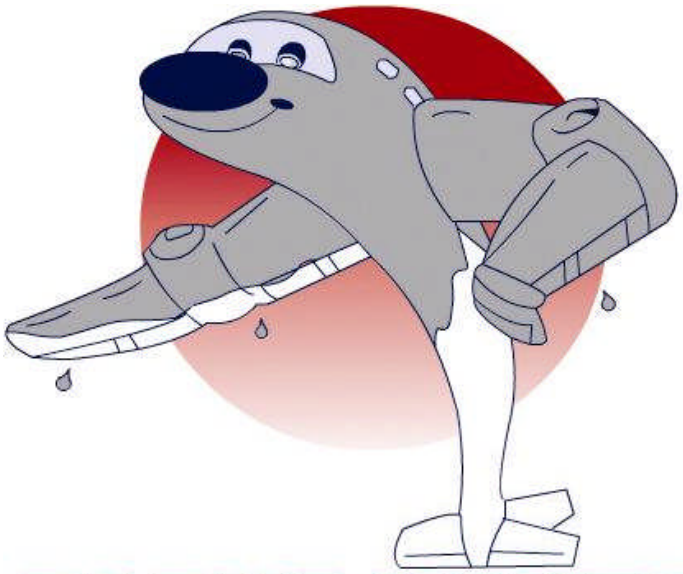


Breaking Adhesive Bonds

Corrosion Science

- Electrochemistry
- The corrosion triangle
- pH effects
- Galvanic table
- Electrolytes and Non-Electrolytes
- Temperature effects
- Effects of oxygen
- Corrosion Inhibitors types and how they work
- ASTM-F-483 Total Immersion Corrosion Testing
- ASTM-F-518 Hydrogen Embrittlement.
- Sandwich Corrosion
- Dissimilar metal corrosion

SUCCESS STORIES.



