

Study act of corrosion in external metal pipe lines and different ways of protection and contrast against mechanical injury and chemical corrosion

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ARTICLE INFO

Article history:

Received: 7 March 2013;

Received in revised form:

20 January 2016;

Accepted: 26 January 2016;

Keywords

Corrosion,
Covering systems,
Pipe Lines,
Chemical and Mechanical Injuries.

ABSTRACT

Corrosion from long time ago was one of the biggest problems of gas and oil industry. Corrosion not only cause to high costs of repairs ,but stopping production during repairing and safety matters cause to enormous loss .The importance of covering of underground pipes with plastic material in decade of 1970 continuously has been increased .So that in many cases ,replaced to traditional protector on the base of natural pitch and coal tar .In 1980 more progress was in the field of covering pipes with plastic materials that cause to decisively stabilization of polyethylene and molten connected epoxy as new protector for underground and sea pipe lines .So the aim of continuous extension of plastic materials and covering systems was in direction of making protection tools that are flexible for transferring and resting on extension slope from environment temperature and even preserve their integration in extension range of applied temperature .In this paper we try to study the act of corrosion in external metal pipe lines and even different ways of protection and ways of contrast against mechanical injury and chemical corrosion under soil , by attention to the type of soil.

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Introduction

Systems of transferring pipe lines and oil and natural gas in Iran and other places in the world, usually are very long and has many branching, disabling of these lines could have set serious and effective problems on the environment, economic and society. As the result, it's necessary that after install and starting these pipe lines, accurate operation should be perform for the purpose of awareness of disabling manner and intensity of these pipes and probable repair that's needed. On the other side the process of repairing and replacing of damaged pipe lines is very time consuming and costly. So use of polyurethane covering with 100% solid and correction of quantity risk of disabling pipe lines which damaged cause to economic saving of time, polyurethane covering as a polymer material that today is completely replacing polyethylene covering, has many benefits like chemical and mechanical superior properties.

Preface

Corrosion has been taken from "corroders" Latin word and in technical term, each kind of metal decreasing arising from electrochemical process is corrosion. Costs that corrosion damages caused in industrial countries yearly is 4% of national impure income. Which considerable amount of that allotted to pipe lines and related equipments? In corrosion assessment should attend to two elements: first, the type of materials which is chosen for the pipe line and second environmental condition of pipe line from the viewpoint of corrosion. Although other mistakes during the process of choosing materials, designing, making, installation, starting and protecting can cause to create a suitable environment for corrosion or decreasing resistance against its threat. Corrosion phenomenon is one of the basic subjects in industrial field. Corrosion phenomenon is mooted in all industries and there is no limit about this matter. Today metal corrosion in Iran like other countries of the world cause to fade of equipments, machines, jetties, digging equipments, water, gas and oil pipes, energy generator powerhouses, port foundations

and refineries. For this reason, each year, enormous quantities of country capital are wasting. Then, recognition of corrosion and related experiments and ways of protection and applying these ways cause to decreasing of losses and can be counted as an important step in direction of industry self- sufficiency, but by attention to this matter that in our country, oil industry is counted as the oldest and basic industries, the importance and the role of corrosion in oil industry in more tangible. Corrosion phenomenon and campaign with that now obtains its place in oil industry. We hope that organizing of corrosion management in this ministry has the rightly effect on plan of corrosion phenomenon in oil industry and other country industry organs. About economic assessment and corrosion damages, some statistics and numbers presented from some advanced industrial countries. Statistics of industrial countries indicate to 4-5% of national impure production. Some of them are pointed: corrosion loss in USA in 1994 reported 300 million \$ and it is estimated that this number arrives to about 400 million \$ in year. In German in 1994, 117 milliard Mark reported for corrosion loss. In Iran, by estimating, number of financial loss arising from corrosion is about 12500 million Rials in 1997. By suitable programming we can decrease this number 25%.environment is a phenomenon that today is much mooted. Is there any relation between corrosion and environment? Explain yes, corrosion phenomenon cause to wasting of material, energy and capital and one of the results of corrosion is environment pollution. For example, a pipeline leak due to corrosion causes oil entering the ecosystem which damages the environment. But it should be noted that while preventing, the environmental parameters should be considered. For example in the use of corrosion inhibitors as corrosion catalyst materials, we should be careful that some of them like Chromate, Zinc, Polyphosphate, Nitrate and Nitrite can damage environment themselves, so their use should be monitored carefully, because sinking and entering of these materials can have certain poisoning effects on aquatic

animals of ecosystems. Although Chromate is the most effective inhibitor material which is available today, it has use restrictions because of polluting the environment.

