DuPont™ StreaMax™ Internal Coating System for Downhole Production Tubing

a report by
Accoat

Today, global sustainability of oil and gas production, is the common denominator of oil- and gas- producing countries, as well as the nations that rely heavily on the import of such energy sources in order to cater for their own energy needs. It is to be noted that a significant portion of oil production comes from maturing fields prone to increasing corrosion issues resulting from increased water cuts, increased chloride levels, as well as increased H_2S and CO_2 content in some instances. Internal corrosion control in downhole production tubes is necessary today in order to ensure oil production sustainability.

On the other hand, in addition to internal down-hole corrosion control, the oil and gas production industry suffers from internal deposition issues that are as severe as corrosion and carry an inherent threat for production continuity. Some of these depositions issues entail asphaltene and $BaSO_4$ depositions. Such deposition types result in frequent well shutdown and require costly maintenance and work-over.

DuPont has developed in recent years a new generation of coating system, DuPont™ StreaMax™ coating, geared towards the internal corrosion protection as well as internal deposition prevention of down-hole production tubes for oil, gas and water injection wells.

The DuPont StreaMax coating system is based on a new resin matrix and coating design consideration. For corrosion control, DuPont StreaMax XC has been designed in order to cater for extremely harsh environments where the well environment involves high H_2S content (above 15%), and high-salt produced water as well as high CO_2 content. The DuPont StreaMax XC development has taken into consideration the need for shifting from low-pressure/low-temperature (LP/LT) design envelope to high-pressure/high-temperature (HP/HT) design envelope. Such down-hole coating system has been approved by a major oil and gas producer in the Middle East for such applications.

For deposition reduction, DuPont StreaMax XF has been developed in order to deal with difficult types of depositions, such as asphaltene and BaSO4 depositions.

Technology Background

Several years ago, DuPont launched an initiative to develop new coating technologies for down-hole production tubes for oil and gas wells, geared towards corrosion prevention, flow assurance and flow enhancement. This initiative was the result of several requests raised by major oil and gas companies looking for new down-hole coating technologies.

In mid-2005, based on the feedback received from a major oil and gas producer, DuPont started to research and develop a new down-hole coating technology that could withstand extreme corrosive conditions at high pressure and temperature. The project target was to develop a new coating technology that could withstand the following conditions:

- operational pressure: 8,500psi;
- operational temperature: 325°F;
- H_2S content in the gas phase: 16% minimum;
- CO_2 content in the gas phase: 5% minimum;
- water phase with salt content;
- coating must retain good adhesion to the metallic substrate after a rapid decompression (less than one minute); and
- good abrasion resistance properties at high temperature.

Existing coating solutions do not have a design envelope capable of meeting all of the above conditions. Also, in existing coating technologies, derating the coating mechanical and chemical properties with respect to pressure and temperature is a must. Thus, the use and design of another type of coating system using a new resin matrix is unavoidable.

Proposed New Coating Solutions

DuPont discovered fluoropolymers in 1938. Fluoropolymers have unique features, compared wit other polymers, which include retaining their excellent corrosion resistance and very high thermal stabilities up to 260°C for some fluoropolymer grades.

In addition, DuPont has made significant progress with respect to the design of fluoropolymers in the last 70 years and possesses the capability of formulating engineered coating solutions based on fluoropolymer resins. DuPont decided to capitalise on the extensive knowledge related to fluoropolymers in order to design a new fluoropolymer based coating technology that could meet the design criteria listed above.

