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THE USE OF A DUAL POWDER SYSTEM AS AN EXTERNAL PIPELINE COATING

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ABSTRACT

This paper discusses the possible use of a dual powder system, the latest external coating for buried steel pipe. The suitability of dual powder system for high mechanical properties (gouge resistance, impact resistance, penetration resistance, etc.) and/or heat resistance are discussed. The advantages includes easy plant application process, high quality, easy repair and its suitability for joint coatings, etc compared to single layer fusion bonded epoxy resin coating, coal tar enamel and three layer polyethylene. Some cases that dual powder system was used in China pipeline construction projects were introduced too.

Keywords: Dual powder system, Pipeline, coatings

INTRODUCTION

Dual powder system (DPS) for steel pipe is one of the latest pipe coatings. As a new multi-coat concept coating, DPS is another tool to use in corrosion control and can be used with success on steel transmission and distribution pipes as an external coating. Since 1990s, when DPS was introduced into the pipeline market and has been used on several major pipelines including the Houston Ship Channel Crossing (horizontal drilling), USA; Alliance (Canada) and Duke Energy, EGP, Australia, [1]it has shown a marked, steady growth due to its excellent anti-corrosion properties, high mechanical properties, and relatively low cost compared to 3-PE. All these advantages have increased its usage, particularly at river crossings, rock areas and high mechanical damaged areas; and pipelines operating at high temperature. Even though it is considered relatively new to the industry, yet it is a reliable coating. More and more pipeline projects select DPS as the fist choice for high mechanical resistance and good anti-corrosion protection. The success of DPS is based on five key factors: [1] [2] [3][4]

- Excellent mechanical properties; especially gouge resistance
- High anti-corrosion properties
- Easily apply in coating plant & joint coating site
- Totally homogeneous, including with repair coating and weld coating (Only sleeves and liquid epoxy coatings are considered)
- Avoid cathodic protect shielding problem

THE DEFINITION OF DUAL POWDER SYSTEM

The coating is composed of an anti-corrosion layer of normal epoxy resin, and a modified epoxy resin on the outer layer. Epoxy used in the base coat is normal fusion bonded epoxy for pipe coating requirement. The top-coat is epoxy modified with a plasticized FBE or vulcanized FBE for different properties [5]. The base epoxy resin layer interacts with the metal and at the same time it interacts with the modified topcoat. The inner layer and the outer layer of DPS are completely compatible; always a 20~50 μm mix-layer exist as an intermediate layer because of coating process. This provides good adhesion between the layers and the integrity coating provides high resistance to cathodic disbondment.

Figure 1 shows the typical sketch of dual powder system.

Typically a 250~400μm of the base coat thickness is recommended. Recommended top coat thickness range from 350μm to 600μm. The proportion of base coating thickness to top coating thickness is recommended between 1:1.5 to 1:1.2. The thickness of each layer should be tested according to ASTM D4138 *Standard Method Measurement of Dry Film Thickness of Protective Coating System By Destructive Means* requirements. [6]

This combination is applied in two layers on one time for additional mechanical toughness. It has been tested and it is extremely durable in high impact tests and demonstrates good flexibility. DPS maintains a consistent strength during hardness tests, and has proven to be gouge resistant when used at rough terrain areas (rocky areas, areas with hard soil, etc)[7] . Also, this DPS is designed to provide maximum gouge resistance without sacrificing the compatibility with CP. This system was created by DUPONT and first successfully used in Vintage Oil U.S.A. in 1992. In 2002, a dual powder system was applied in China successfully and a test standard of technical specification of DPS was issued by China National Petroleum Company. [5]

A production layout is schematically represented in Figure 2. [2] A different layout can also be used, for example, heating the steel with flames, using the mixed recycled powder by the independent guns, etc.

