The metallurgy options for tubing

The metallurgy of tubing is a very important factor while choosing tubing for a particular environment. Generally the tubing is made up of carbon or low alloy steels, martensitic stainless steel, Duplex stainless steel or other corrosion resistant alloys like Nickel-base alloy etc.

METALLURGY FOR TUBING:

Carbon steel is an alloy of carbon and iron containing up to 2% carbon and up to 1. 65% manganese and residual quantities of other elements. Steels with a total alloying element content of less than about 5% but more than specified for carbon steel are designated as low alloy steel. Carbon steel is the most common alloy used in oil industry because of its relatively low cost.

Though corrosion resistance of these steels is limited still they have been used in oil industry since long satisfactorily. They are suitable for mildly corrosive environments like low partial pressure of CO2 & low partial pressure of H2S.

A material selected for a particular environment may not remain suitable in the case the environmental conditions change. CO2 can cause extreme weight loss corrosion & localized corrosion, H2S can cause sulphide stress cracking and corrosion. Chlorides at high temperature can cause stress corrosion cracking and pitting of metals, while low pH in general increases corrosion rate.

For example the following material are considered to be resistant to sulphide stress cracking :

- Low and medium alloy carbon, containing less than 1% nickel.

- AISI 300 series stainless steels (Austenitic) that is fully annealed and free of cold work.

The following materials have been found to have little or no resistance to sulphide stress cracking:

- AISI Grades 420 and 13% Cr martensitic stainless steel.
- All cold finished steels including low and medium alloy steels, many variety of stainless steel.

The limitations of Carbon steel, 9-Cr-1 Mo, 13-Cr, Duplex stainless steel are encountered in various environments and downhole operations.

METALLURGY OPTIONS FOR TUBING:

The various metallurgical options examined for tubing and other downhole equipment are Carbon & Low Alloy Steels, 9 Cr-1Mo steel, 13% Cr stainless steel, Duplex Stainless steel and nickel based alloys. A brief of the suitability and limitations of these materials in various environments encountered in oil and gas wells:

9Cr-1Mo steel.

This steel is immune to stress corrosion cracking in the presence of chlorides like other nickel free low alloy steels. Corrosion resistance of this steel in the presence of H2S is poor. Hence it is not used in tubing metallurgy commonly.

13Cr Stainless steel.

This steel can be used upto 100 atms CO2 partial pressure and upto 150 degree Celsius temperature with chloride upto 50 gms/L. This martensitic grade is known to be susceptible to sulphide stress cracking in sour

environment. This material is generally used for sweet wells where minimum souring is expected.

Duplex Stainless Steel.

Duplex SS has excellent corrosion resistance in CO2 environment. The limitation of their usage is their susceptibility to stress corrosion cracking at high temperature and limited resistance to sulphide stress cracking, when H2S is present in the produced fluid.

Nickel Based Alloys.

Nickel based alloys are required to be used in extremely corrosive conditions involving very high partial pressure of H2S and CO2 along with presence of free sulphur or oxygen.

SELECTION OF TUBING METALLURGY:

From the various metallurgical options I have analyzed, it can be concluded that low alloy carbon steel is not suitable for the wells where high corrosion risk involved, particularly in offshore. If low allow materials were to be used, an intensive corrosion inhibitor treatment program is essential. However, even with the best of programs, the solution to the problem would be trial and error.

Although 9Cr-1 Mo steels are resistant to CO2 attack, they should not be considered for this application since their application in chloride environment is limited up to 10 gms/l (1%). With the high concentrations of chlorides coupled with the high well bore temperature; this material is not suitable for downhole use in these wells.

Duplex stainless steel is susceptible to chloride stress cracking and should not be used with the CaCl2 packer fluid. Also, the price for Duplex material is three to four times the cost of 13 Cr SS material, which would make it economically unacceptable.

Hence, in spite of the additional up-front cost for tubing , it is recommended that based on the caliper survey results , high corrosion risk wells of field should be re-completed with 13% Cr SS L-80 tubing material.

PROBLEMS OBSERVED:

The occurrence of metal loss corrosion in pipeline is caused by the presence of corrodents in the produced water. Internal corrosion in pipeline can be caused by the presence of mill scale, slag inclusions, improper heat treatment, improper welding, too high or too low velocity etc. The erosion/corrosion effect can be caused by too high fluid velocity. Water and sludge build develop with too low fluid velocity that may cause pitting and bacteria infestations. At low fluid velocity, water will tend to segregate to the bottom of the pipeline. Once the pipeline is water wetted, the corrosion begins. When corrosion is not controlled, time to first failure due to corrosion will be normally from three to twelve years depending on the wall thickness and operating conditions.

Corrosion of most material is inevitable and can seldom be completely eliminated. But it can be controlled by carefully selecting material and protection methods at the design stage. For example, as carbon steel is less resistance to corrosion allowance is given in addition to the design thickness when they are expected to handle moderately corrosive fluid. Similarly,

external surface of the pipeline are protected from corrosive soils by providing protective coatings. Still, there is always unexpected failure which results from one or more of the following reasons :

- Poor choice of material.
- Defective fabrication.
- Improper design.
- Inadequate protection/maintenance.
- Defective material.

CONCLUSION:

- Corrosion due to presence of CO2 gas along with unfavorable water chemistry is the cause of the piping failures.
- It is recommended that tubing metallurgy shall be of L-80 13 Cr stainless steel with premium joints.
- The downhole metallurgy shall be 13 Cr SS.

These elastomeric materials include:

- Nitrile:

A rubber compound with base material as Butadiene Acrylonitrile.

- Viton:

A fluoroelastomer manufactured by Dupont.

- Fluorel:

A fluoroelastomer manufactured by 3M company.

- Ryton:

A polyphenylene sulfide manufactured by Philips Petroleum Company.

REFERENCES:

- Effect of microstructure & Cr content in steel on CO2 corrsion. By Masakatsu Veda, Aki Ikeda, Japan.
- Prediction of the risks of CO2 corrosion in oil and gas wells. By Jl Crolet, Mr Bonis.
- CO2 corrosion in oil wells. By Gunalton , Zadko.