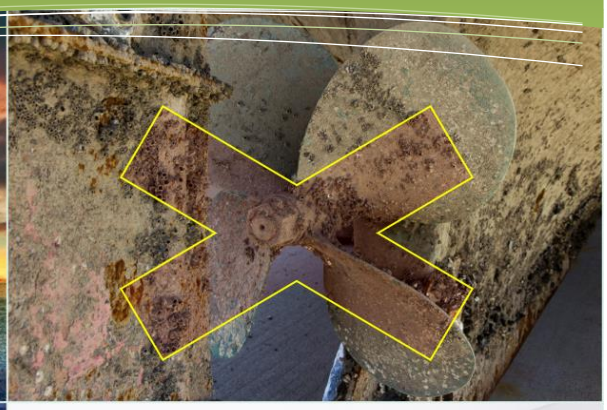
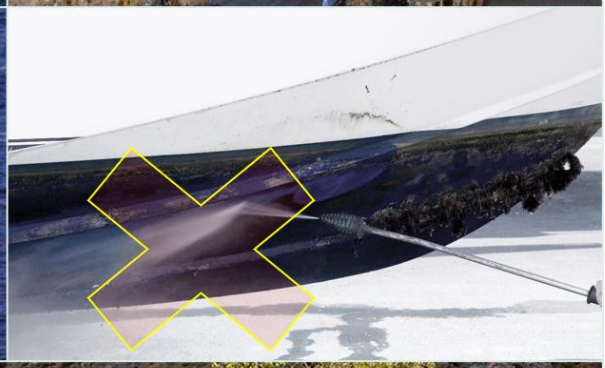
CORROSION PROTECTION WITH PARADIGM CHANGING FIELD APPLICABLE FLUOROSEAL® 100% PVDF COATING

AiT COATINGS





"Protection of metals from corrosion is a topical issue affecting all areas of the world's economy. The losses due to the damage associated with marine transport corrosion during the period of construction or operation constitute approx. 50–80 billion USD and approx. 3 % of world GDP. Statistics show that 90% of ship failures are attributed to corrosion"

https://www.researchgate.net/publication/324045191_Corrosion_and_Wear_Analysis_in_Marine_Transport_Constructions

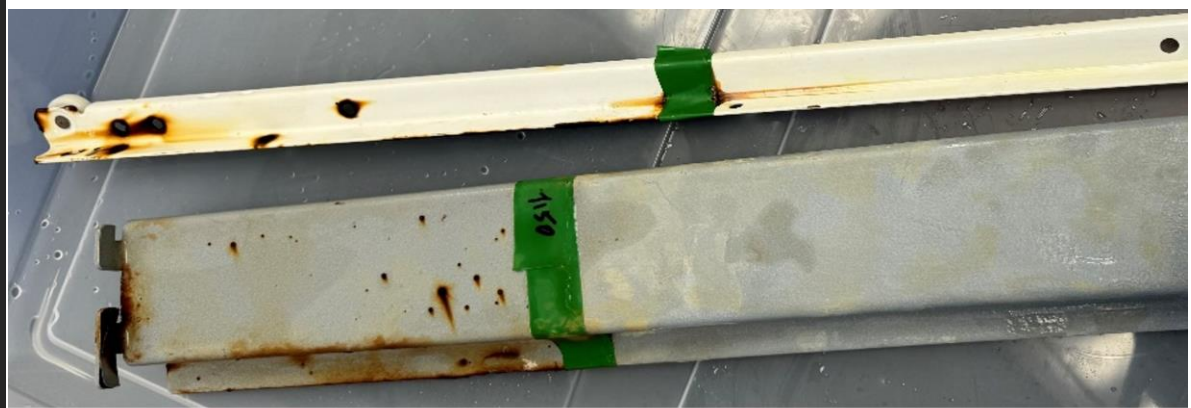
To be effective in protecting the ships and infrastructure from corrosion damages, the coating must at least meet the following requirements:

- Field applicable coating onto the large areas of exposed structures both above and below waterline by roller or brush or spray coating method and "cure" at ambient.
- The coating must be itself resistant to UV exposure for more than 50 years: so that the protection coating does not need constant maintenance. The coating should also block UV from reaching underneath the coating to prevent UV damages to the structural coating on the structure.
- The coating must have ability to block moisture penetration. Lesser moisture penetration will prevent the water pockets to be accumulated inside the ship hull coating interface. Lesser moisture also reduces the possibility of Cl-, Na+ and other salt ions being carried along to cause corrosions.
- The coating should have the ability to block corrosive gases such as CO_2, H_2S from carried by the moisture or penetration and react with the retained waters inside the coating-steel interfaces.
- FLUOROSEAL® coating with PVDF molecular structures are proven to provide the highest barrier capabilities of field applicable coating.

