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Fluoropolymer Coatings and Linings for Offshore, Oil Gas & Chemical Equipments - Meeting the Needs Under Harsh Conditions - From the Applicator's View

By

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ABSTRACT

The main tasks for Oil Gas pipeline transportation and Equipments are fail-safe, timely, profitable and ecologically safe oil, gas and petroleum products delivery without quantity and quality losses not withstanding enormous distances between oil well and end point.

Due to Corrosion, Which is a very Serious Issue in Oil and Gas, Chemical, Pharmaceutical and Petrochemical companies, There is a massive damage to Equipments and Pipelines which sometimes accounts to thousands of dollars. For this reason, major metallic equipments and parts must be protected from corrosion resistance.
Fluoropolymer / PTFE Coatings and Linings provides solutions for corrosion protection, flow assurance (and accordingly - cost effectiveness) based on high gloss and anti-stick internal coatings and additives for viscosity.

Although commonly used methods of corrosion protection viz Rubber Lining , Fusion bonded Epoxy Coating, Dual Layer Poly Ethylene Coating and linings have been present in the market over the years, there is a demand and requirement for a Superior High Performance Coating for specific applications and chemical resistance where all the traditional methods tend to fail.

Here emerges the market for Fluoropolymer coatings and linings designed to help today's processing professionals face the challenges of protecting
Large and complex containment vessels and related piping systems..

The problem with Traditional Coating Methods

Extensive testing and field use have proven that the future of coated fasteners lies with Fluoropolymer Coatings. Previously, hot dip galvanized, cadmium or zinc plated fasteners were considered the standard. But these coatings could not stand up to the corrosive atmospheres prevalent in many industries. After 500 hours of salt spray testing (ASTM B117), fasteners coated with these conventional methods showed severe corrosion and, in some cases, failure.

Fasteners coated with Fluoropolymer coating withstood these harsh conditions with no noticeable deterioration. Even after as many as 1,000 hours, Fluoropolymer / PTFE coated fasteners still could be easily disassembled.

What is Fluoropolymer Coatings?

Fluoropolymer coatings are blends of high performance resins and Fluoropolymer lubricants. Most of the useful properties of Fluoropolymer are due to fluorine, the most electro-negative element and the most reactive non- metal. Its atomic radius is the smallest next to hydrogen, and it forms extremely strong bonds with other elements. When reacted with carbon in Fluoropolymer, the extremely strong, tight bond produces an extraordinary combination of properties**.** These single coat thin films provide excellent corrosion and chemical resistance. Other benefits of Fluoropolymer coatings include reduced friction, resistance to galling, non stick, non wetting, electrical resistance and abrasion resistance. Fluoropolymer coatings are applied to fasteners and various OEM components to provide a longer life before replacement.

Extraordinary Properties

- **Chemically inert Nontoxic**
- **Non-wetting**
- **Nonstick**
- **Low Coefficient of Friction**
- **Highly fire resistant**
- **Low dielectric constant**
- **High temperature ratings (- 100 Degree C to + 260 Degree C)**

BENEFITS OF PTFE ON STUD BOLTS

PTFE (Poly Tetra Fluoro Ethylene) was discovered by accident in 1938 by Dr. Roy Plunkett They were looking for a non-poison coolant based on fluoro polymer. After several experiments with compounds Dr. Plunkett discovered that the compound was polymerized during the night. After several weeks of testing they found out that the new material was resistant to all:

- **Acids**
- **Solvents**
- **Temperature up to +260 ºC and – 200 ºC**

Furthermore they learned that the coefficient of friction was the lowest of all known solid materials. The newly discovered polymer offered many new appliances for various industries. One of the most important applications was found in defense, air force and nuclear industry.

Then there is the environmental aspect. PTFE is a perfect substitute for cadmium. It equalizes cadmium in corrosion resistance and exceeds it in coefficient of friction. The maximum temperature is 260 ºC and PTFE can be produced in different colors.

PTFE ON FASTENERS

To get a good result a proper preparation is a necessity. Especially for appliances with strict conditions like Offshore And Petrochemical. When you apply PTFE coating on a blasted substrate, the advantage of ease of use will remain, but the material still isn't corrosion resistant. Therefore the material first needs to be treated with a corrosion resistant primer before covering it with PTFE. This is not necessary with Stainless Steel. To apply the coating correctly to the bolted joint the conditions during heating are of great importance. This needs to be done in special furnaces, in which the layers melt into each other. This results in a hard, corrosion resistant coating (ASTM B-117), which protects even after dismantling and assembling a number of times.

