SELECTION METHOD FOR OFFSHORE PIPELINE COATINGS

Corrosion protection for offshore pipelines is essential to ensure the integrity of the pipeline and the system. One of the common methods to prevent corrosion is the use of coatings to the structure. The pipeline coating plays an important role in the corrosion protection of the system by providing a barrier between metal and the corrosive environment. Since, inspection of the coating is difficult in applications like deep water installations; therefore, coating used on the pipeline should be durable and expected to provide the same life as that of the pipeline (usually from 10 to 40 years).

The selection of correct coating is therefore crucial for effectiveness of the anticorrosion system. The selection process can be challenging because of the availability of a large number of products with the limited availability of product performance data. Not always the manufacturer's information can be considered adequate because of the varying nature of application environment and misapprehension of the capabilities of the product. Since, it is difficult to evaluate the performance accurately, the coating selection criteria has been greatly subjective. Technical criteria have been difficult to establish. Nevertheless, a large number of laboratory test methods do exist to characterize the coating performance but these are not always clear how results correlate with the actual service performance due to the lack of information on actual performance of the coatings; therefore these test methods are hardly considered as acceptance criteria for selection of the coatings.

In this article an approach to the selection for offshore pipeline coatings has been presented. There are a number of factors involved in the performance of coatings for offshore pipelines which provide a basis for the selection of coatings. These factors are broadly classified into two main categories; Technical and Economical factors. The technical factors may include flexibility, adhesion, cathodic disbondment, resistance to water absorption, ease of repair, chemical resistance, weather

resistance and impact resistance. The economical factors consist of cost of the coating including various sub-cost components. Combination of both these factors constitutes the selection method for the required coating (Figure-1).

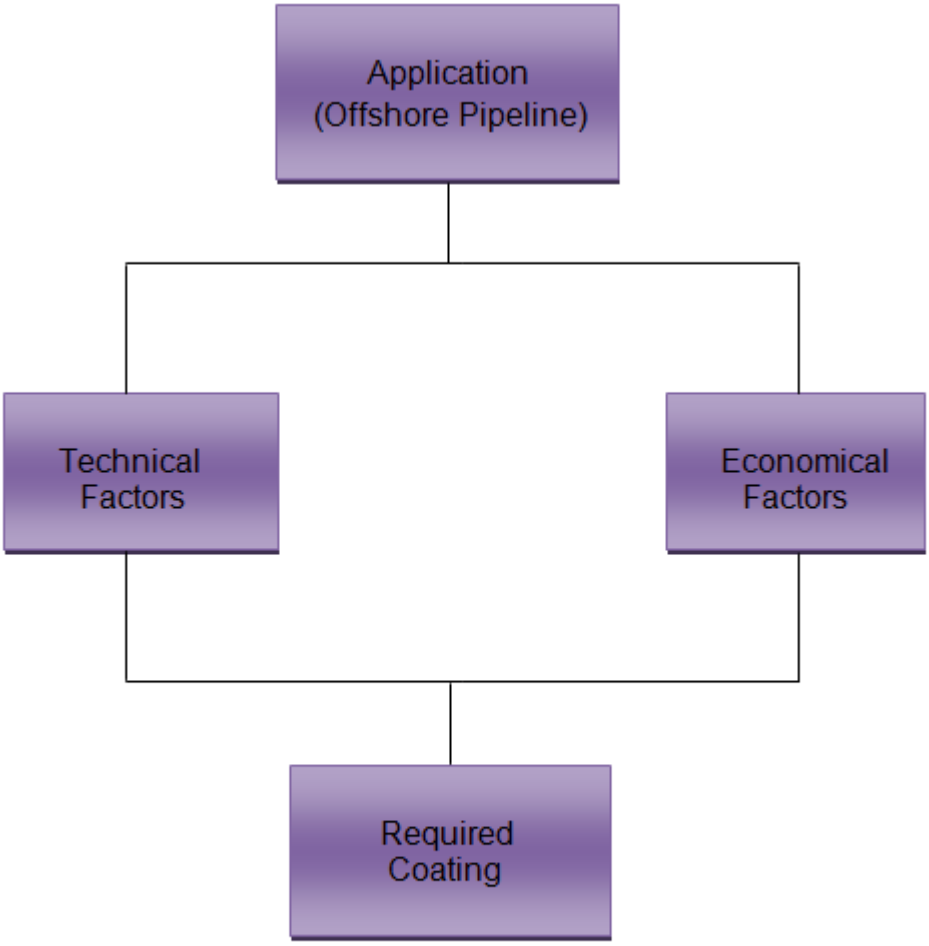

Figure 1: Coating Selection Method

(1) Considering Technical Factors

The technical factors included in the appraisal and selection of coatings for offshore pipelines are based on the pipeline coating manufacturer's and supplier's recommendations, pipeline construction companies' information and pipeline owners and operator's views. This criterion can be taken as a basic guideline and may need

to modify for each case depending upon the experience of the corrosion engineer, pipeline engineer, history of the pipeline, its maintenance and service records, type of application and the service environment. The procedure is represented in the form of a rating or scoring system which takes into account of coating property/ characteristics and its importance on the application.