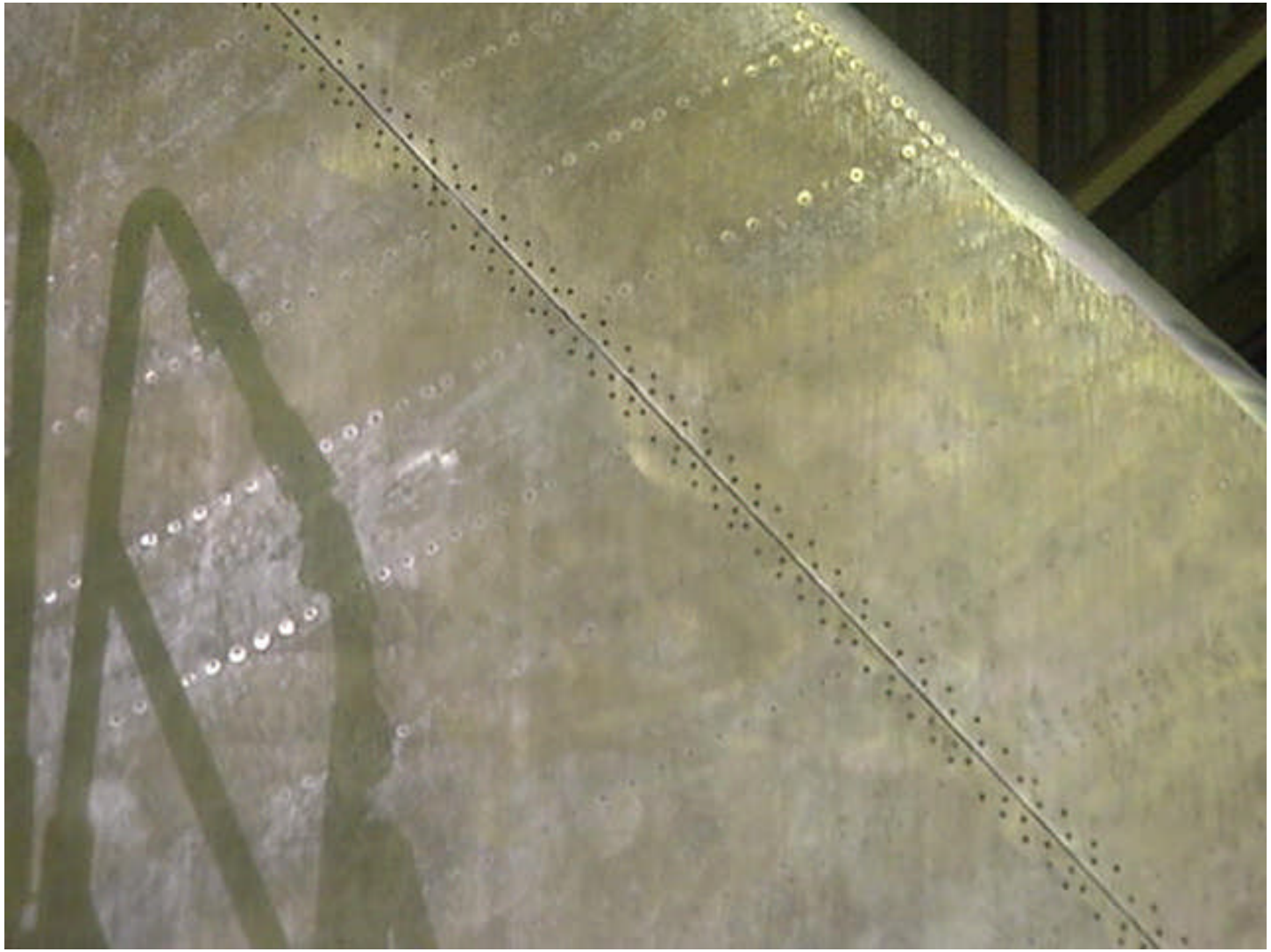
PLANE NAKED
Paint Release Agent

DEKOTE