"Year upon year the cost of naval corrosion has increased until it is estimated today at 4 % of the Gross National Product."

"Naval environmental conditions that accelerate corrosion and degradation include moisture, salt water, oxygen, ultraviolet light, and high temperatures. These ambient conditions may not only significantly accelerate corrosion, but they may also degrade protective coating systems."

https://www.academia.edu/7875840/Naval_Corrosion_Causes_and_Prevention



Steel bars coated with a gray and white epoxy coatings from commercial sources are partially coated with field applicable, patent-pending CPC7550 100% PVDF top coat (~50μm thickness). The portion protected by epoxy coatings only when exposed to salt-water (water with dissolved corrosive ions) suffered extensive corrosion in 65 days under the accelerated conditions of 60°C-5% saline solution. By comparison, epoxy coated steel when top coated with field applicable 100%PVDF coating showed no sign of corrosion. The accelerated conditions are roughly equivalent to 2-3 years of ambient temperature seawater submersion condition. That is, CPC7550 dramatically extend the operational time for ship at sea by years without needs for dry-docking.

SHIPS AT SEA SUBJECT TO ONE OF THE MOST CORROSIVE ENVIRONMENTS ABOVE AND BELOW THE SEA WATERLINE

- **FLUOROSEAL® CORROSION PROTECTION COATINGS BLOCKS ACIDIC CORROSIVE GASES AND MOISTURE LADEN WITH DISSOLVED CORROSIVE GASES AND SALT IONS TO PROVIDE MORE THAN 10 YEARS OF CORROSION PROTECTION**





Ships built with steel are traditionally protected by paints of all kinds. Epoxy and/or polyurethane are predominant among them:

- Epoxy-Polyurethane molecules are vulnerable to UV degradation
- Epoxy-Polyurethane are molecularly porous with high permeability to moisture laden with corrosive acidic and ionic elements.
- Ship hull and infrastructure <u>above waterline</u> are vulnerable to degradation and corrosion failure by:
  1. UV induced molecular damages of traditional epoxy-polyurethane coating to allow direct exposure of steel to salt-spray and salt-fog
  2. Gradual penetration of corrosive ions and/or acidic gases laden salt-fog and salt-spray.
- Ship hull and infrastructure <u>below waterline</u> are vulnerable to corrosion failure by:
  1. Gradual penetration of corrosive ions and/or acidic gases laden salt-water
  2. Mechanical damages induced direct salt-water induced steel corrosion
  3. Bacteria, seaweeds, barnacles and other bio-elements

<u>FLUOROSEAL® PVDF Coatings:</u>

1. Field Applicable Ambient Storage 1-Component VOC Free Coating
2. Apply Over the Existing Epoxy or Polyurethane Coatings
3. Air Drying to Clear Overcoat (CPC-EXT-7150)
4. Air-Drying, Crosslinking Version (CPC-EXT-7280) for Abrasion and Chemical Resistance
5. Air-Drying, Crosslinking with Biocide Enhancement for Below Waterline (CPC-EXT-7284)
6. Patent-pending 100% PVDF top-coating (CPC7550)
7. Proven corrosion protection <75µm coating thickness
8. Proven UV blocking to protect the underlying epoxy-polyurethane
9. Proven moisture and rain barrier

