

## Use of Polyurethane Coating to Prevent Corrosion in Oil and Gas Pipelines Transfer

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**ABSTRACT:** Corrosion is one of the major problems in the oil and gas industry is one that automatically allocates huge sums annually. Polyurethane is a thermoses polymer with various applications. Using form this polymer has spread for military applications by Otto Bayer in 1930. In one general look polyurethane is product of Iso Cyanate and ploy with each other, So that: Iso + ploy = polyurethane. Spend large cost for application and launching oil and gas transitions, has cleared the necessity protection from them agonist corrosion. In this direction protection coating with specific properties such as high electricity resistance presented to market by various companies that each of them has special advantage and disadvantages. In this research has tried while analysis coatings specifications of gas and oil transitional pipelines, has compared properties and common qualities of them with each other.

**KEYWORDS:** Corrosion, Polyurethane, polymer Coating, Gas and Oil Pipeline.

### 1 INTRODUCTION

Steel pipelines are common device for transition of natural gas and raw oil all over the world, that with spending large costs perform and unchanging. Often this pipe passed (across) from earth corrosive environment or sea bad, repair and reconstruct. Of them is very expensive and its follow with many problems. According to this, protection from oil and gas pipes line is necessary that the most common. Various coatings for protection from oil and gas transitional pipe line have present. To market, that each of them has special advantage and disadvantage. In this research has tried (attempt), within analysis necessary specification for this coatings, compared the most common properties and specification with each other. Coatings specifications (properties) of oil and gas transition pipe lines. Due to electro chemical nature of corrosion pipes buried in earth or sea beds, and the most important specification of protection coatings. Is high electrical resistance and remain stable this specification during time? In addition to, due to implication sever intensions from soil stress, to buried pipes in them, especially in soil with high absorption ability and alternative weather burial, having high strength adhesion and cohesion and resistance to develop crack for protection coatings, is necessary. Whereas the existence of various chemical material such as salts, acids, material and many microorganism in soils and seas, cleared the necessity of chemical resistance of this coatings. The durability of coating during transportation storage and pipe installation mechanical properties (Stoke resistance abrasive Flexible and resistance against penetration of sharp edges of rocks and stones). Thermal resistance, easy repairmen of coating damages during installation and are as necessity specification (qualities) of protection coatings of oil and gas transition pipes. Beside, due to stimulate using from coating and catholic protection, also protection coatings resistance are very important to catholic disbanding. According to mention qualities, different types of protection coatings have produce and present for external. Coating of oil and gas transition pipeline, in the following has mention to their main and common groups of them, including for coatings, fusion bonded epoxy coatings and poly olefin coatings.

**Tar Coatings:** Tar coatings are the oldest coatings that used in oil and gas transition pipes. Some dominant qualities (specification) of them are lack of penetration against water and moisture and high resistance of corrosion, low price and easy operation. While fragility tracked and adhesion drop, in cold weather and flexible in hot weather less mechanical strength, maybe sustain loss or damage during transportation and installation, less resistance against unraveled rays are

considered as their disadvantages. Although combined tar coatings with fiberglass or mineral filling material such as silica, has solved solid disadvantages of them, but with become hard environmental regulations and increase acceptance of other coatings, has reduced the amount of tar coatings application. Although has spread using from improved tar coatings with all type of epoxy resin or your than.

**Fusion Bonded Epoxy Coatings:** Fusion bonded epoxy coatings are as powder coatings that often apply by electrostatic sprinkle on warm preparing pipes. This coating has good (suitable) mechanical and physical properties and follow with urethane coatings has used on installed pipes on earth surface. Fusion bonded epoxy coatings are naturally hard, fragile and tendency to absorption specific water in high temperature. Also, most of them has used for installed pipes coating in dry environment.

