

## The Application and New Mechanism of Universal Produce the 3-Layer Polyethylene Coating

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### Abstract

Each of these coating systems are the advantages and limitations of its own that in many situations one is preferable to another, but in many other circumstances, there is the possibility of using both systems and makes it difficult to choose. In such situations must there is a good way to evaluate and compare that is reliable to would help in choosing the right system. Underground pipelines of new phase the wells gas and oil, are covered with Cole tar or strips of polyethylene from AL TENE that if performed correctly, the problem of corrosion is not observed. Good performance of coating depends heavily on the amount of adhesion to the metal surface. Initial adhesion and durability in terms of strike are factors that cause the high efficiency in the long run. The measure of initial adhesion has relationship with flow of the coating and wetting of its surface by applying of the coating and clean and ready of the pipe surface. This paper reviews the application and new mechanism of universal produce the 3-layer polyethylene coating and in end the new solutions are investigated.

**Keywords:** polyethylene coating, adhesive, oil and gas wells.

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### 1. Introduction

Over the years, very pipelines designed and built to various transports (such as pipes to transport of fluid and gas and crude oil, water). Transparent coatings of polyethylene (used in America) to the limited has been used in the main routes of transmission oil wells and fluid corrosive. With use of this polyethylene coating on the pipe line, feature durable pipes have increased to 3 years. In recent years, polyethylene coatings have been built and installed on large factories. Experiments with global terms that are belonging to companies to increase production capacity and have been done the genre availability of materials and their size

**Table 1: Physical Features of High Coating Polyethylene**

Physical Properties of Top-coat Polyethylene

Physical properties	Unit	Test Method	SK ET509B (typical)
Melt Flow Rate at 190°C/2.16kg	dg/min	ASTM D1238	0.30
Density	g/cm <sup>3</sup>	ASTM D792	0.949
Tensile Strength at yield	kg/cm <sup>2</sup>	ASTM D638	180
Tensile Strength at Break	kg/cm <sup>2</sup>	ASTM D638	300
Ultimate Elongation	%	ASTM D638	800
Hardness	Shore D	ASTM D2240	60
Vicat Softening Point	°C	ASTM D1525	120
Brittleness Temperature	°C	ASTM D746	< -70
Melting point	°C	ASTM D3418	128
ESCR (F50, 10% Surfactant)	Hr	ASTM D1693	>1,000
Water Absorption	wt %	ASTM D570	< 0.01
Carbon Black Content	wt %	ASTM D1603	2.0
Oxygen Induction time at 220°C	min	ASTM D3896	15
Volume resistivity	Ωm	ASTM D257	>10 <sup>16</sup>
Dielectric withstand	kV/mm	ASTM D149	38

The unique Rheological features of these polymers are specific that have ability of coating form in temperatures below 500 Fahrenheit.

**Table 2: Physical Features of Polyethylene**

Physical Properties of POLYGLUE®

Physical properties	Unit	Test Method	LE149V	LE200T	LE100A
Melt Flow Rate at 190°C/2.16kg	dg/min	ASTM D1238	1.6	4.0	4.9
Density	g/cm <sup>3</sup>	ASTM D792	0.921	0.927	0.916
Tensile Strength at Break	kg/cm <sup>2</sup>	ASTM D638	200	180	180
Ultimate Elongation	%	ASTM D638	850	800	820
Hardness	Shore D	ASTM D2240	48	47	47
Vicat Softening Point	°C	ASTM D1525	102	102	86
Brittleness Temperature	°C	ASTM D746	< -70	< -70	< -70
Melting point	°C	ASTM D3418	121	121	120
Water Absorption	°C	ASTM D570	< 0.01	< 0.01	< 0.01

### 1.1. Use and Advantages of Covers

Each of these coating systems are the advantages and limitations of its own that in many situations one is preferable to another, but in many other situations, there is the possibility of using both systems and makes it difficult to choose. In such situations there is a good way to evaluate and compare that is reliable to would help in choosing the right system. Important in factor of cost is that often alone dominant on other parameters and caused selection a system against other systems.