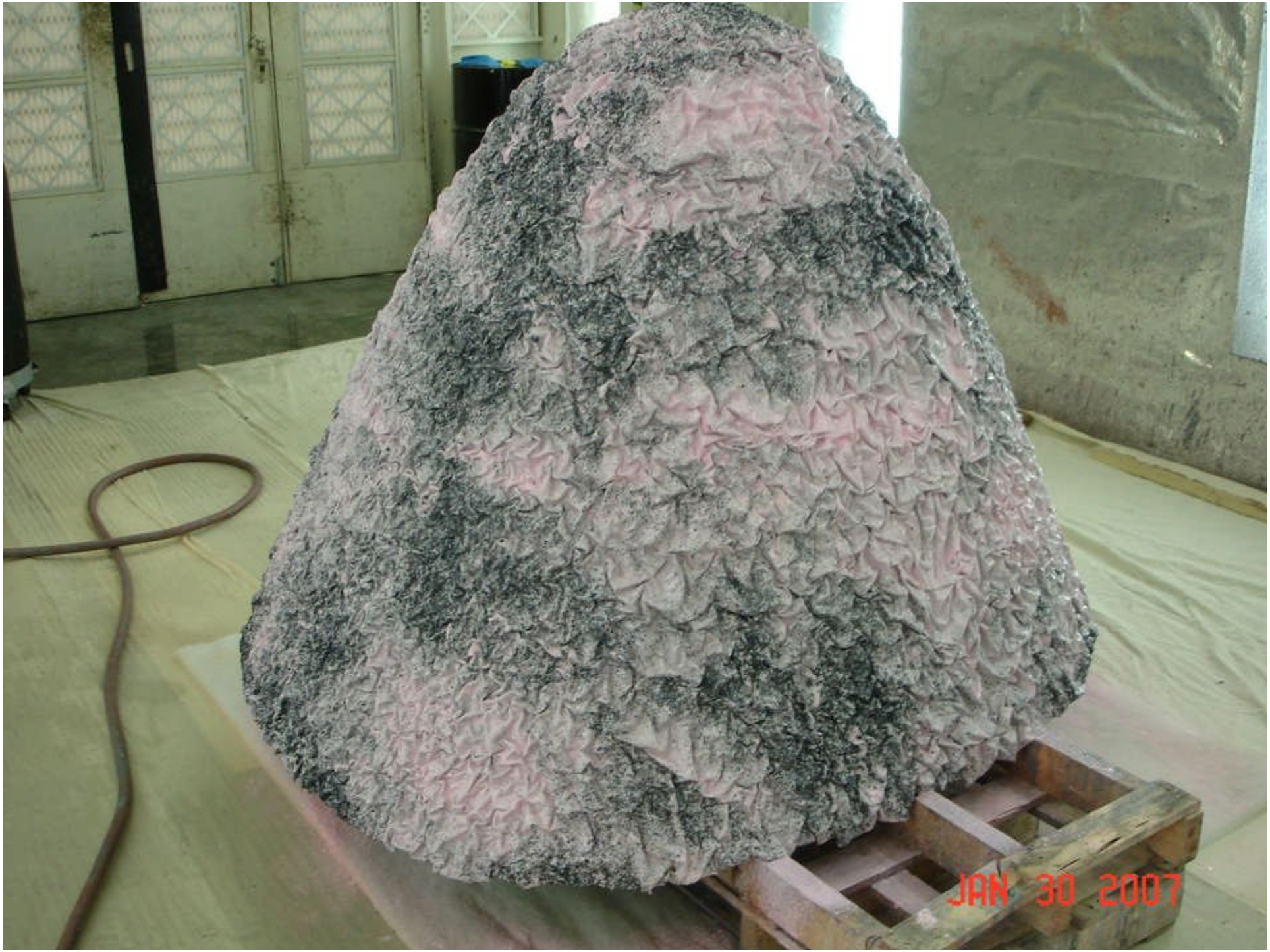
Quick Strip

PLANE NAKED RESULTS

No Corrosion. Alodine still visible.




