A successful Reinforced Thermoplastic Pipe (RTP) Candidate for Upstream Oil Fields Development

Abstract

New upstream oil fields developments require fast materials delivery, ease and quick installation. Upstream Corrosion Control Cost is very prohibitive. Therefore, the need for corrosion resistant material adding reliability to deliver production fluids is critical. Moreover, the reliability of flowlines transporting disposed water and oil at Saudi Aramco requires improvement due to corrosive transported fluids and sever operating environment. The non-metallic flexible RTP pipe is believed to be a feasible alternative to the carbon steel (CS) pipe. The CS pipe experiences frequent leakages, coating failures and high maintenance costs resulting in loss of production and eventually, high operational costs. Saudi Aramco has successfully field trial tested three non- metallic flexible Re-enforced Thermoplastic Pipe (RTP) flowlines in upstream oil field of the Arabian Desert transporting disposed corrosive water to injection wells for more than six years in service. These operational flexible RTP flowlines showed very reliable and superior field performance with zero leakages. The life cycle of such operational RTP Flexible Thermoplastic pipes to date is zero dollars being a cost effective and reliable candidate. It has been concluded that RTP non-metallic pipe is a potential candidate for new field development due to its low installation cost, low life cycle cost and reliability. Consequently, the RTP pipe is a viable replacement to the Carbon steel pipes.

1. RTP Pipe Technology

Reinforced Thermoplastic Pipe (RTP) comprises composite system combining the flexibility, ease of use, and chemical resistance. The RTP pipe composite structure shown in figure 1 consists the following: 1) fluid-tight, corrosion resistant HDPE liner; 2) Fibre reinforcement for strength; and 3) Ambient resistant white HDPE cover, fully desert climate proof, to protect from UV, abrasion and solar heating.

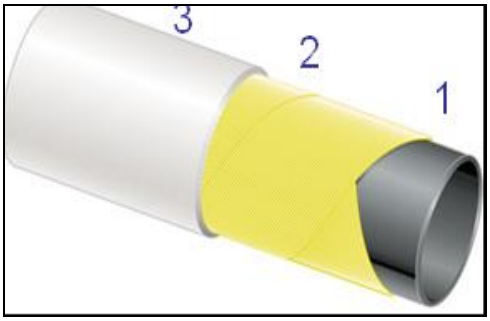

Figure 1: RTP Pipe composite structure

2. Introduction

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Pipe inspection activities detect significant corrosion damage and coating deterioration exhibited on carbon steel pipes transporting disposed water and hydrocarbon fluids jeopardising the pipe integrity leading to various failure modes result in shutdowns with production associated with safety and environmental effects. Periodic steel pipe inspection and repair work consume considerable budget and labour intensive. This shortcoming supports the requirement for an alternative pipe candidate that is corrosion resistant such as the flexible non-metallic thermoplastic pipe. The introduction of the non-metallic RTP Flexible pipe in Saudi Aramco upstream oil fields came as a result of the cost of corrosion associated with the CS pipe and frequent CS pipe leakages. Upstream fields flowlines leakages and metal loss occur as a result of internal and external corrosion, coating damage and poor or failure the CP system. Current producing oil wells experience increasing water cut causing accelerated corrosion damage to steel pipes leading to frequent CS pipe replacement and high pipe repair costs. The Hawtah oil producing wells all are artificially lifted using Electric Submersible Pumps. Hawtah producing wells produce oil with increasingly high water cuts transported through flow lines with pipe size range from 6" to 12" with underground and above ground installations. The flowlines transporting the water required for injection maintaining reservoir pressure are rated class 300# made from carbon steel API 5LX42 NACE certified. The water injection flowlines are currently operating at 1450 psig @ 120 F. Pipe leakages occur in the region between the 3 and 9 o'clock positions after a distance of 40 meters downstream the GOSPs prevailing throughout the entire pipe length to the injection well. All the upstream oil transporting flowlines are flowing to a Gas Oil Separation Plant (GOSP) to separate water and gas from the oil. A typical Saudi Aramco GOSP facility is shown in figure 2. The separated water is transported through flowlines to the water injection wells.