### 1.2. Nomination of Economic Scale

Economic scale is an important criterion for comparing and selecting the desired method of economic evaluation and the cost. Generally, economic analysis for decision-making is an integral part of engineering design and appropriate measures in this case, is to minimize costs.

## 2. Covering the Pipeline

Coverage of the pipeline, while working, is exposed on many items. Such as humidity, pressure, bacteria and..... But, the lack of sunlight is a positive option for the pipeline; Apply the coating on the pipeline have very cost. Therefore, selection of coating and how it applies is very important. Also for pipes that buried in soil, it is impossible that their coating like other structures, replaced in a short period and the cover should be lasted over 20 years. Therefore, features that a cover is required are:

1 - Resistance to water and moisture: Dry soils have often moisture and the coating of pipeline is sometimes wet, so the coating hadn't ability of absorbing the moisture, because absorbing of water cause increased the weight and will loss the electricity resistance.

2 - Resistance to pressure variable: Perching the pipe under the soil can lead to pressure on the tube. Also, existence of rock particles, movement of soil by moisture and also other particles in the soil is caused the pressure variable and inconsistent. In fact, coating should be a protective physical and do not separated from the surface.

3 - Resistance to capillarity of water: Water penetration due to capillarity cause to depart of the coating from steel, any kind tiny crack or whole cause to this effect. Unless the contact between coating and the pipe is solid and very sticky, In fact, Primer color has such duty that created a lot of adhesion between the tube and coating and prevents from seeping the water and separation of coating.

4 - Suitable with temperature changes: Temperature changes can impressive because the rate of expansion of steel and the cover is different. Expansion and contraction resulting to movement in the tube, but usually it is moving smoothly and slowly. Because the coating has been resistant to temperature changes and to this effect don't separate from the tube.

5 - Resistance to the dissolved: Water is able to solve some of the material, but normally coatings are insoluble in water. Also the cover should, in addition to being insoluble in water, to be resistant toward other than solvents. Particularly resistant against to oil and its derivatives

6 - Resistance to absorptive soil: Soil may absorb some of the material. Clay, Silica gel, charcoal and some other compounds have absorbent properties. Soil is fully contact with coating and absorbed of some elements from coating by soil to be possible coating brittle, porous, and to low its resistance to corrosion. About pipes that are supported with cathode, electric resistance of coating is also a determining factor. Whatever to be more the quality and the electrical resistance of the coating, less electrical current is required for cathode protection. An excellent and full coating needs to small fraction of an ampere for per mile of pipe. About the pipeline are used to bandage technique for coating pipes. Strips used are with commercial composition and are slight of the polymer strips. These strips can be divided into two categories: hot and cold. Heat is needed for install of hot strips. Also, can be classified the strips according to the used conditions. For example, bands of mountain areas are different from wilderness areas bands. For the bandage of pipes, at first surface cleaning should be done. Cleanup operations are performed by the sandblast. Compressor and pot of sandblast transport to the pipeline location and operation of sandblast is done by specialists.

### 3. Coating Operation

Steel surface must be dry and free of any contamination (oil, grease, corrosion protection temporary, etc.) that is harmful to the cover attached. After the neat front layer, a layer that is on the tube should be marked. All silver sheets, weld and defective layers should be dredged from the tube. After removing this defect, thickness of the pipe sediments and fittings must not be greater than the acceptable minimum. Chemical behavior of the steel, moreover of corrosion can cause to burn cortex. Covering facilities include a cover layer mechanical primitive, extruder in polyethylene, polyethylene unit and is a mechanism for pressing the sheets extruder in polyethylene contrary to the steel pipe. Polyethylene is within a single sheet that a high adhesive by combining two extruders, one for the attachment of polyethylene and other for compounds polyethylene with a die like T to form.

#### 3.1. The First Layer

Immediately after the tube a form by film is created from liquid or resinous of powder. Minimum thickness drier should be by 20 to 60 micron. (Equal to ISO 2808)

### **3.2. The Basic Characteristics and Tests for Epoxy Powders**

Epoxy powder contains substances that are used against heat, which is to use of cap in 3 layer polyethylene coating system for steel pipe.