Assessments of pipe line safety during operation

In production, installation and exploitation process of gas and oil pipe lines, related defect due to use of primary materials with low quality, lack of correct installation, changes of around environment of pipe line and also harmful materials exist in oil and gas causes to firmness decreasing, useful age of pipe line decreasing and even decreasing of safety properties. By attention to performed researches, the most important negative elements that effect on the proficiency of oil pipe line include the below cases:

I. Corrosion, lack of correct installation, damages and external forces, that all of these elements cause to fade of material quality used in pipe line.

II. Underground events like earthquake that these cases affect on the pipe line hardly and suddenly and can change natural environment around the pipe line.

III. Bad quality of materials used in instruction of pipe line

Buried foundations in soil like steel pipe lines of gas and oil nets are exposed to corrosion from soil. Soil is a complex corrosion natural system that formed from air, water, solid particles. Because of soil electrolyte properties, the main way of metal corrosion exist in soil is electrochemical way. In fact, steel materials that exist in soil, corrosion as Anodes and become oxide. amount of pipe lines oxidation, depends on the pH of soil, oxygen density and also existence of negative corrosion ions like HCO_3^- , SO_2^- , CO_2 , CL_2 . The most important corrosion types caused by soil include monotone corrosion, minor (molds and troughs) and corrupted corrosion that from view point of results of entered damages to pipe lines, minor corrosion is the most important and the most prevalent of them.

Statistic method

On the basis of scientific and experimental corrosion data's, repairing time of pipe line first sinking is a function of a determined math division. By determining of first time sinking division, corrosion predicting operation can be done. On general, life time of a pipe line follows a probability division as bellow: which in that "T" is life time duration, "Ps(T)" is the probability time of pipe line changing, "β" and "θ" are the special parameters that are available by the help of statistic data. In operational state, first of all we should gather corrosion disable pipe line data's, then special parameters should calculate by the help of statistic analysis and finally pipeline probability division is determined. By the help of this division we can determine probability of pipe line disabling.

Solutions for corrosion management

Corrosion management presents preventing strategies and proceeds to taking strategic steps in two fields of technical and non technical rubrics which are followed in non technical fields as preventing strategies are:

1. Increasing awareness about corrosion enormous costs and saving in these costs causes to correct use of present technology and decreasing of costs. So, many corrosion problems is the result of lack of awareness in corrosion management and the responsibility of persons in interchanging operations, inspection, repairing and keeping engineering system.

2. Changing of policies, rulebooks, standards and management methods for decreasing corrosion costs with correct management of corrosion that eventuate to effective control of it and causes to a more safe and reliance operation performance and increases the useful life of equipments.

3. Correction and extension of workers training for introducing and recognition corrosion control which requires putting corrosion preventing and controlling instruction courses in educational and management schemes.

4. Changing and correcting the delusive and false belief of surrounding against corrosion and choosing new decisions in order to prevent this phenomenon.

Protecting Transferring Gas and Oil Pipes by Use of Polyurethane Covering

A) properties of solid polyurethane 100%

1. This covering is without resolver and for the purpose of using it on the surface, there is no need to use resolvers for diluting.

2. Because of high stickiness on different surfaces (Concrete, metal, Aluminum ...) and high stretching properties (can tolerate up to 50% of length increase), this covering is able to tolerate each type of hitting and changing dimension.