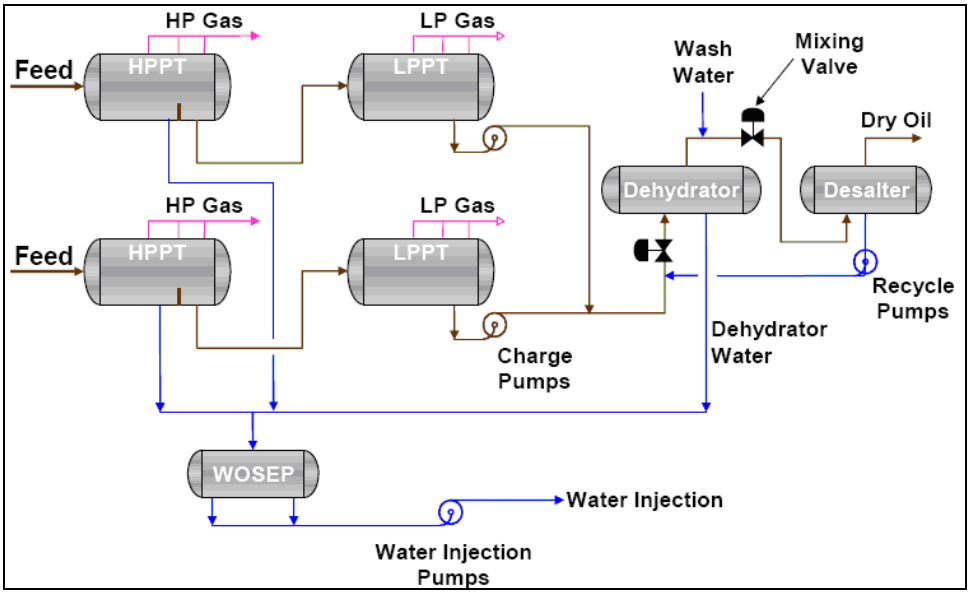

Figure 2: Typical Gas Oil Separation Facility (GOSP)

Background

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Cost of Corrosion Studies in Saudi Aramco operational facilities reported increasing corrosion costs expenditures resulting from frequent corroded steel pipe replacements, coating repairs, loss of production due to steel pipe leakages developed during corrosion process. CS flowlines experience accelerated corrosion with life cycle replacement after 6 to 8 months of installation and operation. The study resulted in several recommendations targeting reducing the upstream flowlines corrosion influence emphasizing on the introduction of the non-metallic materials due to its superior performance and very low installation costs assessing fast field development.

Approach of Eliminating Corrosion

Saudi Aramco has acknowledged that implementation of no-corrosion occurrence is a vital commitment for safe and low cost operations. Consequently, a non-metallic materials campaign has been formed progressing rapidly. Saudi Aramco has developed in-house standards and procedures governing qualifications of installing non-metallic pipelines and fittings, standards and procedures for repair of non-metallic and standards qualifying operating conditions.

Water Injection Wells Data

The entire Hawtah field water injection flowlines network represents a total of length of 192 kilometres with CS pipe sizes of 6”, 8”, 10” and 12” transporting disposed water from the GOSP to the injection wells. Desert terrain type includes sand dunes, solid ground and rocky areas. Sand storms and strong winds are prevailing.

Hawtah Oil Filed RTP Pipe Installation

The field installation started in year 2001 to date with demonstrated superior field performance of the reinforced thermoplastic pipe (RTP) being a potential replacement for carbon steel pipes due to their excellent characteristics such as light weight, ease of installation with no welds required and corrosion free. The RTP Pipe can be installed/laid down on the ground with no supports requirements. Figure 3 shows current RTP flowline installations in Hawtah Oil field transporting high pressure water streams used for injections to maintain reservoir pressure. The illustrations show that the RTP flowline can be supported above ground and laid down on the ground with no supports. This is an added advantage that RTP pipe does not need structural supports except if ground topography elevation requires. The RTP pipe can be laid down on the ground with no RTP pipe external corrosion fear contrary to the CS pipe.

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Figure 3: RTP flowline transporting water injection

The RTP flexible pipe operating in Hawtah oil field is very amendable to be coupled with CS/SS fittings such as flanges, couplers and to CS pipes using electro-fusion welding process. Figure 4 shows two RTP flexible pipe joints coupled to each other using CS flanges.

Figure 4: RTP Pipe flange coupling

Figure 5 also shows an RTP pipe coupled to a metal valve via steel flange coupling indicating the flexibility of coupling the RTP pipe to all kinds of metallic structures such as valves, flanges and steel pipes.

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Figure 5: RTP pipe coupled to metal valve through metal flange coupling

Figure 6 shows another metallic flange coupling of the RTP pipe to a CS pipe indicating the fact that RTP pipe can also be used as a repair section for corroded CS pipes.

Figure 6: RTP pipe coupling to CS pipe using metallic flange connection

The Hawtah RTP pipe installations are very flexible and include buried pipe sections and aboveground lay downs sections as shown in figure 7. This advantage permits easy and negligible cost in performing visual inspection.

Figure 7: RTP Pipe complete joint buried and above ground lay down

Figure 8 shows Hawtah RTP pipe field installation coupling to a CS flange using electro-fusion welding process where the flange is bolted to a CS flowline ends.