The guaranteed layer thickness is between 25 to 30 microns (0.025 to 0.030 mm thick) . When applied to oversized tapped nuts please be aware of an extra layer thickness.

The average coefficient of friction is between 0,12 and 0,16. This can be adapted by raising or lowering the amount of PTFE as solid material in the hardened coating

Why Would Coating Bolts Make Sense In Some Situations?

1. Cleaning and painting of bare steel bolts in the field is likely to be difficult, expensive, and in some cases, not feasible.

2. The plain bolts, after stuffing in the holes, are expected to sit out in the weather for an extended period of time and get dried out and rusty, making correct tightening difficult or impossible.
3. Release or retightening of the bolt within the foreseeable future is necessary (Wind turbine support shafts).
4. Atmospheric corrosion is expected to be aggressive.

Comparisons with other Coatings

Black, cadmium plated, and hot dipped galvanized bolts will freeze when subjected to the corrosive environments found in manufacturing plants, offshore oil rigs etc. Most often removing the nuts requires a cutting torch.

With Fluoropolymer coating, the same nuts and bolts exhibit easy on and easy off characteristics increasing worker safety.

PTFE Coated Stud Bolts | **Zinc Plated** | **Cadmium Plated** | **Hot Dip Galvanized** | **Uncoated**

The PTFE/ FLUOROPOLYMER coated Studs, Bolts & Nuts undergo the following tests:

1) Acid Test Subjected to 720 Hours
2) Caustic Test Subjected to 12.5 ph Caustic for 720 Hours
3) Bromine Test exposed to Bromine Solution for 720 Hours
4) Salt Fog Test subjected to 750 Hours

With a Fluoropolymer coated bolt that rating jumps to as much as 1000 hours. The additional corrosion resistance allows fasteners to be disassembled quickly, saving lost down time and man-hours.

Galvanizing produces a coating that is uneven, rough and thick. The rough surfaces make assembly difficult and a tight even tension on each bolt impossible. If used in sealing joints such as flanges, heads or inspection covers, the inconsistent tension forms an uneven fit resulting in a high probability of leaks. With a Fluoropolymer coated bolt, tighter more consistent tensions are achieved with less required torque.

Technical Data – PTFE / Fluoropolymer Coatings

Fluoropolymer Coating Statistics	
Tensile Strength (ASTM D1708)	**4000 - 5000 psi**
Elongation (ASTM D1457)	**50%**
Impact Strength (ASTM D256)	**13 ft - LB/ in**
Hardness (ASTM D2240)	**60 - 90 HB (Shore D)**
Abrasion Resistance (Tabor)	**> 15 mg**
Coefficient of Friction (ASTM D1894)	**.15 -.35 static**
Dielectric Strength (ASTM D149)	**1400 volts per mil**
Use Temperature	**-100° C to + 260°C**
Chemical Resistance (ASTM D543)	**good**
Salt Spray Resistance (ASTM B117)	**excellent**

Where Fluoropolymer / PTFE Coatings Work?

Due to its unique benefits, Fluoropolymer Coating has been applied to various types and grades of fasteners. The water works industry takes advantage of the superior corrosion resistance properties by coating Hex-head bolts for underground service. Stainless steel fasteners, used in many different industries, are coated for lubricity and anti-galling.

The most widely used application is on B7 studs with 2H nuts. These fasteners are commonly used by turnaround groups, operations and maintenance departments, and contractors at many chemical plants, refineries, and offshore platforms. The coating's chemical resistance, and easy on/easy off characteristics are perfect for these environments.

Advantages of High-Build Coatings

The advantages of high-build coatings are:

1- Drastically reduces permeation through the coating and possible corrosion of the metal substrate.
2- Lowers the metals content of the fluid being handles due to the reduction of the permeation, substrate corrosion, and back migration of corrosion products.
3- Extends the life of the coating when exposed to an abrasive media.
4- Thick coatings can be repaired by welding if mechanically damaged. Thin coatings (<20 mil) must be stripped and recoated if repairs are not possible.
5- Thick coatings operate better under pressure/vacuum cycling than thin coatings.