CSC
NASA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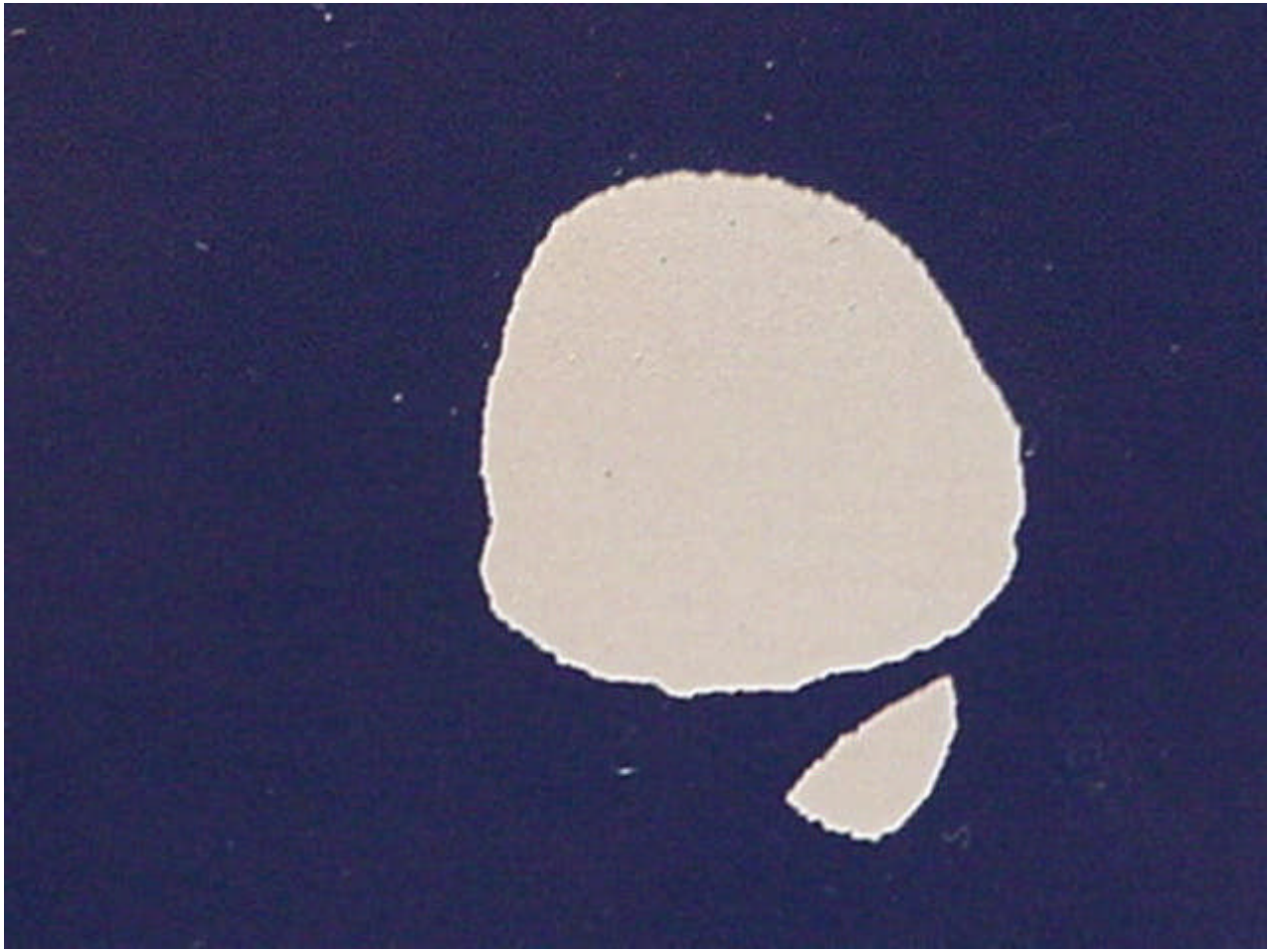
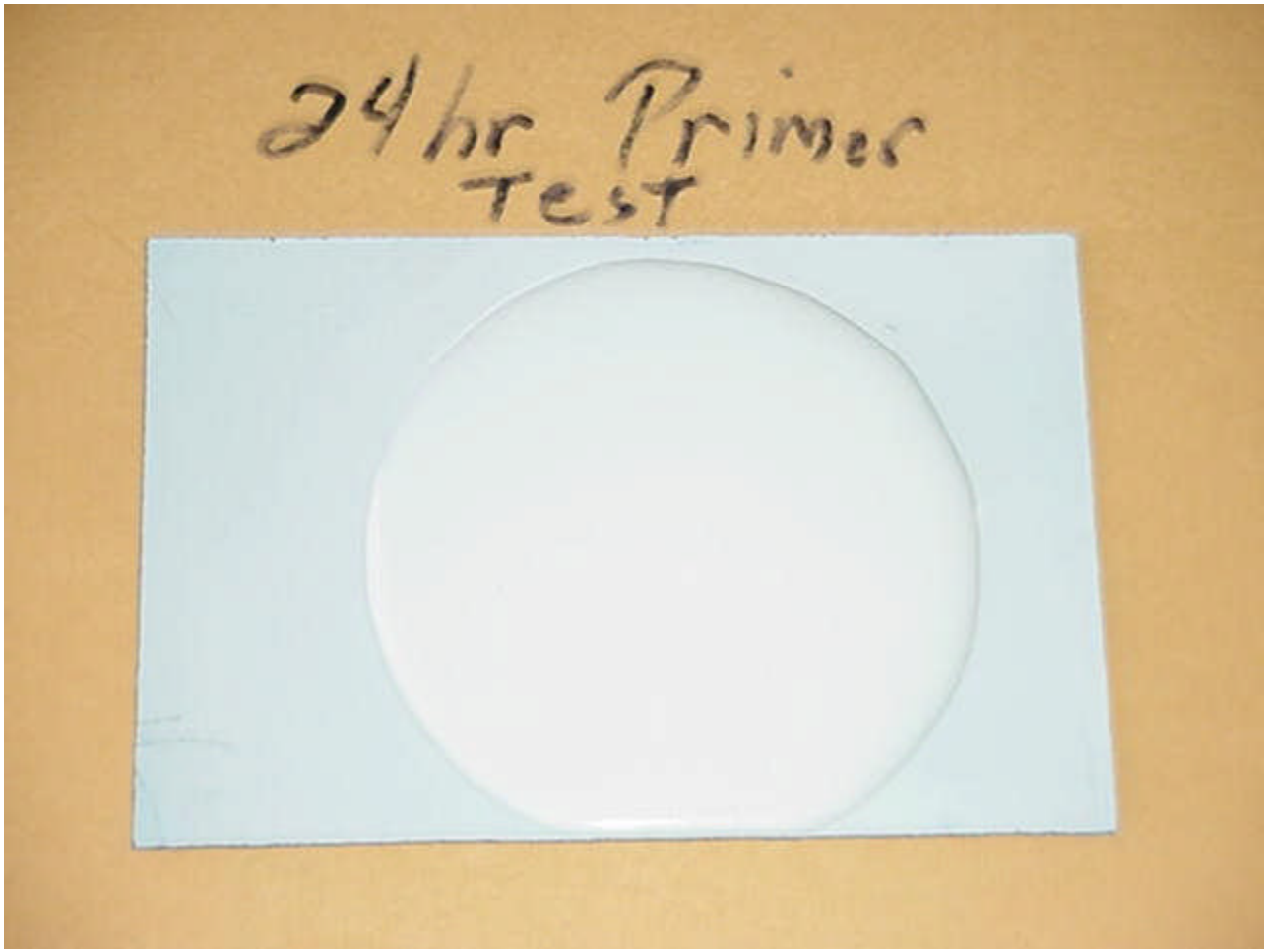
OEM Composite panel with Desothane topcoat.