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Figure 8: RTP Pipe coupled to a CS pipe via flange connection

Figure 9 demonstrates Hawtah RTP pipe field installation with pressure gauge inline installed indicating flowline operating pressure. The gauge is also hocked up to a steel fitting coupled through the RTP pipe using electro-fusion process concluding that the RTP pipe is very attractive to be used in field applications combining the advantages of CS pipe and non-metallic benefits being corrosion free equipment.

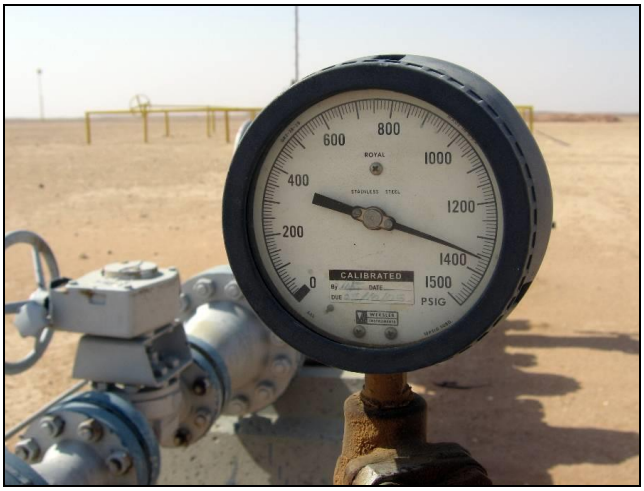

Figure 9: Pressure gauge in-line installed on a RTP pipe

RTP Flowlines Test Results in Hawotah Filed

Table 1 demonstrates RTP flowlines operational in the upstream oil filed of Hawtah transporting the water injection with flowline data and inspection background.

Table 1: Hawtah Field RTP Water Injection Flowlines

Pipe Designation	A	B	C
Pipeline Diameter	4 Inches	4 Inches	4 Inches

Pipeline Length	**295 meters**	**1393 meters**	**270 meters**
RTP MAOP Pressure	**1305 psi**	**1305 psi**	**1305 psi**
Operating Pressure	**1350 psi**	**1054 to 1157 psi**	**1240 psi**
Operating Temperature	**120 F**	**120 F**	**120 F**
Liquid Specific Gravity	**0.995**	**0.995**	**0.995**
Pipeline through Capacity	**3072 BPD**	**8500 BPD**	**8500 BPD**
Installation Date	**June 2003**	**June 2003**	**April 2003**
Inspection Date	**August, 2008**	**August, 2008**	**August, 2008**

The up-to-date RTP flowlines inspection reports indicated no corrosion or pipe deterioration after several years of service transporting corrosive oil water.

Corrosion Prevention Technologies

Carbon steel pipes require corrosion protection for continued safe service. Saudi Aramco invests high cost figures in protecting its CS flowlines from corrosion attack. Figure 10 shows percentages of various corrosion prevention technologies employed to all the CS flwolines. These technologies represent ongoing operational costs and could be avoided of the RTP non-metallic flexible pipe is used as an alternative to the CS pipe.

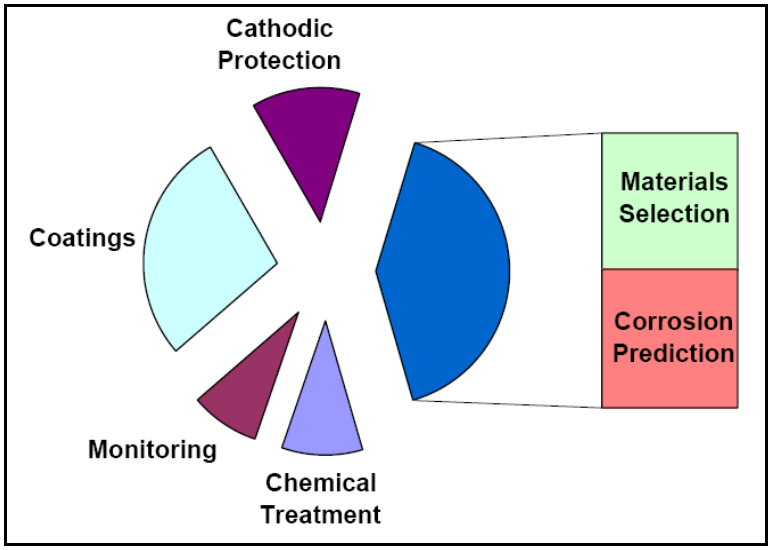

Figure 10: Corrosion Prevention Technologies

Life Cycle Costing (LCC)

The annual average LCC comparison between CS pipe in oil service and the flexible RTP pipe is demonstrated in figure 11. The CS pipe has much higher LCC than the RTP non-metallic pipe.