3. Excellent resistance against fatal ultraviolet rays

4. Excellent resistance against heat shock till 110 °c.

5. If the covering is suddenly damaged, it can be repaired easily.

6. This covering is a self reticent so it prevents fire extension.

7. Pollution doesn't stick on this covering and it can be cleaned easily.

8. Some mechanical properties of this covering can be pointed as: high resistance against rapture (180 kg/cm²), contraction 0%, high stickiness (for example more than 10 mpa for steel) and suitable hardness (75±5shooreD)

9. very low permeability (0.0018 Perm/cm for water steam)

10. Existence of this covering on the surface prevents electricity flow (with 2 mm thickness it can resisted in D.C flow of 15000 v)

11. The half-life time of this covering is 30 years which after this time its mechanical and chemical properties decreases to half but it still can be used.

12. High chemical resistance against corrosive chemical materials with pH= 1-13 comparison experiments between polyurethane and several other protector coverings and their results

A) General conclusion and comparison with other coverings

In transferring lines industry some of the coverings are more prevalent which some most important of them are pointed in table 1. This table is set up on the basis of each covering replication and has 4 states of A for excellent quality, B for good quality, C for acceptable and D for weak. Each property is surveyed separately.

Table 1: Physical and Mechanical Experimental Results for Different Coverings

PVC	Polyethylene seam	3 layer polyethylene	Oil based pitch	Polyurethane 100% solid	Prevalent covering type
C	B	B	C	A	Stickiness
D	B	A	C	A	Chemical resistance
C	B	A	C	A	Electrical resistance
B	A	B	C	B	Flexibility
D	D	B	C	A	Hardness/resistance against abrasion
D	C	B	C	A	Resistance against hit

*If locating under direct sun rays it should be said to the producer

A: excellent B: acceptable C: good D: poor

Different mechanical and physical experiments on tar enamel coverings, fusion bonding, polyethylene, polyurethane dissolved in tar and polyurethane with 100% solid has been performed. These experiments include measurement of electricity flow, sinking, stickiness on the stainless steel, resistance to hit, increasing of length, separation radius, traction firmness, and manifest properties after heat shock. Also, resistance of these coverings had been tested in different environments. It's necessary to say that these experiments has been performed with national standards and result of these experiments has been interpreted with these standards .in this section the results of these experiments are reviewed.

Table 2 shows the corrosion resistance of different coverings used in deferent environments. It also shows the usage of these coverings in mentioned an environment which shows whether the covering was suitable for that environment or not. as it is shown in Table 2, the polyurethane covering with 100% solid is suitable in most corrosive environments and use of this covering is highly recommended.

Table 2- corrosion resistance of different coverings and how to use them in different environments

	environment	Tar enamel cover	Polyethylene	Polyurethane immersed in pitch	Polyurethane 100% solid
1	Resistance against corrosion in normal temperature	Poor	Good	Very good	Very good
2	Weak acid 10% 50% medium 50% < concentrated	R NR NR	R R R	R R R	R R NR
3	Weak base 10% 50% medium 50% < concentrated	LR NR NR	R R R	R R R	R R NR
4	salts	NR	R	R	R
5	Solvents, Alcohols Ketones	NR NR	NR NR	NR NR	NR NR
6	Use as a suitable cover	NO	NO	YES	YES

Low costs of this covering

The Industry of polyurethane covering has decreased the costs by extension of systems that have a little more filler. Polyurethane covering 100%solid is more commercial and more economic than PP, PE, FBE and color neoprene which are expensive and have harder operations than PU.

Because coverings like polypropylene and neoprene are performed in several layers and steps, which itself indicates costs differences. On the other side, easily repair that can perform in any environment is the most important advantages of covering pipes with polyurethane. Also with a completely transparent surface after applying the cover on the body it's possible to trace any defects and so prevent defects extension.

Compatibility with environment

Despite the existence of isocyanine groups in formulation of polyurethane 100%soild, this material as a compatible product with environment doesn't causes any damage to environment and workers that use suitable safety equipments. Polyurethane 100% solid doesn't create any pollution in any steps of production, storage, transferring and usage. Some of polyurethane 100% grades have confirmation of use in contact

with water and nutrition plants. The result of gas analysis on the polyurethane 100% is reported that the percent of HCN ascending from polyurethane 100% in blazing condition is zero.