### **3.3. Flexibility**

Flexibility should be measured according to DIN 53152.

### **3.4. Pressure Resistance**

Pressure resistance of the epoxy film should be minimum 120 kg / cm at 20 ° C was performed.

### **3.5. The Second Layer**

The polymer second layer created adhesion between layers 1 and 3 and should be compatible with both layers. Minimum of thickness should be between 160 to 200 microns. In Copolymer film (first layer - adhesive) is used limited between layer of epoxy mixing and a layer of polyethylene.

### **3.6. The Third Layer**

Pigments and additives may be collected based on polyethylene and should be uniformly distributed. Polyethylene film (top layer) used to mechanical resistance to prevent of deterioration and may be used in the transportation and transmission pipelines.

### **3.7. Advantage between the Second and Third Layer of Coating**

1 - Additional adhesion and chemical resistance properties are obtained by mixing epoxy. (First Layer - Corrosion Protection)

2 - The physical and chemical force obtained by Copolymers corrosive formed (middle layer) and polyethylene (top layer)

### **3.8. Burning Process of Pipes in the Initial Stage For:**

- Removal of surface contaminants (salts, soil, plants, oil and other contaminants)
- Minimize surface layers
- Removal the moisture

## **4. Methods**

New air with high-pressure to remove salts and soils

Hydrocarbon solvents (family of toxic aromatic flammable hydrocarbons or minerals) to remove organic contaminants

Heating of the surface layer to remove moisture and burning the organic contaminants in dredged to clean up the temperature of 75 ° C

## **5. Tests**

Contractor must export the test required for all tests production covered include the company.

The thickness of the test

This test should be performed 3 times over 8 hours of product. At any time in accordance with DIN 30670 standards is performed.

### **5.1. The Thickness of the Test**

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### **5.2. Testing of Surface Tension**

This test should be performed 3 times over 8 hours of product transformation. Test should be performed at room temperature and 2 purposes include of pipe lining and check of it with items on the table is desired.

Corrosion of the pipe coating layer cause to explosion of equipment so if the process do not complete for paint and coatings to be back again

### **5.3. The Relationship between Temperature and Tension**

The test of tensile based on a method, has been done from simple test of polyethylene film.

### **5.4. Effect of Temperature**

Metal surface temperature also plays an important dual role in the occurrence of corrosion under the coating. Control of corrosion under the hot coating is organizer than cold coating; the cause of this phenomenon is water vaporization under the insulation and increases the concentration of impurities with water.

In closed systems, increasing the temperature, cause to accelerates the rate of electrochemical reactions and increases the corrosion rate. But in open systems, raise the temperature can increases the corrosion rate. However in open systems, raise the temperature can cause to vaporize the water, destroy the corrosive environment and reduce the corrosion rate. Also, the high temperature reduces the useful life of protective coatings. Underground pipeline of new phase wells, are with Coltar coating or polyethylene strips from AL TENE that in the right performance of coverage, the problem of corrosion is not observed.

Corrosion in underground pipelines is the major problems that strategic industries of oil and gas and petrochemical are facing with this. Since the pipelines in the industry play a vital role, protection and control of these structures is vital. Failures caused by corrosion in steel and other metals covered, as corrosion under coating occurs when the insulation is in proximity of moisture. Corrosion under coverage in addition to lead the costs of repair and the production is stopped; it can also jeopardize the safety of staff and facilities.

Insulation and coating of pipes and tanks can be done to prevent, maintain temperature, process stability and energy efficiency. However, the dry cycles and continuous to become soggy of material under the insulation, can provide initial conditions for stress corrosion cracking or pitting corrosion.

