# Cost comparison between duplex steel and carbon steel engineering essay

Pipelines are commonly used in the oil and gas industry for the transportation of hydrocarbon either processed or unprocessed. In some cases, a line transporting processed hydrocarbon from a processing plant to a point of use, while in other cases, a line transporting unprocessed hydrocarbon from a remote gathering point to a processing plant. Whichever the case is, pipelines are a major infrastructure in the oil and gas business requiring significant amount of funds for construction. For instance, the gas pipeline from Turkmenistan to China set to be the longest and most expensive such pipeline in the world with about 6500-7000 kilometers is estimated to cost about US$ 26 billion1.

Therefore, this study seeks to compare the pipeline cost between the uses of two different selected line pipe materials -carbon steel and duplex steel. The emphasis of the study is to establish the cost differential between the uses of the two selected line pipe material and the relative cost of each line pipe type to the other.

The study is structured such that a considerable cost estimates for pipelines on land, swamp and offshore location using the selected line pipe material is collected for 10 and 20 kilometer lengths. The data so collected would be inspected, collated and analysed using statistical tools such as tables and charts in order to determine the type of statistical relationship that may exist between the pipeline costs using the two different identified line pipe material type.

## 1. 2 Background of the Study

Today, pipeline projects in Nigeria are more complex than ever before. The relative high cost of pipeline projects and the security threats in the Niger delta region of the country all combined to demand that adequate cost implication of a selected line pipe type is analysed for both functionality and durability. Majority of pipelines in Nigeria are of carbon steel line pipes, some of which tends to fail in integrity after a few years of operation mainly due to corrosion and activities of vandals. It has now become imperative that other types of line pipes such as duplex steel be investigated relative to the traditional carbon steel in terms of cost so that the actual additional cost if any, for the use of duplex steel can be compared with that of carbon steel. By doing this, the cost comparison between the two types of line pipe can be evaluated on the same empirical basis for the purpose of making an informed decision.

## 1. 3 Statement of the Problem

One of the major problems in the pipeline construction projects in Nigeria is that cost components of the line pipes are rarely considered relative to the other advantage a particular line pipe type offers. This can be seen in the use of carbon steel line pipes for almost all types of pipelines in Nigeria such as for flow lines of very short distances, risers etc and in such areas as offshore locations where corrosion activities are at most. And where effort is made to do this comparison, there are no reliable data available for companies to harness from so that decisions are made based on empirical evidence.

1Pipeline and Gas Journal August 2008, PP16

## 1. 4 Need for the Study

There is a need for this study as it could generate very important information on the cost comparisons for the two selected line pipe types-carbon steel and duplex steel. With empirical data, tradeoffs could be made between marginal costs on the use of a particular line pipe type to the other if some advantages like anti corrosion are considered.

## 1. 5 Aim of the Study

The study is aimed at availing stakeholders in the oil and gas industry with empirical facts on the estimated cost comparison of the two identified line pipe types-carbon and duplex steel-in the overall pipeline cost.

## 1. 5. 1 Objectives

To determine the cost of pipeline using any of the identified line pipe types

To related the line pipe type cost to the overall pipeline cost

## 1. 6 Area of Study

The study is limited to the Niger delta region of Nigeria. The findings here cannot be used out rightly in other parts of the world without modification. This is as a result of many factors affecting the cost of pipeline projects in Nigeria such as security, dearth of competitive contractors, productivity, outright corruption and the estimating methodology.

# 2. 0 Literature Review

## 2. 1 Pipelines in Oil and Gas Industry

The earliest pipelines according to Canadian Energy Pipeline Association were probably built in China around 500 BC to transport natural gas from

brine/gas wells to heat brine in order to recover salt. Bamboo sections were split lengthwise and horizontal nodes are then removed and the halves were then glued back together and bound with twine. The first gathering systems in North America were constructed of hollow logs and were used to transport natural gas short distances from well sites to nearby towns, distribution systems were also constructed to deliver the natural gas to buildings and street lights2.

Pipelines were used mainly in villages and settlements for centuries in carrying water. The history of oil and gas pipeline as they are used today begins after what is considered the first commercial oil well was drilled in Pennsylvania in 18593. According to records, early pipelines were built using threaded pipe that workers screwed together with large tongs. It wasn't until about 1920 that welding the separate lengths of pipe together became an accepted construction practice; oxyacetylene welding was introduced in 1920 but was replaced by the late 1920s with electric welding4.