To enumerate the importance of each property of the coating, a number from 0 to 15 is provided to each property, where 1 indicates the lowest importance and 15 the highest. This is provided in the Table-1.

Technical Factors/ Coating Characteristics	Importance on application	Rating/ Scoring range
Cathodic disbondment	High	0 - 15
Flexibility	High	0 - 15
Service Environment	Medium	0 - 10
Adhesion to metal surface	Medium	0 - 10
Impact resistance	Medium	0 - 10
Ease of repair	Medium	0 - 10
Resistance to water absorption	Medium	0 - 10
Compatible with substrate and surface preparation	Medium	0 - 10
Concrete adhesion	Low	0 - 5
Weathering resistance	Low	0 - 5
	Total	0 - 100 (Max.)

Table-1: Coatings Rating System

It is imperative to have a fundamental understanding of these characteristics before application of this method [1].

Cathodic Disbondment

It is a usual phenomenon that some mechanical damage occurs to a coated pipeline during its handling or laying. Such damage promotes holidays which in turn cause corrosion of the pipeline. To prevent corrosion at these sites, cathodic protection is mostly used.
In cathodic protection method, the cathode component is protected from corrosion by bringing its electrode potential value to equilibrium electrode potential value. However, the following cathodic reaction can occur at the surface of the pipe:

$$2H_2O + 2e^- \rightarrow H_{2(g)} + 2OH^-$$

The hydrogen gas can cause lifting of the coating while the concentration of hydroxide ions causes the coating to leach out and thus lose adhesion. Because of this loss of adhesion, more moisture penetrates through coating to the pipe surface and therefore increases the disbondment process. The coating selected should have the property of resistant to cathodic disbondment where cathodic protection of the pipeline is used.

Flexibility

It is the most important characteristic for a pipeline coating to have. The coating must have enough flexural strength to deform/ flex without breaking or cracking due to the movement of substance in the pipeline; otherwise holidays will be developed which will result in cathodic disbondment of the coating and thus corrosion will start to occur. This characteristic of the coating should also be considered for deep water pipelines because of bending stresses at large water depths.

Compatibility with the substrate and surface preparation

The coating selected for new installation and for retrofit must be compatible with the substrate metal on which it is applied. The substrate metal can be a new steel pipe or a used pipe. Likewise, the level of surface preparation should be achieved consistently according to the substrate surface condition. The coating should be flexible to accommodate the extent of surface preparation irregularities.

Service Environment

Coating should be capable to perform in various environments be able to accommodate the future changes in service environment. These may include temperature, water depths, redox potential of water, pH values, potential for mechanical damage and the marine organisms.

Adhesion

This is an important property of the coating which relates to both flexibility and cathodic disbondment. The adhesion of the coating on the surface of the metal must be capable to withstand the potential mechanical damage to the coating which can occur during handling or lying of the pipeline.

Resistance to Water Absorption

For corrosion to occur, rate of anodic reaction should be equal to the cathodic reaction. For anodic reaction (metal loss) to occur, moisture and oxygen (e.g., oxygen dissolved in the water) are needed to complete the cathodic reaction. If moisture is penetrated into the coating; then above requirement of anodic and cathodic reaction are met and hence corrosion can occur resulting in the loss of adhesion, and formation of blisters and cracks in the coating. The coating should, therefore, be selected which is resistant to this moisture penetration.

Ease of Repairing

The coating should be easy to repair damage or holidays. Coating used must be compatible to the field joint repairs.

Impact Resistance

This characteristic of the coating involves the ability of the coating to withstand sudden or impact load without rupturing, disbonding or other mechanical damage during its handling or installation. Coating selected should be capable to resist such damage.

Concrete Adhesion

A concrete coating is done on the pipeline for weight stability and to withstand the buoyancy of water and consists of a layer of concrete coated on the pipe. During pipeline operation, hot liquid can cause expansion of pipe, so adhesion of concrete coating if gets loose can move the pipe longitudinally with respect to the coating which subsequently causes damage to anticorrosion coating. Therefore, concrete coating should be able to resist this effect.

Illustration of the use of Rating System by an example

The rating system is illustrated by an example in which two coatings are evaluated by using their characteristics data from the published literature [2-3]. The two coatings can be compared with this method and the one which got the high score can be chosen. The values of ratings of coatings (based on field data, available laboratory data and information of coating formulations) are taken in the technical rating system. The system can be modified by excluding/including the required coating characteristic depending upon the type of application and the ratings can be adjusted depending upon the nature of severity of the application against which the characteristics of the coating is required.