It is worthwhile remembering that dual powder system can be processed with standard powder spray guns. [8]Compared with single layer FBE coating or 3 layer PE/PP coating, dual powder system can achieve a higher production rate. [3] [9]

PROPERTIES

Multi-layer coating technology can combine the advantages of epoxy resin[10] (i.e. good intercoat adhesion, high cathodic disbonding resistance and excellent interfacial adhesion properties) to give outstanding physical-mechanical properties, as well as high chemical resistance, low water permeability and wide service temperature range -40°C to 110°C for this modified epoxy resin.[2][3][8][11][12]

Typical properties of DPS

FBE base coatings are poor for mechanical properties; of course, by using only FBE as top coating without base coating are poor on both anti-corrosion properties and mechanical properties. Dual powder systems avoid poor mechanical properties of single layer epoxy coating and cathodic shield problems, keeping the excellent corrosion protection properties of epoxy and mechanical properties of multi-coatings. [5]

For different purposes, many different special top coating were designed as high temperature, offshore coating, like Arco offshore pipeline, 95℃ services temperature, constructed in 1996 in Indonesia ocean areas coating.[12] Typical physical properties of dual powders system are shown in TABLE 1. [7][13][14]

Comparison among anti-corrosion coatings

In the past, bituminous materials were widely used as external pipeline coatings because it is easy to apply. Unfortunately, they soften at high temperature and become brittle at low temperatures; not mentioning that they are susceptible to damage during handling and transport. Due to environmental concerns, the use of bituminous materials has reduced significantly especially in areas that are more susceptible to environment damage. Nowadays, FBE coating and 3-layer-PE has been widely used as external pipeline coatings. But these anti-corrosion coatings present some weaknesses as discussed, which may reduce their application range. FBE is essentially poor mechanical material that can be easily gouged especially at rocky areas, thus often epoxy-coated pipes are in swamp or desert environments and, in all cases, they must be carefully handled.

Cathodic shielding problem is the important problem of PE coatings.[4][5] Polyethylene can withstands a maximum temperature of 70°C. [15] These may cause pit corrosion under cathodic protection and defects on the coating during storage, handing and installation especially in hot areas; additionally PE indentation resistance is not high, especially as temperature increases[16].TABLE 2 and TABLE 3 gives a comparative evaluation of four materials used in anticorrosion coatings, analyzing the coating resistance during storage, transport and laying operations, the coating capability to protect the steel against corrosion and the coating resistance with the time[2][17].

Gouge test

In order to control the mechanical properties of DPS, as one of the pipeline construction requirement, gouge resistance is an add quality control item. According to a recent survey, the integrity of external coating before backfilling, most of the mechanical damage are nicks[14][18]. Gouge resistance is the most important property of DPS; it is much better compared to FBE [18]. The use of DPS can reduce the number of scratches and reduce the cost of patch in the field.

Because the dual powder system has a strong coating gouge resistance and strong adhesion is achieved between the coating and the steel, generally there is no fatal mechanical damage and disbondment up to 60℃[18]. Figure 3 and Figure 4 shows the variation in gouge with temperature in comparison with polyethylene coating. By choosing special modified epoxy, it is possible to obtain high gouge resistance and impact resistance both at high and low temperatures. The dual powder coating does not require any rock-shield due to the very high indentation resistance even at very high temperature area, such as tropic desert. With the same token, problems that may occur when pipes are stored in piles or handle in hot areas are strongly reduced.

QUALITY CONTROL

It is widely known that coating quality control is important for corrosion control, however often one does not understand the impact of a poorly written specification on the coating performance. DPS is a new coating material, void of quality control specifications or technical standards for design or applying of dual powder system. For this reason, dual powder system application technology requirement standard was issued by China National Petroleum Company, ARCO Company, Duck Energy International Company, etc respectively.

Total coating thickness and each layer coating thickness should be strictly tested. Reaching production coating properties criterion can ensure the quality of this system. Raw material and production process control is the base of quality. Additionally gouge test is also one of most important mechanical properties test requirement as a measure for quality control of DPS. Recommended test is per standard of NACE STG 35/TG04 (draft) *Gouge test external pipeline coatings requirements*.

REPAIRS

Dual powder system provides outstanding mechanical properties and for this reason they are usually not damaged during shipping, storage, handing and installation. In any case procedures are available for practical, efficient restoration of the coating area that has been damaged. If damage of the coating is caused before backfilling, repair is not required. If the metal is not exposed or the exposed area is very small, epoxy hot melt stick can easily be used. For major damage, two part epoxy liquid materials can be used.[19]

FIELD JOINTS

Field joints coating quality is as important as mill coating's. Girth welds on mill-coated pipe must be coated in the field, and materials have include heat shrink wrap around sleeves, liquid epoxy and liquid urethanes, liquid vinyl esters, fiberglass composites, bitumen , butyl tape wraps and dual powder system. Different procedures may be applied depending on the pipeline construction conditions and operating temperature range. For poor condition and standard temperature operating pipelines heat shrink tapes with epoxy primer and liquid epoxy material can be used. DPS system apply in field is the best quality joint coating in condition of excellent applying environment. [20].