DuPont StreaMax XC Coating System for Corrosion

High H_2S Corrosion Autoclave Test

DuPont StreaMax XC coating was tested at the following conditions:

- test pressure: 8,500psi;
- test temperature: 325°F;

- gas phase: 16% H_2S, 5% CO_2 and 79% CH_4;
- water phase with 155,000 NaCl content;
- hydrocarbon phase;
- test duration 24 hours; and
- rapid decompression from 8,500psi down to 1,500psi within 30 seconds

Figure 1

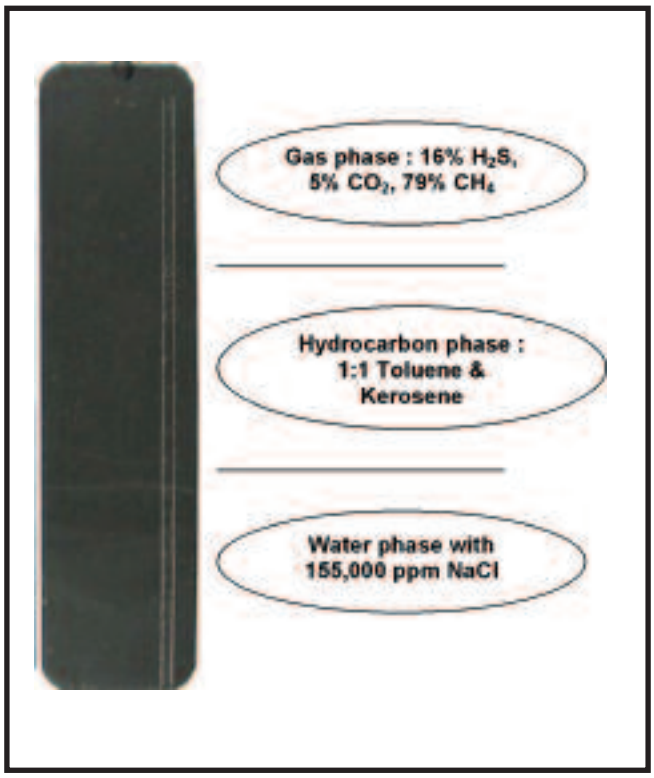
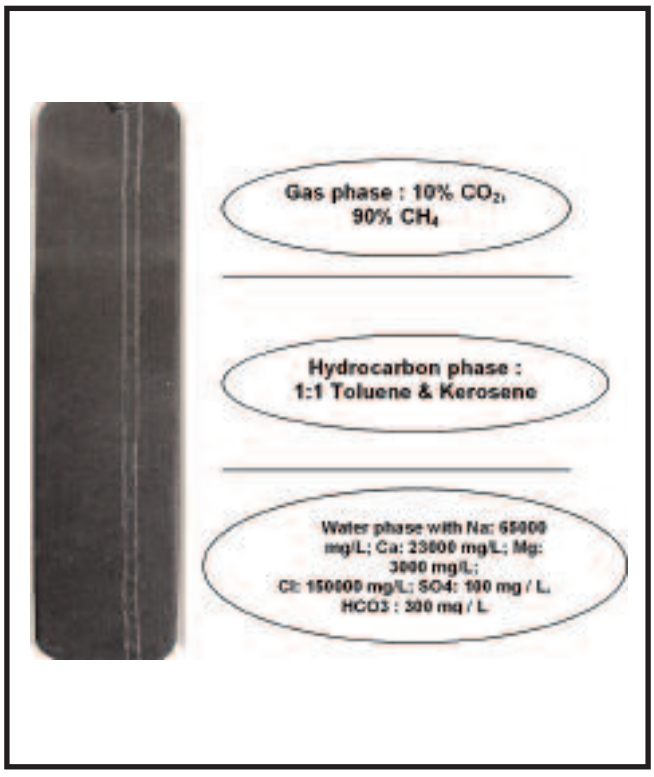


Figure 2



The purpose of this test was to assess the degradation of the coating adhesion to the metallic substrate as well as the occurrence of any blisters that would eventually extend down to the metallic substrate following a very severe decompression from 8,500psi down to 1,500psi within 30 seconds only.

The effects of severe decompression in oil and gas fields following a sudden well shut-down are usually detrimental to the coating adhesion integrity to the tubular. Clogging of down-hole production tubes by coating debris because of the loss of the coating adhesion following a severe decompression has been witnessed in the past and requires well shutdown for cleaning purpose. Such failure can result in very high losses to the oil/gas operators.