Technical Factors/ Coating Characteristics	Importance on application	Rating range	Rating/ Score evaluated	
			Coating - A	Coating - B
Flexibility	High	0 - 15	14	8
Cathodic disbondment	High	0 - 15	15	7
Service Environment	Medium	0 - 10	10	5
Adhesion to metal surface	Medium	0 - 10	8	4
Impact resistance	Medium	0 - 10	9	5
Ease of repair	Medium	0 - 10	7	4
Resistance to water absorption	Medium	0 - 10	6	7

Compatible with substrate and surface preparation	Medium	0 - 10	6	3
Concrete adhesion	Low	0 - 5	3	4
Weathering resistance	Low	0 - 5	2	2
Total		0 - 100 (Max.)	80	49

Table-2: Example of Coatings Rating System

(2) Considering Economical Factors

The Cost Vs Performance of the coating is a vital factor during selection of a coating. In some instances, cost is not as important as of performance and vice a versa.

The total cost of an effective coating system consists of sub-components like cost of material, application, installation, inspection and repair. Other cost components include compliance to regulatory obligations and overhead costs. The total cost must be determined in conjunction with the technical factors/ rating system.

A compromise can be reached between the performance (in terms of rating system) and the cost of the coating. A trade-off point can be achieved by considering the technical factors and the economical factors giving the most viable coating for the offshore pipeline system.

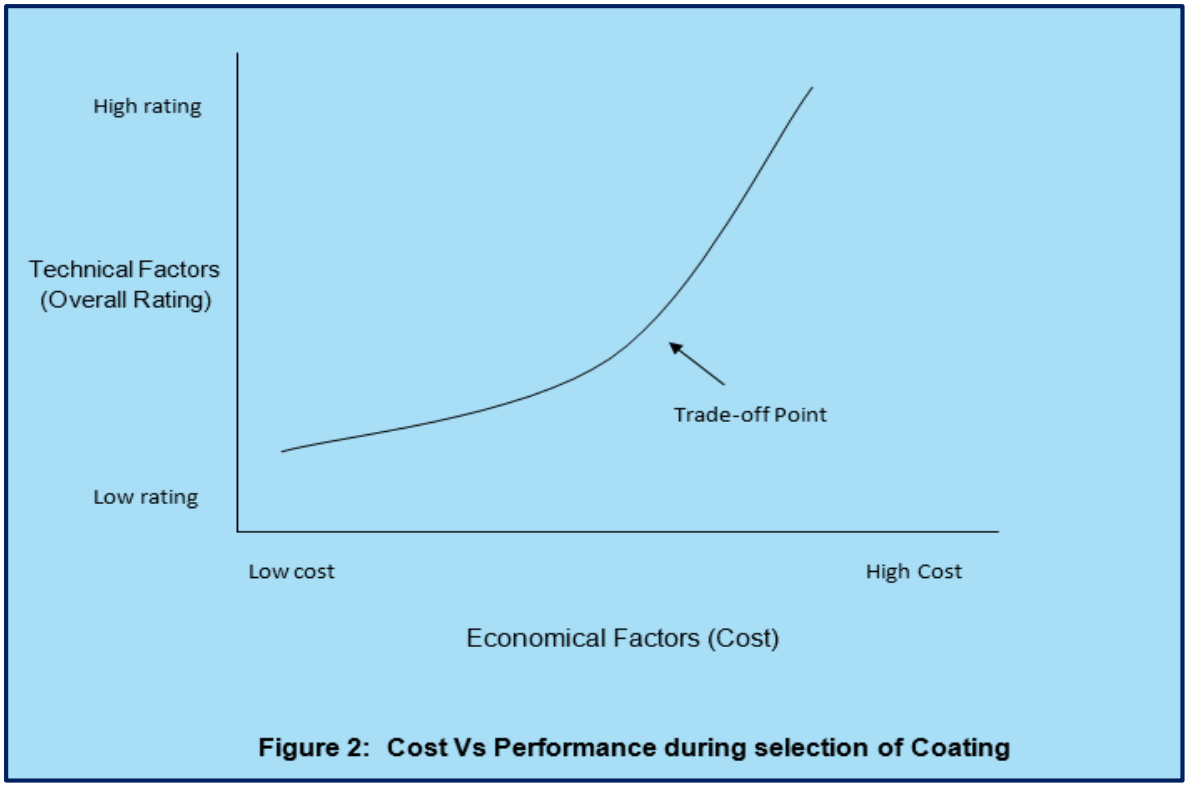

Figure 2: Cost Vs Performance during selection of Coating

Conclusion

This system of selection of pipelines coating has maximises the effectiveness of the coating selection process by comparing the performance of different available coatings and their costs to select the appropriate coating amongst them for a specific application. This method suggests a simple and structured approach and eliminates ambiguities in the coating selection process. The system can easily be adjusted according to the requirements of a particular pipeline project.

References

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3. K.E.W. Coulson, S. Nunez, L.C. Choate, J.L. Banach, "A Review of Gas Industry Pipeline Coating Practices", December 1990, A.G.A. Catalog No. L51586.