### **5.5. Corrosion Mechanisms under Coating**

Corrosion under coating begins in the presence of water and oxygen. When water and oxygen are present in the metal surface, corrosion occurs as a result of metal dissolution (the anode effect). This chemical process balance by reducing the oxygen, The rate of corrosion under the coating depending on the sort of insulation, the amount of available oxygen, the amount of impurities in the water, temperature and heat transfer properties of the metal surface and dry or wet conditions of metal surface. In the absence of oxygen, corrosion rate to be negligible. However, carbon steels and low alloy have typically low corrosion rate in alkaline environments, but the chloride ions ( $Cl^-$ ) can cause to localized pitting below of covered. If the sulphur and nitrogen acids, which are acidic, from impurities in the water and air penetrate into the insulation, or if the water is acidic, occurs general corrosion. Sometimes, air and water impurities, especially the nitrate ion ( $NO_3^-$ ) cause to outbreak of stress corrosion crack (SCC) external, under coating in carbon steels or low alloy that are not tension. Mentioned phenomenon is more significant, when the process of alternating dry and wet environment, cause to increase the concentration of impurities.

## **5.6. Effect of Coverage**

Corrosion under insulation types is possible. Sort, only play a role in the speed and quality. The main effect of coating in this type of corrosion is to assemble annular space for gathering and remaining the water. Water can be supplied from external sources of rain or the fluids condensate.

Chemical composition and properties of coating have the role in corrosion. Covering material can absorb water and supply the proper water environment for electrochemical reactions. In addition, chemical compositions into the coating such as chloride and sulphate can play a role in the electrolyte, which can accelerate corrosion.

## **5.7. Performed Experiments**

Potentiometric experiments: To determine the properties of cathode protection Galva true, Potentiometric test adopted according to standards ASTM G 71-81, ASTM G 3-89, ASTM G 82-98, and result of this, is confirmation of properties Galva true cathodic protection.

Experiments study of Mechanical Behavior: study of mechanical behaviour of the coating includes measure of adhesion to the surface, test of hitting, weather tolerance, study of tolerance of thermal expansion and contraction.

## **6. Conclusion**

### **6.1. Study of Cause Separation of the Coating 3-layer Polyethylene Pipeline**

Pipes coating technology is developed with advanced oil and gas transmission lines. 40 years ago coal tar was the best protection for the tubes. Today, from synthesis resins used for coating and in the factory during the processes that are controlled with high precision, can be applied on the tube. The first line coating of deafens is against a corrosive environment where the pipe is buried. Second line of deafens is cathodic protection that is a vital element to keep and integrity of the lines. On the other hand, excessive protection current cause to decline of coating, to the reason for keeping the protection current in safety level, the increase efficiency of coating from the correct apply on metal surface that is fully prepared is important. Good performance of coating depends heavily on the amount adhesion to the metal surface. Initial adhesion and durability in contact situations are factors that are cause to high efficiency in the long term. The quantity of initial adhesion has the relationship with flow of coating and wetting of the surface by applying a coating and depends on clean and ready of the pipe surface.

The most of these coatings that today have consumption market than other types are:

1 - (Fusion bonded epoxy) FBE

2 - Polyurethane (from a technical point of view and the polyurethane substance is the best type of coating that used from 1970 and standards of the Draft recommended, DIN 30677-1998, DIN-30617-1992, ANSI/AWWA-C222-99 practice NACE-TG281-2002 is written for this coating. The high cost of this coverage is that, it is mainly used in special cases, such as locations with high heat.

3 -Three-layer polyethylene coating is containing epoxy layers, adhesive and polyethylene. Each layer provides properties for cover to increased performance for long life. Epoxy layer, which provides cross-links have very good adhesion, and show high resistance against corrosion and the oxygen penetration, but against the mechanical impacts at the time of stored, is vulnerable run and transport of the line. Layer of polyethylene is a very good protective to prevent physical damage. The major problem that is with this coverage, there is no adhesion between polyethylene and metal, so that used to adhesive layer that is a polymer modified for bonding of epoxy to the polyethylene.

### **6.2. Compared to Existing Standards and Specifications for the 3 Layer Polyethylene Coating**

3 layer polyethylene coating are described on the distinct national standards. The oldest and most common of those is the German standard DIN 30670 (two layers) , French standard NF A49-710 which is used in smaller scale and the Canadian standard CSA Z7245.21 which first appeared in the



early 90 and in the past few years gradually find international confirmation . These standards not only are different in the specification, how to process control and testing procedure, but they have their own philosophy. The major weakness in the DIN standard is that provider of coverage don't required to use of primer (epoxy), also are not called for cathodic disbandment test, and clear value to peal adhesion is very low. French standard NF has identified many weaknesses.