Oil and gas pipeline system are known for their efficiency and very low transportation cost. A thorough investigation in the 1980s concluded that crude trunk lines consume about 0. 4% of the energy content of the crude transported per 1000km, products pipeline use about 0. 5% of the energy content of the products moved per 1000km, these rates compare with estimates of 0. 8% for coal trains, 1. 0% for oil movement by rail and 2. 5%, for natural gas pipelines and 3. 2% for oil trucks2.

## 2. 2 Oil and Gas Pipes

Thermal insulated steel pipes are commonly used for oil and gas transportation. However, oil pipelines could be made of either steel or plastic though majority in use is the steel pipe. The size of gas pipelines could range from 2-60 inches in diameter whereas, for oil pipelines it ranges from 4-48 inches inner diameter depending on the requirement.

Steel pipelines could lie buried for hundreds of years; have extraordinary properties including excellent stress crack resistance to natural gas, superior impact resistant, low permeation to methane and hydrogen. The insulation material is usually polyurethane foam (PU) which has high thermal efficiency and is mechanically strong.

Small, medium and large diameter steel pipes are available however, the high strength of steel makes bending and forming more difficult, Electric Resistance Welded (ERW) steel pipe are used for oil and gas processing and transmission lines which assures consistent quality in its application, ERW pipes are equally good in hot or wet applications like river crossing and rough terrains4.

2Canadian Energy Pipeline Association, http://www. cepa. com/pipeline accessed on10-01-2011

3John, L Kennedy. 1993. Oil and Gas Pipeline Fundamentals, 2nd Edition PP2

4John P. O' Donnell, " Petroleum 2000: Pipelines Continue to Play Major Role," Oil and Gas Journal, August 1977, PP279

## 2. 3 Features of Carbon Steel Line Pipes

Carbon steel is the most common pipe material in power, chemical and hydrocarbon industries. 5

Steels are classified according to their chemistry or chemical composition. Steel pipe and fittings are alloys of iron and carbon, containing less than 1. 7% carbon. They can be classified into three fundamental groups such as carbon steel, low alloy steel and high alloy steels. Carbon steel consist of iron, less than 1. 7% carbon, less than 1. 65% manganese, incidental amounts of Silicon (Si), Aluminium Al) and limits on impurities such as Cr, Co, Ni etc.

The common steel for oil and gas pipeline is API 5L and can be mild, medium and high. Mild steel is a carbon steel with less than 0. 30% carbon, medium 0. 3%-0. 6% and high steel over 0. 6% carbon.

Steel pipe is generally used for pressure piping. The advantages include long laying lengths, high internal and external strength and the availability of varying pipe thickness to meet almost any design pressure. It has good flow characteristics and fire resistance and is low in initial cost. The most serious disadvantage is its low resistance to corrosion which makes it a requirement for internal and external protection, with galvanising the most commonly used method6.

## 2. 4 Features of Duplex Steel Pipes

Duplex steel pipe was originally developed in Sweden back in the 1940's; they were originally created to combat corrosion problems caused by

chloride-bearing cooling waters and other aggressive chemical process fluids7. Duplex steel combines the advantages of ferritic and austenitic steel: extreme strength, resistance against stress corrosion cracking and degrading corrosion: making it especially suitable to resist the extreme forces found on platform riser7, as shown below.

## Figure 1: Exemplary Offshore pipeline riser8

5Piping and Pipeline Engineering: Design, Construction and Maintenance, Integrity and Repair. PP 47, George, A, 2005 EBooks Corporation.

6Facility Piping Systems Handbook: For Industrial, Commercial and Healthcare Facilities, Michael Frankel, 2010 PP2 3rd Edition.

7Duplex Pipe from SPM http://duplexpipe. com/

8Source: http://www. total. com

The amplified strength of duplex steel allows for reduced wall thickness and reduced weight; it is used mostly in onshore application in pipeline where high erosion rates are present. Carbon steel elbow installations have been replaced by duplex material in high flow velocity gas pipelines with erosion due to solid particle. It is also useful for pipelines in cold regions because it also retains its strength in low ambient temperatures9, for example down to -400c.

Other benefits are stronger than 300 series thickness steel which also brings weight advantages, cheaper than some stainless steel, high resistance to

pitting, crevice corrosion and stress corrosion cracking, higher heat conductivity and lower thermal expansion than austerity steels9.