CASE HISTORIES

There are over 900 km length dual powder system pipe of different diameter different wall thickness, and different projects all over the world.[12] Since 2000, DPS was successfully used in China. Now nearly over 200 km pipeline length and over 5 important projects use this coating system.

Zhenghai-Hangzhou refined oil pipeline, from Zhenghai refinery company to Hangzhou city, OD355mm pipe, 158km; FBE coating is the main coating, and DPS coating was used in rocky areas, river and mountain crossings (over 10km length), the first project that DPS was used in China. Also, DPS coating was used for directionally drilled Qiantang river crossings of this project.

The West to East pipeline project, the longest gas pipeline project in China, (nearly 4000km and OD1016mm,X70 steel pipes); DPS was used in this project at bends due to its good mechanical properties. The coating thickness is 800~900um, the base layer thickness is over 300um and the top layer thickness is over 500um, over 2000 fittings were coated.

Yonghuning oil pipeline, from Ningbo to Nanjin, OD426mm pipe , DPS coating was used in Yangze river crossing and rocky areas, for over 36km length. The constructing pipeline, Zhongwu gas pipeline, from Zhongxian to Wuhan, DPS was applied at bends with nearly 2000 fittings were coated. DPS also were selected as pipeline coating for over 45km during Nanjing city gas pipeline project. Additionally, DPS were also used at river drill crossings at the Yangtze River for over 8 km, over 100km of the DPS coating was used on the Shanghai Gas Pipeline of OD810mm and OD762mm and finally over 3000 bends were coated with DPS on the pipeline from Maoming to Kunning. There are 2 more projects scheduled to be completed next year that will use DPS as coating on the pipeline and the bends.

CONCLUSIONS

Even though, the dual powder system is relatively new in the anti-corrosion coating market, its use has shown a remarkable growth. The growth is strongly driven by the effectiveness of this coating system against damage and also corrosion protection, as confirmed by engineering companies. The coaters have appreciated its easy process ability, both coaters and laying companies have recognized the low level of damage due to its superior mechanical properties. Dual powder system has recently been used successfully in China, mainly at rocky areas, bends and horizontal drilling pipelines, proving the excellent anti-corrosion and mechanical properties of this multi-coating and the possibility of using it to protect in main part of future pipeline.

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TABLE 1

TYPICAL PHYSICAL PROPERTIES OF DUAL POWDER SYSTEM COMPARED WITH DIFFERENT BRANDS

	Test condition	Brand 1# base coating /top coating	Brand 2# Base coating /top coating	Brand 3# Base coating /top coating
Gouge test (μm)	30kg	164~184	164~184	305~356
	40kg	280~292	280~292	482~559
	50kg	400~416	350~385	584~660
Impact resistance	@-30°C	>18J	>18J	>9J
	@23°C	>23.5J	>23.5J	>23.5J
Bending	@-30°C	1.5o/PD	2.5o/PD	1.26o/PD
	@23°C	2.0o/PD	3.0o/PD	2.0o/PD
Cathodic disbondment (mm)	65°C 48h	1~3	Excellent	1~3
	80°C 24h	3~5	Excellent	3~5
	65°C 28ds	2.6~6.8	1~3	13~18
	80°C 28ds	2.4~3.3	3~5	14~16
Water/soak adhesion	75°C 48h	1	1	1
	75°C 28ds	1	1	1

TABLE 2

COMPARISON AMONG ANTICORROSION COATINGS: TRANSPORT, HANDLING AND LAYING

	DPS	FBE	PE	Bitumen
Damage resistance(Gouge resistance)	10	6	7	4
Impact resistance	10	6	10	4
Weathering resistance	10	8	8	3
Abrasion resistance	10	6	9	3
Flexibility	9	9	10	7
Environment pollution	10	10	8	2