- ☼ Used in all chemical processes with hazardous, corrosive, abrasive and/or toxic media
- ☼ Well established in the chemical, pharmaceutical and petrochemical industry
- ☼ Ideal in any plant because of their good chemical and physical resistance and their long Lifetime in service

Advantages of Fluoropolymer Coatings and Linings

- ☼ Chemical inertness against nearly all substances
- ☼ Broad application temperature range (-30°C to 260°C)
- ☼ Very smooth material surface and anti sticking behavior
- ☼ Possibility of being electrically conductive
- ☼ Impact resistant ,Absorbs pressure variations or impacts , Vibration decreasing
- ☼ Insensitive to UV-light ,**No** softening agents used and Weather resistant

Coating Selection

The selection of the proper coating material is based on:

1- Chemical exposure

2- Permeability of the coatings to the materials to be processed
3- Pressure if handling gaseous materials
4- Purity, FDA and USDA requirements
5- Maximum operating temperature
6- Abrasives, if present
7- Cost

Applications of High-Build Coatings

There are currently Six major polymers that BLINEX FILTER COAT PVT LTD applies as High-build coatings. Rarely does one occupy an application to the complete exclusion of all other materials. Each specific application must be considered before selecting a material for use.

1- Mixed beds
2- Water storage tanks
3- Pumps
4- Piping
5- Chemical storage tanks
6- Valves
7- Chemical day tanks
8- Filter housings
9- Wet bench components
10- Vacuum degasifiers
11- Agitators
12- CMP components

Coatings / Linings Thickness Selection Criterion

If the corrosion Rate of carbon Steel is > 10 mpy (mills per year) use THICK LININGS

If the corrosion Rate of carbon Steel is < 10 mpy (mills per year) use THIN LININGS

1 MILS = 1/1000 INCH

1 MILS = 0.0254 MM

TYPES OF LININGS

THICK LINING (> 25 MILS) OR 0.635 MM

THIN LININGS (< 25 MILS) OR 0.635 MM

USE THIN LININGS FOR

- **Product Purity**
- **Non Stick**
- **Localized Corrosion**

USE THICK LININGS FOR

- **Corrosion Prevention**
- **Permeation Resistance**

Coatings V/s Linings – Difference

Let us describe below the difference between coating and lining, as we understand:

A coating is applied to a thickness of 10 microns to 1500 microns (0.01mm to 1.5mm). On the other hand lining can be between 3mm to 5mm or 3000 microns to 5000 microns.

Lining is normally preferred where one needs to store various corrosive chemicals. Fluoropolymer lining is normally a sheet of Teflon/PFA/Tefzel/PVDF material either stuck to the shape of the vessel/item to be lined and various sections of lined Fluoropolymer are then welded together by same polymer welding rod.

This is a procedure in case of big storage vessels. Some times no glue is applied and various sections are simply welded together.

As you can see there will be some air entrapped between the liner and the metal. Because of this when the lined vessel or pipeline is heated and cooled, there are chances that the lining will get buckled / collapsed and the lining then fails.

Also since the lining is only mechanically bonded to metal it might fail in vacuum conditions.

As against this, in case of coated part since coating involves a through cleaning a surface with required roughness of the surface to be coated (through grit blasting) creates a better bond with the metal through a primer. The required thickness of material (Fluoropolymer) is than developed through multiple coats of the same material each time, each layer is baked in the oven and ultimately the thickness is reached. This way there is no air gap between the metal and the total thickness of the coated Fluoropolymer hence, it is a perfect system to be used in vacuum condition. Also because of relatively less thickness of the Fluoropolymer as against the lining the heat transfer is better, heat sensing is better.

Also in coating process the Fluoropolymer layer becomes an integral part of the metal to be coated hence, it can take thermal shock better then lining which is normally loosely held.

Fluoropolymer coating is available in following grades:

1. PVDF
2. TEFZEL
3. FEP
4. PFA / PTFE

The continuous service temperature in case of

1. PVDF is 120c and below
2. TEFZEL / is 150c and below
3. FEP is 195c and below
4. PFA/PTFE is 260c and below

Before deciding on a particular coating system we need to know the continuous upper limit temperature condition/ usage condition and chemicals involved.