Canadian CSA Standard for polyethylene provides thickness of 2 to 3 times narrower than the DIN, because it is denser than of polyethylene that is used in Canada.

### **6.3. Major Factors in Coating Disband in Tubes Coated with Polyethylene**

The separation depends on the following factors:

- How (quality) factory applied coating
- The conditions and characteristics of coating exposure

The epoxy powders that are used in three layers of coatings, classified in two different groups. First group that has the property of the primer and second group that has coating quality, these materials have significant differences in terms of apply and thickness and temperature, and generally in the industries is tend to use of high quality epoxy coating. Because the final consumer can be determine higher thickness that will result better properties for system. Study of reference list of company Jotun Powder Coating, UK demonstrates the use of epoxy layer with thickness higher of 150 microns, especially is in pipes at higher size. Epoxy layer must have sufficient thickness so should be avoided as to create holiday. Early experiences and experiments that having done in the field show increase more than 40 holidays of 40 feet for a layer with thickness of 150 microns. According to Dennis Neal advice, President Company U.S.A Harding & Neal that has a long history in the field of coatings and corrosion should be considered a minimum thickness of 250 micron for epoxy layer. Time is important and sensitive factor in the run- layers of adhesive and polyethylene on epoxy. At first adhesive with the chemical groups in the epoxy powder that are still uncured to establish a strong chemical bond, so at this stage epoxy should not be fully trained. On the other hand the adhesive and polyethylene connected physically. This is done by pressure through rollers and being sensitive of time is for this reason that from one side epoxy for bonding with adhesive should not be thoroughly cooked and the other hand should be get gel-like state, so can resistance against pressure of rollers, on other words, all of these steps must be performed in less than a few seconds. Users of coating should be careful that applying a solution for resolve the issues three layers do not cause another problem. For example, the separation at the seams with lower the temperature epoxy decreases of 239/ 4 degrees C to less than 2 / 232 ° C3i, but while the FBE at lower temperatures to be cultivated, but the high viscosity of the melt in the heat doesn't allow to flow epoxy and complete wetting of the metal surface, and this cause will be to opposite effect in terms of heat and moisture on the adhesion of coatings and too cathodic voltage. Below context is from Dennis Neal, one of the exporters in coating.

Disbandment occurs on 3layer coating at STEEL/FBE interface. The extent of disbandment depends on exposure conditions and quality of the coating.

Two problems are quite widespread:

- i) The FBE layer is under cured because the application temperature is low to allow the adhesive to chemically bond to FBE.
- ii) There is no adhesion between the FBE and the adhesive because the temperature is higher and the FBE is fully cured before the adhesive is applied. (7).

In article from one of the company's CEPA (Canadian Energy Pipeline Association) result of experience in this company is expressed to prevention of a SCC by system covered. In this article mentioned: the best proven method for reducing SCC in a new pipeline, is use of high-efficiency coatings and effective cathodic protection. Coatings must necessarily possess the following characteristics.

- Pipe surface must be separate from contact with the electrolyte or environment that causes.  
(Covered with a metal surface has durable adhesion)

- The separation of the coating, the cathodic protection can with cross of coating carrying to metal surface.

- During the preparation of surface for coating, pipe so the change that is less susceptible to SCC.

3 layers polyethylene is one of the coatings with high efficiency. Although it appears that the limited (compared to other coatings) has been used in fields.

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 Oshea 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. Oshea 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.

#### 6.4. Other Influencing Factors in the Separation of 3-Layer Polyethylene Coating

This is a flow that published into electrolyte from the sources separated of the cathodic protection system. This is cause to disorder in the distribution protected system. Basically, where that the protection current comes to the lines, apply stronger protection of cathodic and stray additional uncontrolled currents can cause overprotection and to causes phenomena such as separation of coating.

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