Duplex steel pipes are mainly used for production and transmission of oil and gas, Structural and mechanical components, Heat exchangers, Cooling pipes, Cargo vessels and containers, High strength wiring

9Capabilities of MFL Inspection in Duplex Steel Pipelines, http://www. roseninspection. net accessed on 10-01-10

7Duplex Pipe from SPM http://duplexpipe. com/

# 3. 0 Data Collection, Presentation, Analysis and Discussion

## 3. 1 Data Collection

The data used for the study is based on cost estimate generated for a multinational oil company operating in the Niger delta region of Nigeria. However due to the confidential nature of the data, the cost was broken down into points with no unit of measurement.

## 3. 2 Data Presentation

The cost data is hereby presented in table as shown below. The cost estimates are grouped into three major terrain types as land, swamp and offshore location. Within each terrain, the cost estimate is further classified into carbon steel (CS) and duplex steel (DS) for 10 kilometer and 20 kilometer pipeline lengths.

Diameter (Inches)

## Land Cost (Points)

## Swamp Cost (Points)

## Offshore Cost (Points)

CS 10 km

DS 10 km

% of CS to DS

CS 20 km

DS 20 km

% of CS to DS

CS 10 km

DS 10 km

% of CS to DS

CS 20 km

DS 20 km

% of CS to DS

CS 10 km

DS 10 km

% of CS to DS

CS 20 km

DS 20 km

% of CS to DS

8"

20

33

60%

29

54

53%

29

49

58%

44

82

54%

53

101

0. 52

63

129

49%

10"

22

38

57%

32

63

50%

32

56

57%

49

94

52%

55

108

0. 51

66

141

47%

12"

24

43

57%

36

72

50%

35

63

56%

54

106

51%

57

114

0. 50

70

153

46%

14"

27

46

57%

39

78

50%

39

68

57%

59

114

52%

60

119

0. 50

73

161

45%

16"

29

51

57%

43

86

50%

42

75

57%

66

127

52%

62

125

0. 50

78

173

45%

18"

36

69

52%

54

119

46%

52

96

54%

81

165

49%

72

146

0. 49

93

211

44%

20"

39

79

50%

60

138

43%

56

108

52%

89

189

47%

81

164

0. 50

99

235

42%

24"

47

103

46%

73

183

40%

67

137

49%

107

243

44%

85

190

0. 45

115

295

39%

30"

59

144

41%

94

263

36%

83

187

44%

136

338

40%

99

245

0. 40

141

403

35%

36"

72

194

37%

117

359

33%

101

245

41%

169

450

38%

114

312

0. 37

169

532

32%

40"

94

245

38%

132

431

31%

129

304

42%

191

534

36%

125

363

0. 34

189

631

30%

Table 3. 0 Estimated Cost for Different Pipeline Sizes on land, Swamp and Offshore Location.

Source: Authors Data

## 3. 3 Data Analysis & Discussions

### 3. 3. 1 Pipeline (10km length Offshore) Cost Comparison between Carbon Steel and Duplex Steel Lines.

The chart below in fig. 3. 1shows the costs for 10 kilometer length offshore, for the two selected line pipe types. It could be seen from the chart that the cost for 10 inches carbon steel line is 55 points compared to 108 points for Duplex steel of the same size. Plate 3. 1 shows the percentage cost of carbon steel pipeline relative to duplex steel pipeline. For example, the cost for 8 inches carbon steel pipeline is 52% cost for the equivalent of duplex steel. The conclusion will be drawn in the next chapter.

Fig 3. 1 Offshore Pipeline cost comparison btw Carbon Steel and Duplex Steel Lines (10km)

Plate 3. 1 Percentage Cost of Carbon Steel to Duplex Steel Pipeline Offshore (10km)

## 3. 3. 2 Pipeline (20km length Offshore) Cost Comparison between Carbon Steel and Duplex Steel Lines.

The chart below in fig. 3. 2shows the costs for 20 kilometer length offshore, for the two selected line pipe types. It could be seen from the chart that the cost for 20 inches carbon steel line is 99 points compared to 235 points for Duplex steel of the same size. Plate 3. 2 shows the percentage cost of carbon steel pipeline relative to duplex steel pipeline. For example, the cost for 12 inches carbon steel pipeline is 46% cost for the equivalent of duplex steel. The conclusion will be drawn in the next chapter.