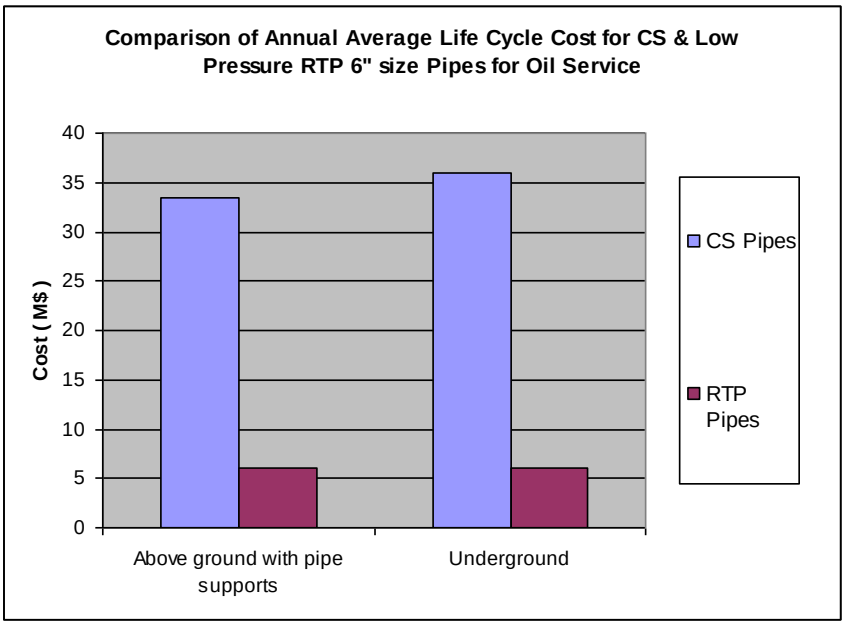

Figure 11: LCC comparison between CS oil service and RTP pipe

The annual average LCC comparison between CS pipe in water injection and the flexible RTP pipe is demonstrated in figure 12. The CS pipe has much higher LCC than the RTP pipe.

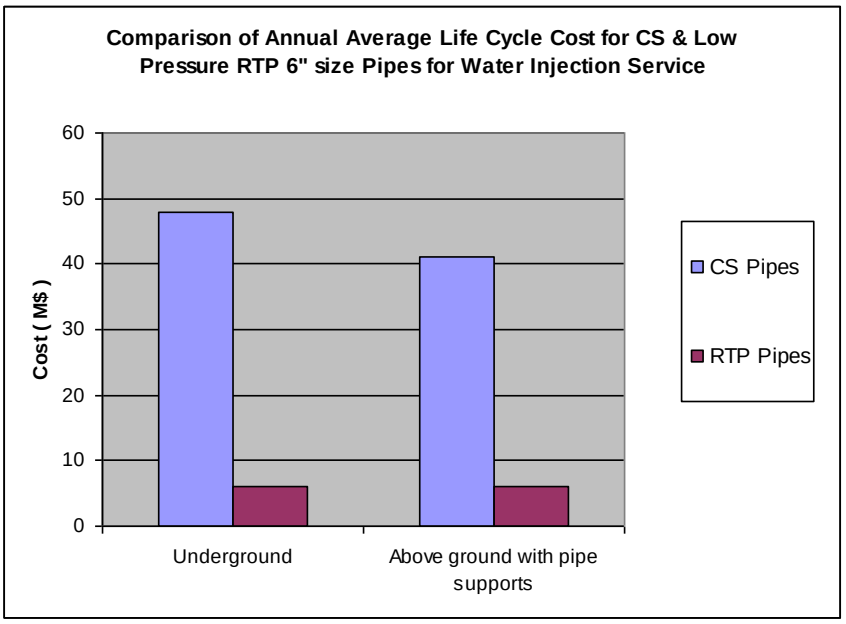

Figure 12: LCC comparison between CS water injection service and RTP pipe

Conclusion and Recommendations

Field experience showed that the RTP flexible pipe is has superior performance and very reliable equipment compared the CS pipe. The three installed operational RTP pipes flowlines have been in service for at eight years with no

history of failures or ruptures. RTP has a very low operational and life cycle cost compared to the CS pipe. The RTP pipe is a potential candidate for new field development due to its superior benefits in terms of low installation cost, corrosion free, re-usable, easy to transport and extended working life. Saudi Aramco has been pursuing aggressive efforts and launched a campaign attracting non-metallic materials, particularly, pipes to Saudi Aramco operational facilities in order to reduce the increasing cost of corrosion, elevating safety and operational reliability as a potential alternative to the CS pipes susceptible to corrosion attack.

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