## 2 POLYOLEFIN COATINGS

Poly olefin coatings include polyethylene or poly propylene that has mechanical strength; fairly low pride and high resistance to carrion. The big problems of these coatings are less adhesion of them to steel pipes. For solve the problem has recommended to use three layer coating system including epoxy lining, middle layer, improved copolymer polyolefin and surface coating is polyolefin. In this systems cohesion and resistance to catholic disbanding by epoxy lining and penetration to water and oxygen, mechanical properties and chemical resistance has supply by polyolefin larger. Epoxy lining by spindle and middle coatings and polyolefin surface coatings has apply on pipes by extrusion methods. Low resistance against penetration sharp edge of stones and rooks especially in high temperature, mad crackup due to soil stress and low thermal resistance, has made some restrictions to using from polyethylene coating. While high stroke resistance in extensive range of temperature and resistance against penetration of sharp edge of stones and rocks even in temperature more than 100C, has spread largely using from there layer systems on base of polypropylene. Polyurethane is a thermoses polymer with various applications. Using form this polymer has spread for military applications by Otto Bayer in 1930. In one general look polyurethane is product of Iso Cyanate and polyol with each other, So that: Iso + polyol = polyurethane. Term of "100% Solid" Used for Coatings that in them has been any Solvent for dissolve, carrying or reduce amount of coating resins. In addition to, Resins that usually are liquid, after implementation (use) completely change to Solid. Contrary to common coatings Such as epoxies that just limit number of them has been usable for coating, polyurethane coatings have large output from types and shapes; (forms). Tem (Statement) of polyurethane coating is general. Tem, because already contains all things, from wood Seal to building floor and underground tanks coatings. Nowadays, various type of polyurethane has used in money applications. Flexible polyurethane foams has used for make bed, pillow and car Seat. Hard foams has used for insulation of freezers, refrigerators and roofs. Many Sport Shoes manufactures, has used impact resistance and elastic polyurethane in make shoes surface. In automobile industry, parts such as dashboard and bumper cuttings has mad by polyurethane. In addition to, polyurethane coatings also has used as bridges, seals, surface or tanks lining. Tem "100% Solid" make a little short Range of all kind of polyurethane Bust yet there are hundred different types of Iso Cyanate and polyol that by them has produced much polyurethane in this range. Another factor that could limit polyurethane by it is type of used Iso Cyanate in them. The most common isomers that used in polyurethane production are aromatic. Polyurethane that make by aromatics, have economic profit, and doing their work well, But when put against sun light, become as chalky and dark. Corrosion feature and other physic features of aromatics a system has not affected by sunlight. But if required, are used these coatings in applications that their appearance are important, and cover surface of them should be coatings. Automobile colors named as dominate sample of this type of polyurethane.

## 3 POLYURETHANE COATINGS PROPERTIES

There are many reasons for tendency to using 100% solid polyurethane coating for pipeline coating.

First of that, using this material has excellent results and this material are famous. Due to harmless, these materials are more adjustment than anti corrosion traditional coatings with environment.

Secondly, due to quick rate of cooking this material, could be put coating pipes under holiday pores test and buried.

Third, this material has ability to cook in low temperature, this subject is impossible in other coatings at last, due to this coatings for application are not need to exothrimicity, and they are applied in any thickness or length and diameter of pipe.

Response nature of Iso Cyanate and polyol for polyurethane production is exothermic. Due to this reason, the reaction itself provides needed heat. At last this coatings could be applied in any environment temperature, until apply this coatings

unlit 40C’ temperature under zero without using extra heat, is not impossible. In spite of properties that mention, 100% solid polyurethane has other good properties, such as:

- 1- Without pothole
- 2- High hardness and impact resistance
- 3- Good flexibility
- 4- Strong adhesion to metal surface
- 5- Be resist against steam penetration
- 6- Separable resistance due to climate factors
- 7- Chemical resistance

The polyurethane coatings can be classification according to type and their additive quantity. But this additives, usually is added to reduce extra price. Also, should be attention additives that reduce price, will be reduce quality. Adding 10 to 20 percent filling material (especially tar) has effective impact on price reduction, but the impact on coating qualities is small. Increase 40 percent or more will reduce price intensively, but will reduce coating properties so much. The common usable filling in 100% solid polyurethane, are tar materials. In this state, usually is use raw oil, asphalt or tar pitch, although should be attention tar pitch is carcinogen.

**Table 1. Example from Results of Effectiveness Tests in Some Type of Coatings, Gathering among Various Data of Manufactures**

Value	Epoxy	Polyurethane Test
Higher	1/8 Joules	2/3 Jews
Lower	2 mandrill	1 mandrill
Lower	120 milligram pert	52 Milligram pert
Lower	9/7 Cm <sup>2</sup>	3/2 Cm <sup>2</sup>
Higher	705 N/Cm <sup>2</sup>	1410 N/Cm <sup>2</sup>
Lower	0/0041 perm. Cm	0/0041 perm. Cm