Figure 1: Steel Pipe Covered with Polyurethane 100% Solid

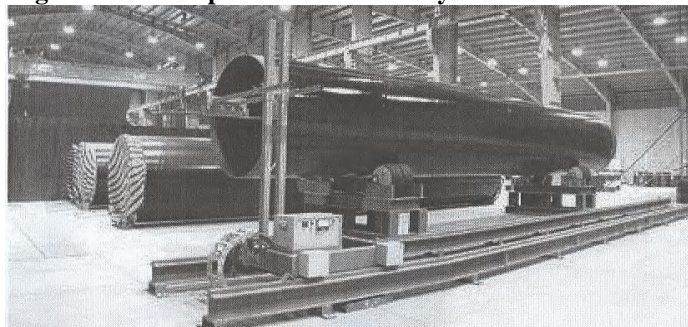


Figure 2: A View of Steel Pipe with Three Fold Cover Polyethylene



Figure 3: View of cover process of Polyethylene

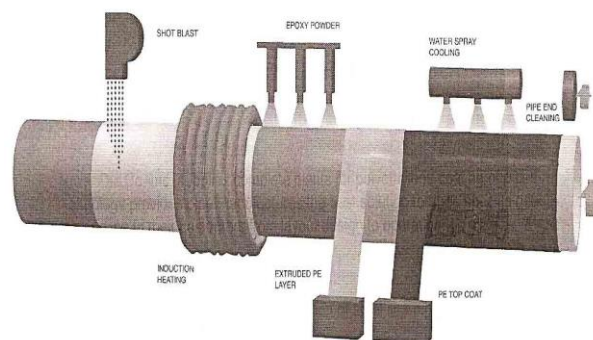
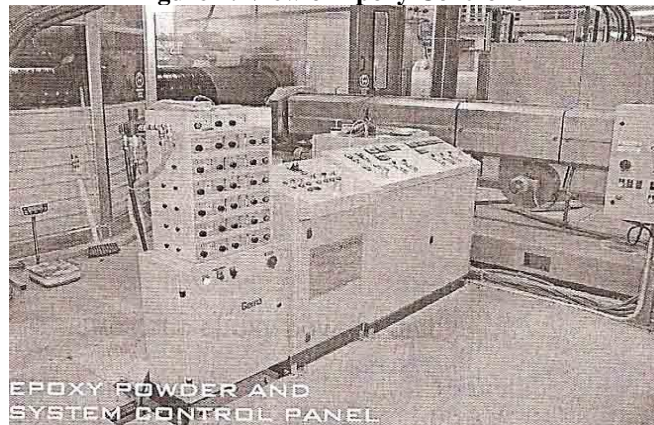


Figure 4: View of Epoxy Controller



Suggestions

A) Prevention Methods in Design and Construction

1. Use of coverings with high firmness and stickiness like 3 layer polyethylene covering, melt epoxy covering and polyurethane covering.
2. Full caution when using pitch coverings (oil and coal tar)
3. Not using plastic band coverings as the main covering
4. Assist above cases for scum coverings

5. Cleaning the surface of pipe as the 2.5 SA standard and complete elimination of factory oxide layer.

6. Decreasing the Face Reinforcement in factory in order not to have any empty space between covering and pipe

7. Full caution when using spiral weld pipes because of long weld line considering probable risks of stress corrosion

8. Designing output pipes of compressor stations until the first valve after the station or until the first 20 kilometers after station with the same class in order to decrease pipe stress and to eliminate stress corrosion

9. Using the temperature under 50 °C for output gas of station in order to decrease damages due to stress corrosion

B) Prevention Methods in Operation Steps for Pipe Lines Which Stress Corrosion Cracking Has Been Seen or Is Predicted in Them