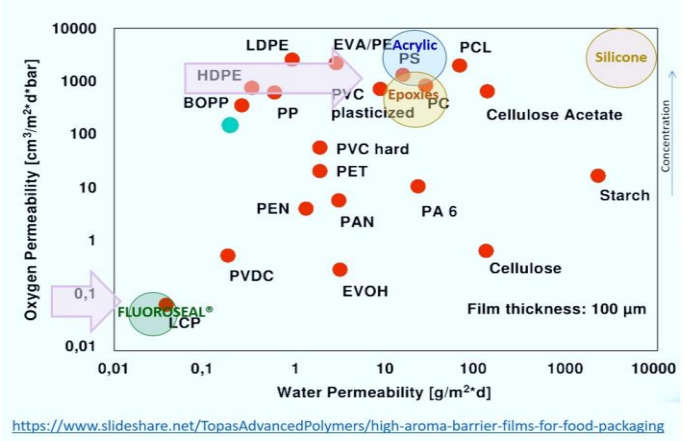
<u>PHYSICAL CHARACTERISITCS OF FLUOROSEAL® PVDF Corrosion Protection Coatings</u>

	CPC 7150	CPC 7280	CPC 7550
SPECIAL ATTRIBUTES	1) Transparent, flat finish 2) Primerless, VOC-Exempt Coating 3) Roller-Brush or Spray 4) Corrosion & antifouling	1) Transparent, flat finish 2) Primerless, VOC-Exempt Coating 3) Roller-Brush or Spray 4) Corrosion & antifouling	1) Corrosion + Antifouling 2) Field Applicable 100% PVDF Protection 3) Roller or Spray 4) VOC Free Coating
WATER-MOISTURE PROPERTIES	STANDARD AND CONDITIONS (@25ºC)		
Water Absorption (D570) %	<0.01 (Typical Acrylic: >0.4)	<0.01 (Typical Acrylic:>0.4)	<0.01 (Typical Acrylic:>0.4)
Water Permeability (gm.mm/m².d) @ 1atm	0.0009 (Typical Acrylic: >5.2)	0.0009 (Typical Acrylic: >5.2)	0.0009 (Typical Acrylic: >5.2)
Percentage of PVDF (%)	>70%	>70%	100%
THERMAL PROPERTIES	STANDARD AND CONDITIONS (@25ºC)		
Glass Transition Temp (Tg,ºC)	-45	-45	-45
"Melting Point" (ºC)	>120	>120	NA (Cured & Cross-linked)
CTE (Coefficient of Thermal Expansion, ppm/ºC)	95	75	80
Thermal Conductivity (BTU-in/hr-ft²-ºF)	1	1	1
Thermal Decomposition (ºC)	>350	>350	>350
MECHANICAL PROPERTIES	STANDARD AND CONDITIONS (@25ºC)		
Hardness (Shore D)	50	80	50
Tensile Modulus (Psi/Mpa)	40000/(275)	200,000/(1,375)	180,000/(1,238)
Flexual Modulus (Psi/Mpa)	30,000/(206)	150,000/(1,031)	135,000/(928)
Tensile Elongation (%)	300	30	300
OPTICAL PROPERTIES	STANDARD AND CONDITIONS (@25ºC)		
Refractive Index (D542)	1.43	1.43	1.43
ELECTRICAL PROPERTIES	STANDARD AND CONDITIONS (@25ºC)		
Dielectric Strength (KV/mil)	0.8	0.8	0.8
Volume Resistivity (ohm-cm)	$1.8x10^{14}$	$1.8x10^{14}$	$1.8x10^{14}$

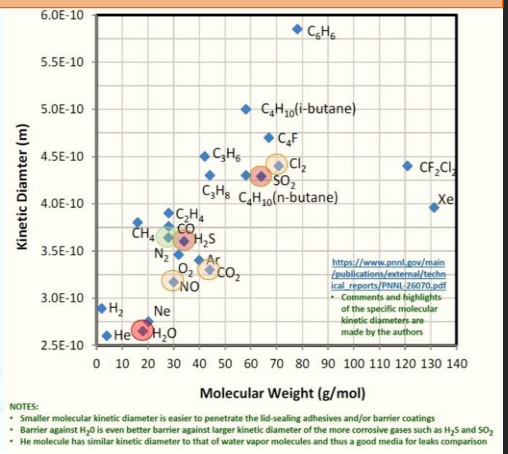


FLUOROSEAL® PVDF Corrosion Protection Coatings are Engineered as Clear Over-Coating, Crosslinked for Abrasion and Chemical Resistance, Enhanced with Biocides

"Concrete is mostly damaged by the corrosion of reinforcement bars due to the carbonation of hardened cement paste or chloride attack under wet conditions" https://en.wikipedia.org/wiki/Concrete_degradation