Recently two additives have added to 100% solid polyurethane coatings. One of them is ceramic powders. These powders have cause coatings with having. The same quantity of elasticity, stroke resistance, has more corrosion resistance. Other additive, are anti – microbial and in washing that cause more protection from coating and under surface from microbiology corrosion. 100% Solid polyurethane has used for internal coatings of cast iron pipes of water and disposal in America since 1988. The purpose from using polyurethane as internal coatings of swedge pipes is prevention from corrosion of internal coatings of pipes and also prevention from microbiology corrosion. The existence of much amount of sulfate in swedge cause to produce H<sub>2</sub>S, as result, in state that speed of Swedes movement in pipes are low (level region) , produced sulfuric acid, and due to it , internal coatings pipes destroyed severely. Experience presented that iron case pipes without internal coatings, in this condition has corrode less than 3 years. In analysis has done in Virginia water and swedge research center, samples of cast – iron pipes with 100% solid polyurethane internal coatings has put in Acid sowphric 20% and evaluate internal surface resistance. This analysis has present high resistance of this coating. From 1988 until now, about 610 kilometer from internal coatings of pipes with 12 to 48 inch diameter has used in virginal swage network, and covered by 100% solid polyurethane and this usage has increase process. Covered swedge pipes, has not found any problem during work and operation (application) method of this coatings are very ideal.100% solid polyurethane coating, is non- toxin and has effect on smell or taste of drinking water and is not pollute it. For this reason, it used widely as internal coatings of water drinking pipes and has cover internal coating of water drinking tanks. With adding antibacterial factors to 100% solid polyurethane could be achieve coating that prevent from bacterial growth in the water. Also with adding special compound to 100% solid polyurethane, achieved coating that has high chemical resistance and used for internal coatings of chemical transaction pipes.

Stripe coat is a coating film of color which is applied before and after a full coating on the edge or weld lines of metal skeleton. This kind of coating is applied in order to create an appropriate structure and enough resistance against corrosion in these regions. Therefore SC has more protection for the edge of the coverage or weld line. It is applied before preparation of surface or before a full coating. Technical knowledge {number1} is relevant to community of protective coatings that has the following recommendations about SC {color usage, the shape of painted area and keeping of color of steels.

1. If SC has been determined for a project, it would have been before Primer or a complete coating in order to use for all corners, gaps, nails, screws, welds and sharp edges.
2. It should involve around the edges at least 2cm.
3. To prevent from peeling of Primer during the actions, it should reach to touch dry {it should be dry enough and non-sticky} and then use Primer {so this time should not be too long because it cause to regions without Primer become corrode.}
4. Maybe SC use once after Primer action, especially if much time is needed to dry.

Most SC is used for all edges, vertebrates and the weld because liquid colors move and flow in these parts. This phenomenon is the result of tension of surface and contraction of color film during drying. If this event happens, the color film will become thinner at location or close of edges. When color destroys in the regions of vertebrates, screws and welds can lead to crisis. Because these factors cause the continuity of skeleton become destroy. Overall SC has 2 important advantages: the first one cause to cover small defects and differences of surface such as: porosity of welds, the second one: If enough time gave to SC for drying, it would have prevented from flowing of last coating on the edges and causes more problem for them. Colors with high percentage of solid toward colors with low percentage of solid are less apt to be thin in the edge of the regions because overall, colors with high solid have more curing time and against Viscosity are higher and have less tension on the surface. Frequently corrosion of environment clarifies that whether SC is necessary or not? Often SC is affordable in environments with high corrosion such as: inside the tanks, water storage tanks and chemical materials. In environments with low corrosion, by choosing suitable materials and also by strict quality of control without using SC, maybe it reaches to appropriate protection against corrosion. SC is not necessary for very weak corrosive environments which the moisture is very low in it.

Wholly low solid colors with low viscosity, have more advantages toward SC because fast self-stabilizing colors do not remove of the edges like non natural base of Zinks with high solid degree and high Viscosity such as {epoxy adhesives }. However SC is used for sharp regions and the edges which maybe have not suitable thickness for coating. We should remember that the first advantage of SC is reducing the thickness of coating. We can use SC for all the coating layers. Excess colors increase the residual tension of film of coating that leads to gap or become membranous. Operator of color and expert at first maybe choose the best method by quality of control. Overall quality requirement of SC is consisted of:

1. Filling defects and ups and downs regions on surface.
2. Make a suitable sticky surface for a complete coating.
3. Thickness should not make more than acceptable for the complete coating.

These two methods have quality cases like below:

1. coating with brush
2. coating with air spray

Coating with brush is used for little spaces that are consisting of weld edges, screws and vertebrates and spray for large areas.

The methods of using should be prevented from high thickness that destroys the film.

Overall, from desirable characteristics of stripe coating we can hint to below cases:

In view of capability, high percentage of sticky on the various length of proliferation) this coating can tolerate each strike and dimensional changes.

Very good resistance toward heat shocks to 110°C. It has resistance at immersed conditions at temperatures between 30°C and 80°C.