Note:1=very poor.....10=excellent

TABLE 3

COMPARISON AMONG ANTICORROSION COATING: CORROSION PROTECTION

	DPS	FBE	PE	Bitumen
Adhesion	10	10	9	4
Cathodic disbongding resistance	10	9	9	7
Cathodic shield problems	10	10	2	4
Oxygen impermeability resistance	10	10	8	6
Soil stress resistance	10	10	8	6
Microbiologically influenced corrosion	10	10	10	3
Penetration resistance	10	10	7	4
Low temperature resistance	9	9	9	3
High temperature resistance	10	9	7	3
Corrosion detection	10	10	6	6

Note: 1=very poor.....10=excellent

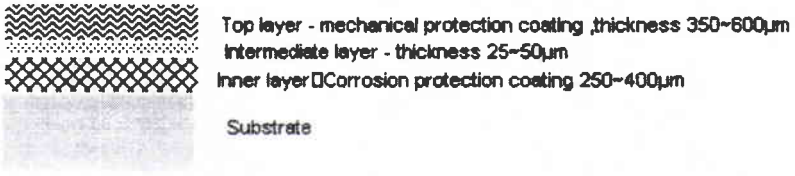
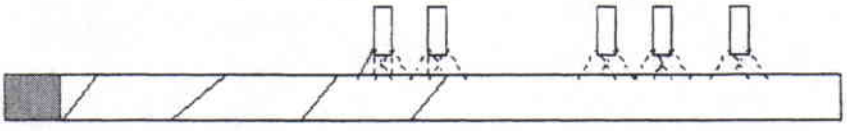


Figure 1 Sketch: Cross Sectional View of DPS



Rusty pipe Blast Clean, Heat First Layer ,Second Layer Quench

Figure 2 Process drawing of the steps taken in the plant to apply dual powder system

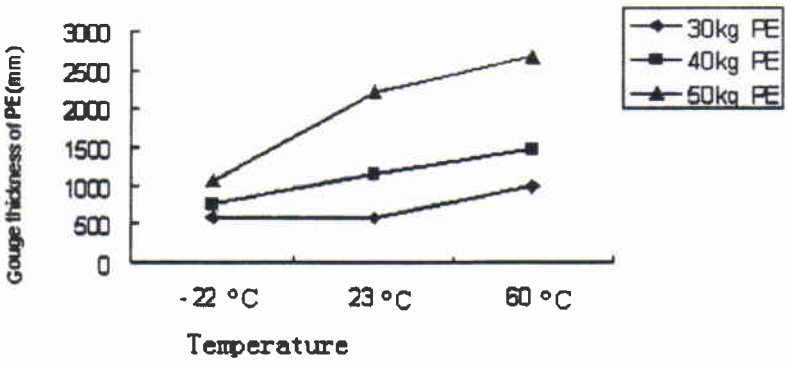


Figure 3 Gouge Thickness of PE vs. Temperature

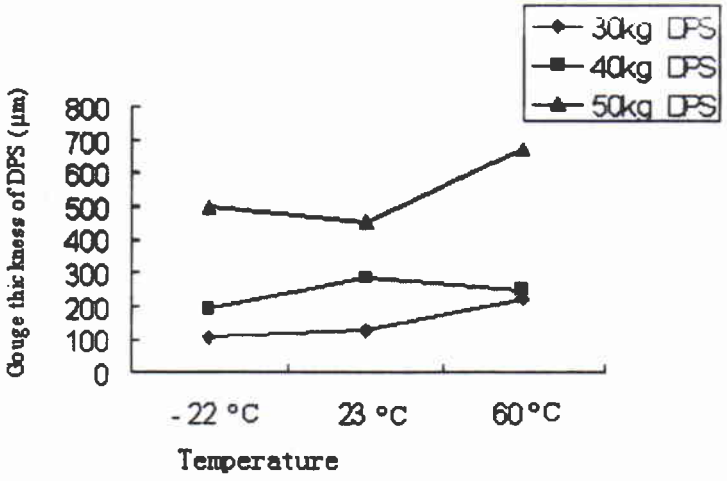


Figure 4 Gouge Thickness of DPS vs. Temperature