1. Decreasing internal pressure of the pipe

2. Leak detection each 6 month on transferring pipe lines with bellow features:

2.1. Pipe covering should be cold plastic and minimum 10 years should be passed from its construction.

2-2. Output of compressor stations till the first valve after station or the first 20 kilometers regardless of covering type

3. Discussing soil conditions of humidity ,type, mixture, electrical resistance, pH

4. Checking catholic protection condition of pipe line.

5. Checking pipe covering and if necessary digging on the pipe in some spots every 1 or 2 years

6. Doing static pressure experiments and repairing damaged spots

7. Using ultrasonic smart ball equipped with crack detection device in order to determine the scope and the exact position of cracks

8. Surveying the corrosion products composition made on the pipe

9. Surveying the acidity strength (pH) statics under the pipe covering

10. Non-destructive inspection on pipe with manual ultrasonic devices

11. Cleaning the pipe surface and placing the new cover

12. Changing the pipe

Conclusion

Generally, corrosion costs include high capacity of the national capitals in countries. By taking a look at experience of other countries we can see that many countries now think about suitable arrangements in order to contrast with damages due to corrosion. A basic need that corrosion experts of America considered is performing studies for estimating metal corrosion costs on the economy of America and compiling of a strategy for decreasing corrosion costs. Therefore on the basis of performed conversations between members of congress and transferring ministry, a correct plan for corrosion costs in transferring (NACE) American society of corrosion engineers in 21 century presented, which has been accepted by the congress in 1998. Most of experts of our country believe that first of all we need a basic movement in the field of providing complete formal statistics in the corrosion field in order to determine the dimension of corrosion in all industries.

1. Corrosion is one of the non-avoidable problems in oil industry

2. Soil properties, especially micro organisms activity in comparison with other elements increases the corrosion speed and destroys the pipe line confidence ability, so this element should be noticed in direction of performing reserved bilateral actions.

3. For the purpose of firmness predicting and retain life time of pipe line, some parameters like disabling probability, corrosion distribution and confidence ability should be considered seriously.

4. Use polyurethane covering for oil industry steel pipes that with high corrosion resistance, prevents demolition of these equipments.

5. Using polyurethane is not dangerous and is completely safe.

6. By attention to the result of the performed experiences, this covering corresponds to the new standards of DIN, ASTM and protects pipes.

7. Polyurethane covering with 100% solid can be used in weak and medium acid, weak and medium base and salt environments.

A) An Analysis of Reasons for Three-Layer Polyethylene Coating Separation

Good function of coating depends to a high extent to its adhesiveness rate to metal surface. Initial adhesiveness and its durability in contact condition are of those factors that result in high efficiency of coating in long term. The extent of initial adhesiveness has a very high relationship with coating flow and its wetting when applying coating and also with cleanliness of surface and its readiness. Durability of adhesive depends on coating properties such as its resistance against moisture penetration and also its endurance against catholic disbandment.

The most leading coatings having more consumption than other kinds are as follows:

1-FBE (fusion bonded epoxy)

2-Poly urethane (from technical view poly urethane materials are of the best coatings used since 1970 on). High cost of this coating has resulted in using it just for special cases such as when temperature is very high. Three-layered poly ethylene coating includes epoxy, adhesive and poly ethylene. Any of the layers provides coating with properties to lengthen its efficiency for a long term. Epoxy layer has a very good adhesiveness due to its transverse bonds and has a very high resistance against corrosion and oxygen penetration. But it is vulnerable to the mechanical hit when storing and line performance. Poly ethylene layer is a very good protection to prevent physical damages.

A main problem with this coating is that poly ethylene does not have adhesiveness with the metal and for this reason an adhesive layer being a kind of reduced polymer is used for pasting poly ethylene to epoxy.

B) Main Factors in Coating Separation Are as Follows

1. The manner three-layered poly ethylene coating (quality) of applying coating in the factory

2. Exposure conditions and properties

Three-layered poly ethylene is one of these coatings with high efficiency, although it seems that it is used in the field in a very limited extent (comparing other coatings) and more laboratory studies and field experiences are needed to investigate if they have aforesaid properties.

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