In cases which coating has sudden injury, it can be easily flexible.

Pollutions are not stick on this coating and can be easily clean.

Very low permeability (stream 0/0018perm/cm)

Existing this coating is increased on the surface of resistance against of transmission of electricity. (2mm thickness can be at dc flow with 15000 voltage)

Time of half-life of coating is 30years so that after this period mechanical and chemical properties reduce to half but it can service too.

It possesses high chemical resistance toward corrosive chemical materials with (PH=1-13)

#### 4 CORROSION MECHANISM

Gases such as carbon dioxide or acetic acid and other short-chain aliphatic acids may be low or high production. The presence of these gases and acid corrosion control is making the complex problems for wells. Corrosion in oil and gas wells has electrochemical mechanism. When the system reaches a temperature below the dew point, moisture is converted to liquid and large droplets on the tube wall may occur. Water plays the role of electrolyte in the electrochemical reaction. The water itself is not corrosive, when acidic gases such as H<sub>2</sub>S and CO<sub>2</sub> are dissolved in water, an acidic environment in the vicinity of the sets that severe corrosion of the steel. The corrosive gases other than oxygen, sometimes in oil wells to gas wells, but the problem are there is no oxygen. H<sub>2</sub>S gas source can be found in the layers of sediment, oil and gas products of the reaction process or activity is bacteria. Further deterioration in gas wells due to localized corrosion occurs, the local corrosion under the insulation, the deposits or to be caused by bacteria and 10 to 100 times faster than the corrosion damage is uniform. Another type of corrosion is localized corrosion resulting from defects or FILC. The apparent deterioration in the situation is different. Presence of CO<sub>2</sub> as a needle shaped defects FILC or rupture occurs. CO<sub>2</sub> corrosion in gas wells can be divided into three temperature regions:

- A) Temperature below 140 degrees Fahrenheit (C60) does not protect the product and the level of corrosion caused by severe corrosion exists.
- B) Above 300 degrees F (C 150), Mgntayt is formed and the environment unless the presence of large amounts of salt water, is slightly corrosive.
- C) Between 300-140 degrees Fahrenheit (C150 -60) has the ability to protect the metal carbonate product layer does not even need a deterrent. But in the presence of ions such as chloride or hydrogen sulfide, or the destructive effect of high velocity fluid layer may be destroyed. Circumstances of high-speed m / s 10 and turbulent fluid flow, creating a protective layer, it is unstable. Aykada Believes that the growth of iron carbonates (FeCO<sub>3</sub>) crystals incomplete causes a small anodic area and the wounded are yellow corrosion.

#### 5 FACTORS IN THE CORROSION OF GAS WELLS

**Temperature:** Effect of fluid temperature corrosion in oil and gas industry in similar chemical environments, Corrosion rate is increased at higher reaction temperature corrosion so often that every 20 degrees Fahrenheit (C<sub>11</sub>) increasing temperature, the corrosion rate is doubled.

Corrosion of steel in corrosive CO<sub>2</sub> gas in the vicinity there are three temperature diets:

- A) Low temperature and non-protective iron carbonate C 60 and the corrosion rate is a function of CO<sub>2</sub> partial pressure.
- B) Between temperature and C150-C60 almost protective iron carbonate layer is formed and the corrosion rate reaches an acceptable value.
- C) C150 Mgntayt top layer is formed which completely cover and It is also resistant to high velocities and extreme turbulence and Is only sensitive to chloride ions.

**Pressure:** High pressure gas wells in the gas solubility in liquid corrosive effects. Gas pressure can reach psi 12000. Partial pressure of corrosive gases is an important point. The amounts of corrosion of a well produced by CO<sub>2</sub> are as follows:

- Partial pressure of CO<sub>2</sub> is Less than 7 psi → non-corrosive environment.
- Partial pressure of CO<sub>2</sub> between 7-30 psi → corrosive environments.
- Partial pressure of CO<sub>2</sub> is 30 psi → highly corrosive environments.

**The Role of Fluid in the Corrosion:** Experience shows that the wells have corrosion problems when Water cut in the total amount of fluid in them is more than 85 percent. Of course, it has plenty of exceptions. Fluid emulsion of water in the fluid conductivity and efficiency as a conductor affects. Mode of the large amount of water wells (without emulsion) produce more corrosive than water wells with Less water cut and more emulsions . Many studies have been conducted to determine the corrosive fluid within the well. Brad Bern 20 different wells of the contract and amounts of water and acidic gas CO<sub>2</sub> produced as the variables considered. He found that the amount of water is more productive; the amount of CO<sub>2</sub> is more soluble in the vicinity of the wall and creates more corrosion.