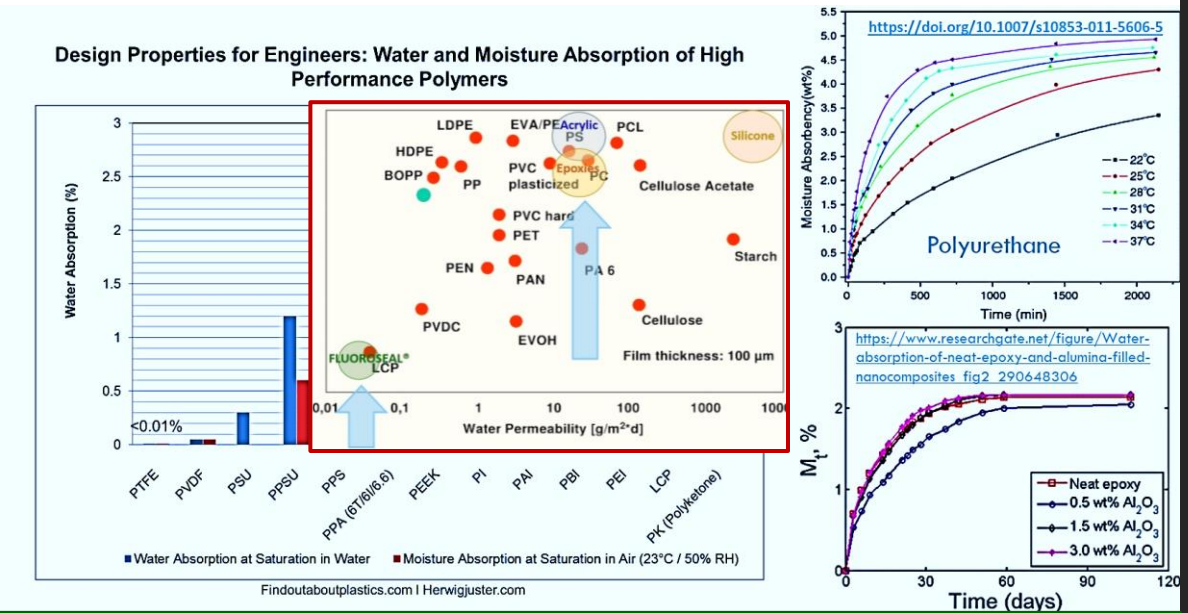


https://www.slideshare.net/TopasAdvancedPolymers/high-aroma-barrier-films-for-food-packaging



NOTES:
- Smaller molecular kinetic diameter is easier to penetrate the lid-sealing adhesives and/or barrier coatings
- Barrier against H_2O is even better barrier against larger kinetic diameter of the more corrosive gases such as H_2S and SO_2
- He molecule has similar kinetic diameter to that of water vapor molecules and thus a good media for leaks comparison

FLUOROSEAL® PVDF is one of most densely molecularly packed coating to most effective in blocking H_2O moisture and O_2 that are the smallest kinetic diameter and thus orders of magnitude lower in permeability to the exhaust corrosive gases such as CO_2, H_2S, SO_2, NO, CO, Cl_2, etc., when compared to other traditional polymer coatings.



Besides having the highest capability in blocking moisture ingression (least moisture permeability), FLUOROSEAL® PVDF is molecularly packed to absorb and retain the least amount of water among all of the common coating polymers.

Transparent UV and Corrosion Protection Coating for Reinforced Concrete and Corrosion Protection:

"Concrete is mostly damaged by the corrosion of reinforcement bars due to the carbonation of hardened cement paste or chloride attack under wet conditions" https://en.wikipedia.org/wiki/Concrete_degradation

- Blocking moisture laden with carbonic acid from CO_2, other acidic gases and salt ions is key in reducing to eliminating these deleterious factors.
- Blocking moisture and acidic and corrosive gases from penetrating inside the concrete further stop corrosion and chemical reaction weakening.
- In comparison to epoxy, polyurethane and alkyd coatings, FLUOROSEAL® PVDF coatings are molecularly engineered to have several orders less moisture absorption and lower in moisture and corrosive gases permeability to provide an effective sealing.
- FLUOROSEAL® sealing coating have 5B crosshatch and outstanding shear-bond strength to provide protection even in the more stringent environment.
- Coatings with low Tg molecular structure for stress absorption and proven extreme weathering cycle and exposures.
- FLUOROSEAL® PVDF sealing coatings are VOC-exempt for brush, roller and spray coating anywhere.
- FLUOROSEAL® PVDF crosslinked series coatings are hardened for use on rooftop and walkway.