CHOICE OF THICKNESS:

For nonstick application generally a coating of 10 microns to 150 microns is applied and is not a porosity free surface.

For corrosion protection a coating thickness of more than 300 microns is applied and the porosity can be checked either by porosity tester through electricity or by chemically.

In case of application like thermo well where heat sensing is important we need to arrive at judicious coating system which will combat corrosion as well as will not interfere with heat conductivity (heat sensing) and ultimately result in longer life of a coated product.

The maximum use temperature in case of:

PVDF is 120 Degree Centigrade
Tefzel is 150 Degree Centigrade
PFA is 260 Degree Centigrade

The Budgetary Price in case of:

PVF is x

Tefzel is 1.5x

PFA is 1.75 to 2.0x

FOUR WAYS TO APPLY FLUOROPOLYMERS

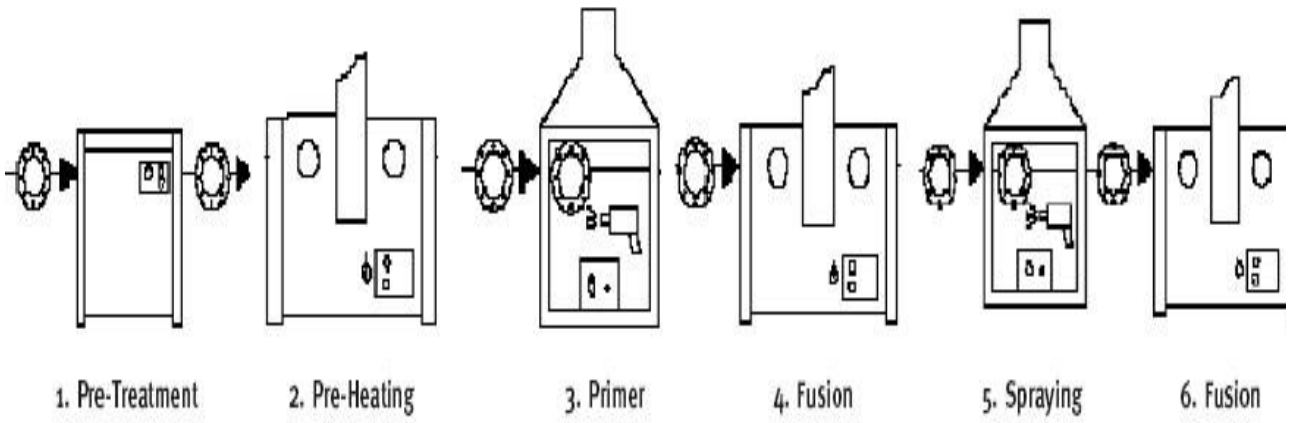
- ☼ Adhesively bonded to the metals
- ☼ Rotolinings

- Spray and Baked Linings (Coatings)
    - Dispersions
    - Electrostatic Spray
- Loose Linings

SELECTION OF THE RIGHT TECHNOLOGY

- Vessel Configuration
    - Dimensions , Complexity
- Desired Fluoropolymer
- Thickness of lining or coatings desired
- Operating conditions : Temperature / Pressure / Vacuum
- Reparability
- Track record
- Cost

Process



FACTORS AFFECTION PERFORMANCE OF COATINGS / LININGS

Major factors

- **Specification - unambiguous and precise**
- **Selection of applicator**
- **Workmanship**
- **Operation**
- **In-service condition assessment**
- **Repairs**

CONCLUSION

Future growth of high-build coatings will come about from:

1- Increasing cost of stainless steel and high nickel alloys
2- Increasing problems in the disposal of other less chemically resistant plastics after they have been exposed to hazardous materials and absorbed some of the hazardous materials. Fluoropolymers tend to
Absorb fewer materials.
3- Requirement of certain industries for reduced metal content to improve yield and quality.
4- Requirements of certain industries for higher product purity preventing the use of plastic materials with high levels of extractable organics.

Despite competition from metals and other materials, high-build coatings continue their expansion into semiconductor, pharmaceutical, chemical and process industry applications. The balance of excellent chemical resistance, high purity and good mechanical properties ensure that this trend will continue.
High-build coatings will be the option of choice, in our opinion, when compared to sheet lining and rotolining for chemical protection.