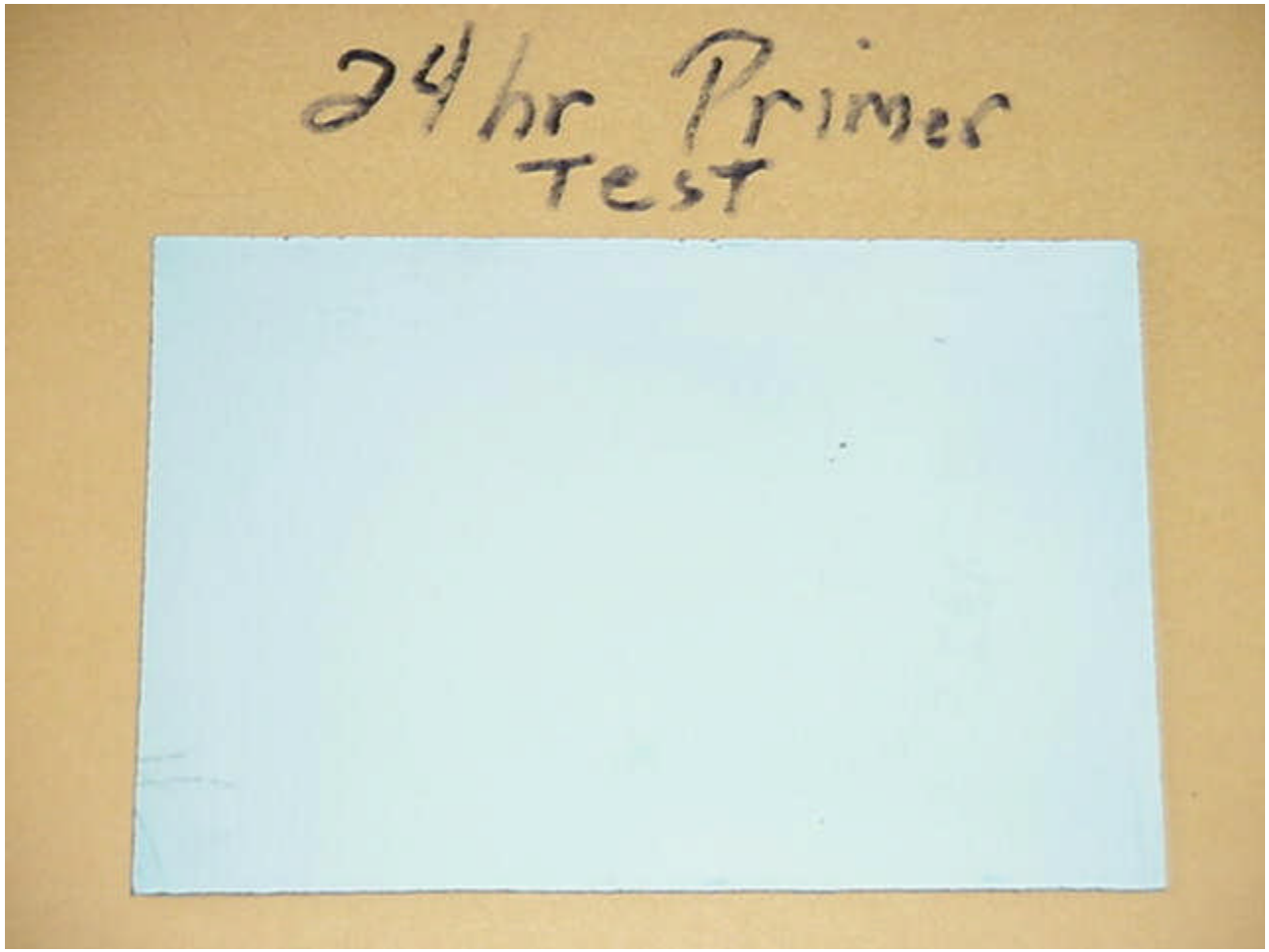
Selective Topcoat Stripping



Stripper applied directly to Epoxy Primer.



After 24hrs No effect.



IN SUMMARY

Coatings Systems are continuously developing and improving.

- APC
- MILC85285
- MILPRF23377
- TTP2760
- BMS Coatings
- Polysulfied
- FR Coatings
- Heat Resistant Coatings
- Rain Erosion Coatings
- Wash Primers
- Sanding Primers
- Fill Primers

1. Aircraft depaint issues require measurable data.
2. Selective coatings removal from composite substrates can be achieved.
3. Desired use of polysulfied primers can be realized with safe PRA chemistry.
4. For best results paint removers need to be developed along with the coating system.
5. Continued focus in the development of Depaint as a science.
6. Work with G-8, OEM’s, CTIO and Coatings Mfgs are critical success factors.
7. Development of an AMS depaint specification that is performance driven and up to date with current coatings and substrate demands. And additionally, meets with today’s safety and environmental concerns.

AEROCHEM has launched its website to share its knowledge.

www.aerochem.net

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