Fig 3. 2 Offshore Pipeline cost comparison btw Carbon Steel and Duplex Steel Lines (20km)

Plate 3. 2 Percentage Cost of Carbon Steel to Duplex Steel Pipeline Offshore (20km)

## 3. 3. 3 Pipeline (10km length Swamp) Cost Comparison between Carbon Steel and Duplex Steel Lines.

The chart below in fig. 3. 3shows the costs for 10 kilometer length swamp, for the two selected line pipe types. It could be seen from the chart that the cost for 30 inches carbon steel line is 83 points compared to 187 points for Duplex steel of the same size. Plate 3. 1 shows the percentage cost of

carbon steel pipeline relative to duplex steel pipeline. For example, the cost for 16 inches carbon steel pipeline is 57% cost for the equivalent of duplex steel. The conclusion will be drawn in the next chapter

Fig 3. 3 Swamp Pipeline cost comparison btw Carbon Steel and Duplex Steel Lines (10km)

Plate 3. 3 Percentage Cost of Carbon Steel to Duplex Steel Pipeline Swamp (10km)

## 3. 3. 4 Pipeline (20km length Swamp) Cost Comparison between Carbon Steel and Duplex Steel Lines.

The chart below in fig. 3. 4shows the costs for 20 kilometer length swamp, for the two selected line pipe types. It could be seen from the chart that the cost for 40 inches carbon steel line is 191 points compared to 534 points for Duplex steel of the same size. Plate 3. 4 shows the percentage cost of carbon steel pipeline relative to duplex steel pipeline. For example, the cost for 16 inches carbon steel pipeline is 52% cost for the equivalent of duplex steel. The conclusion will be drawn in the next chapter

Fig 3. 4 Swamp Pipeline cost comparison btw Carbon Steel and Duplex Steel Lines (20km)

Plate 3. 4 Percentage Cost of Carbon Steel to Duplex Steel Pipeline Swamp (20km)

## 3. 3. 5 Pipeline (10km length Land) Cost Comparison between Carbon Steel and Duplex Steel Lines.

The chart below in fig. 3. 5shows the costs for 10 kilometer length on land, for the two selected line pipe types. It could be seen from the chart that the cost for 30 inches carbon steel line is 59 points compared to 144 points for Duplex steel of the same size. Plate 3. 5 shows the percentage cost of carbon steel pipeline relative to duplex steel pipeline. For example, the cost for 14 inches carbon steel pipeline is 57% cost for the equivalent of duplex steel. The conclusion will be drawn in the next chapter.

Fig 3. 5 Land Pipeline Cost Comparison btw Carbon Steel and Duplex Steel Lines (10km)

Plate 3. 5 Percentage Cost of Carbon Steel to Duplex Steel Pipeline Land (10km)

## 3. 3. 6 Pipeline (20km length Land) Cost Comparison between Carbon Steel and Duplex Steel Lines.

The chart below in fig. 3. 6 shows the costs for 20 kilometer length on land, for the two selected line pipe types. It could be seen from the chart that the cost for 30 inches carbon steel line is 94 points compared to 263 points for Duplex steel of the same size. Plate 3. 6 shows the percentage cost of carbon steel pipeline relative to duplex steel pipeline. For example, the cost for 18 inches carbon steel pipeline is 46% cost for the equivalent of duplex steel. The conclusion will be drawn in the next chapter.

Fig 3. 6 Land Pipeline Cost Comparison btw Carbon Steel and Duplex Steel Lines (20km)

Plate 3. 6 Percentage Cost of Carbon Steel to Duplex Steel Pipeline Land (20km)

# 4. 0 Conclusion, Recommendation and Implementation.

## 4. 1 Conclusion

Based on the data analysis in the previous chapter to compare the cost of pipelines using both carbon steel and duplex steel line pipe types, the following conclusions are deduced:

Pipelines constructed using duplex steel is more expensive than the equivalent size and length using carbon steel.

For offshore locations and length 1-20 kilometer, the cost of carbon steel pipeline ranges between 30%-51% of pipelines using duplex steel line pipes.

For swamp locations and length 1-20 kilometer, the cost of carbon steel pipeline ranges between 36%-58% of pipelines using duplex steel line pipes.

For land locations and length 1-20 kilometer, the cost of carbon steel pipeline ranges between 31%-60% of pipelines using duplex steel line pipes.

From the review of related literature, duplex steel pipes are stronger, have less weight and more corrosion resistant compared to duplex steel pipes.

## 4. 2 Recommendation

From the above conclusions, it is recommended that cost comparison between alternative line pipe types be analysed before decision is made as to the best suitable option to be adopted, so that cost is balanced with other consideration such as strength, anticorrosion, and weight.

Furthermore, it is recommended that where pipelines are exposed to extreme conditions of corrosion activity and where weight requirement could be significant like offshore platform, the use of duplex steel be exploited.

## 4. 3 Implementation Strategy

The above recommendation could be implemented by setting up project services team within an organisation with the mandate of evaluating the cost implication of different pipeline options for different scenarios and findings recommended for management decision.