**Fluid Velocity:** Fluid velocity in the fluid regime and the regime's fundamental role in determining the type of fluid are corrosive and performance inhibitors. Experiments have shown that a diet supplemented fluid and field tests are equal,

Mechanism and the corrosion rate was similar in both conditions. Regardless of diet, fluids, in order to evaluate the effect of corrosion rate in the temperature range considered three, The corrosion of CO<sub>2</sub> at low temperature has a range of corrosion depends on the hydrolysis rate of CO<sub>2</sub> And is independent of the speed . Range 20 to 60 ° C. The rate of corrosion is very little because the phase of the reaction is CO<sub>2</sub>.

**Results and Discussion:** In this part, the results are obtained from experiments.chart1 shows physical and mechanical results. The results are obtained in comparison with available standards shows that Poly urethane coating has favorable properties.

**Chart 1. The Results of Physical and Mechanical Experiments**

Column	experiment	Coating with absence of SC	Coating with presence of SC
1	Transmission of electricity ohm/m <sup>2</sup>	4*10 <sup>2</sup>	4*10 <sup>12</sup> >
		To	
		4*10 <sup>10</sup>	
	Result	Good	Excellent
2	Permeability	7/6-8*10 <sup>2</sup>	./262
	Gms. 24hr/m10 <sup>2</sup>		./0025
	U.S.Perms		
	Result	Very Good	Excellent
3	(mm) tear of beam		
	-1.5V,20-25°C	-	6
	3% NaCl 30 days	13-21	-
	-6.0V,20-25°C		
	3%NaCl 30 days		
	result	Weak	Very Good

Chart 2 shows the resistance of corrosion of using coatings in different corrosive environments. Also this chat states how to applying mentioned coatings that this kind of coating is whether suitable or not? As can be seen chart 2, Polyurethane has good resistance with 100% solid in most corrosive environments and use of this coating is recommended.

**Chart 2. Resistance to Corrosion and How to Apply in Different Environments**

Column	experiment	Coating with absence of SC	Coating with presence of SC
1	Resistance to corrosion in temperature of room	Weak	Very good
2	50% average 10% weak acid	R	R
	50%<dense	NR	R
		NR	R
3	10% weak base	R	R
	50%average	NR	R
	50%<dense	NR	R
4	salts	R	R
5	Solvents		
	1 alcohol	NR	NR
	Variety of Ketones	NR	NR

In oil and gas industries, corrosion monitoring was carrying out with different methods. In our country, corrosion coupons are typically used. While the growth of technology, suggests use of the probe. Probes, especially the electrochemical probes have the faster and more accurately results. Also EIS probes can help to extract the details of local corrosion. It is not possible with other monitoring methods. In this paper, only the monitoring methods and electrochemical techniques were introduced. Details of each of the techniques, described in used sources.

Study of Reference list of the companies such as Socothern (Italy) and Corinth pipe work (Greece) and Jotun powder coating (UK), which is include pipe diameter, type of coverage and other data, indicate that mainly pipes are covered under 24 inches 3 layer polyethylene coating. In panel that recently was formed by experts of corrosion in Britain and America, and resulting is published in an article titled US & UK Industry discusses key challenges: in the Journal of Pipeline & gas journal monthly. John T O Shea former chairman of the British Institute of corrosion, after pose of status of gas network in Britain and its coverage in the high pressure line (164000 km) says: These lines are constantly developed for responsibility to the increased demand and new lines of high diameter are protected against corrosion by use of coatings with high integrity coating. O Shea in answer to the question of what kind of high integrity coating is this coating? Says: Examples of these are fusion bonded epoxy and multi component liquid coating (polyurethane) and don't pointing to use of coating 3 layers polyethylene for coating of pipe diameter. Also in response to the question of what percentage of the 164,000 km of country's pipelines are 3 layer polyethylene coating? Says: very little amount of these lines have this coverage and currently used of cover in the middle pressure pipes with a diameter of 36 inches. He is noted about separated the 3 layer polyethylene coating in Britain lines: they have little experience about 3 layers cover in their country.

## 6 CONCLUSION

100% Solid polyurethane coatings due to suitable properties such as: high adhesion, high resistance to corrosion especially microbial corrosion, suitable flexibility, very good friction and stroke resistance, high chemical resistance and good resistance in high temperature, have various application in external and internal coating of different equipments such as pipes. In addition to suitable (proper) properties, not be toxin and harmless, more adjustment with environment in comparison with traditional cold coatings, high speed of cooking and in result quick use ability and cooking low temperature of these coatings and lack of need to exothermicity has cause.

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