TRANSPARENCY AND FIELD APPLICABILITY ENABLES QUICK REPAIRING AND REPAINTING FOR CORROSION PROTECTION IN USING FLUOROSEAL® PVDF COATINGS

The table below summarizes the critical properties of FLUOROSEAL® Corrosion Protection Coating

Properties Required for Effective Protection of Steel Structures	Polyurethane	Epoxy	FLUOROSEAL® Corrosion Protection (CPC 7150, Clear, UV Blocking) (CPC 7280, Crosslinked, Abrasion Resistant) (CPC 7284 Crosslinked with Biocide)
Moisture-Water Permeability (Relative Ingress Number, g/m²*d)	High (>20)	High (>20)	Very Low (<0.05)
Corrosive Gases (e.g. H_2S, C_2O, etc.) Permeability ($cm^3/m^2*d*bar$)	Very High (>2,000)	Very High (>2,000)	Very Low (<0.1)
Water Repellant	Fair	Fair	Good
Water Absorption (Retention)	Medium	Medium	Low
UV Molecular Stability (Resistance)	Fair (Proven <10 Years)	Fair (Proven <10 Years)	Outstanding (Proven >60 Years)
Choices of Color	1. Colored 2. Customized	1. Colored 2. Customized	1. Clear 2. Customized
Field Application Method	Spray, Brush, Roller (1-or 2-Component, Ambient Storage, Coating Liquid)	Spray, Brush, Roller (1-or 2-Component, Ambient Storage, Coating Liquid)	Spray, Brush, Roller (1-Component, Ambient Storage, VOC Exempt, Coating Liquid)
Cost of Material and Labor	Similar for material and Labor for the same performance level (Thicker: >200 Micron)	Similar for material and Labor for the same performance level (Thicker: >200 Micron)	Similar for material and Labor for the same performance level (Thickness: 50 Micron)

About AI Technology, Inc. and AIT Coatings Division:

With the introduction of FLUOROSEAL® corrosion protection coating solutions (patents pending), AITCOATINGS Division builds on the modified PVDF technology to provide field applicable high fluoropolymer protection for stopping moisture laden with dissolved ions and corrosive gases from penetrating into metal coating interface to cause corrosion. As top coatings, FLUOROSEAL® corrosion protection coatings can extend existing coated steel structures years more maintenance free services.

AIT develops and manufactures its product in two separate ISO 9001:2015 certified facilities totaling over 100,000 sq ft on a 16 and 18-acre in New Jersey, USA. AIT also has worldwide sales operations along with service centers in Africa and China. Since pioneering the use of flexible epoxy technology for electronic packaging in 1981, AI Technology (AIT) has been one of the leading forces in developing advanced materials and adhesive solutions for electronic interconnection and packaging with more than 30 patented technologies.

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AIT COATINGS

THE COMBINED CAPABILITIES OF FLUOROSEAL® PVDF COATING IN BLOCKING MOISTURE LADEN WITH SALT IONS AND DISSOLVED CORROSIVE GASES, AND UV RESISTANCE ENABLES CORROSION PROTECTION OF SHIPS AND MARINE STRUCTURES

- Direct coating over coated or bare steel surfaces will protect the steel structure both above and below the seawater line for years without corrosion.
- Applying the FLUOROSEAL® CPC 7150, CPC 7280 and CPC7550 to the existing coated steel ship hull and other marine assets, will **"arrest" and stop the further corrosion damaging effects from the weathering.**
- In the case of reinforced concrete and steel infrastructure, FLUOROSEAL CRC series are directed to provide immediate relief from further concrete weakening and stopping further rebar corrosion.

SLOWING AND DEGREASE BIOFOULING:

- **The low surface energy and the unparalleled ability in blocking corrosive gases generated by biofouling growth have been proven to provide reduction of growth and easier cleaning due to unavoidable and costly biofouling growth below the waterline.**