This design phase focused mainly on the effects of a severe decompression on the coating adhesion to the metallic substrate. Obviously, if there was no significant loss of adhesion following a decompression of 30 seconds, this would mean that the failure scenario described earlier should not happen on-site.

The corrosion autoclave test results showed that, despite the severe decompression in 30 seconds, DuPont StreaMax coating maintained an adhesion rating of 'A' and no foaming, softening or undercreep occurred. No sign of blisters reaching the metallic substrate were witnessed at all (see *Figure 1*).

Sweet Corrosion Autoclave Test

DuPont StreaMax XC coating was tested at the following conditions:

- test pressure: 8,500psi
- test temperature: 350°F;
- gas phase: 10% CO_2 and 90% CH_4;
- water phase: formation water (Na: 65,000mg/l; Ca: 23,000mg/l; Mg: 3,000mg/l; Cl: 150,000mg/l; SO4: 100mg/l; HCO3: 300mg/l)
- hydrocarbon phase;
- test duration 24 hours; and
- rapid decompression from 8,500psi down to 1,500psi within 40 seconds.

The purpose of this test was to assess the degradation of the coating adhesion to the metallic substrate as well as the occurrence of any blisters that would eventually extend down to the metallic substrate following a very severe decompression from 8,500psi down to 1,500psi within 30 seconds only.

The corrosion autoclave test results showed that, despite the severe decompression in 40 seconds, DuPont StreaMax coating maintained an adhesion rating of 'A' and no foaming, softening or undercreep occurred. No sign of blisters reaching the metallic substrate were witnessed at all (see *Figure 2*).

DuPont StreaMax XF Coating System for Deposition Reduction

Internal deposition could occur because of asphaltene and paraffin build up as well as the build up of $BaSO_4$ scales for instance. A specific grade of DuPont StreaMax coating system was developed by DuPont in order to reduce substantially the deposition rate on the internal surface of the downhole production tube.

For asphaltene deposition, asphaltene flow loop test results, performed on coated tubes with DuPont fluoropolymer coating system, show a reduction two-thirds by weight in asphaltene deposition compared to bare stainless steel. The test is completed by using a laminar flow at a velocity of 0.24cm/sec.

A live coupon test was performed by DuPont in Alberta (Canada) in an oil well suffering from high asphaltene content. A coated coupon was suspended in the concerned oil well, 5,800ft deep, near the bottom of the well. The well operating pressure is 2,500psi at 80°C and is producing a mix of oil, gas and water. After 21 days, the coupon had no asphaltene deposition at all. Prior to this test, the well operator has never witnessed a technology that has zero asphaltene deposition.

For paraffin deposition, static cold finger test results show a reduction of 60% in paraffin deposition hen compared with bare stainless steel. This reduction increases to 80% compared with epoxy coating. The same results were confirmed by a paraffin flow loop test, using paraffin-rich oil under a turbulent flow. The reduction in deposition is 60%, when compared to bare steel. The paraffin deposition on the finished fluoropolymer coating is in the form of soft gel that can be removed easily.

For $BaSO_4$ scaling, preliminary test results, performed by a renowned institute in the North Sea area, shows a significant reduction in $BaSO_4$ deposition reduction when using DuPont StreaMax XF coating system.

Conclusion

Following the extensive research work and testing performed by DuPont in the last few years, an innovative coating solution specifically engineered for downhole production tubes is available for service in harsh corrosive well environments where other existing polymeric coatings fail, and where previously high-grade CRA tubes were the only available solution.

Also, DuPont StreaMax down-hole coating system can be looked at as a solution for an extremely difficult type of scale, $BaSO_4$, where no effective solution for removing this type of scale, deposited on the internal surface of the down-hole production tubes in question, exists. Very often, tubes suffering from $BaSO_4$ end up being lost, thus adding significant cost to the tube life cycle cost, thus increasing production cost.

This innovative coating solution is today being serviced by DuPont and its partners in the North Sea area as well as the Middle East and Northern America through technically advanced coating application processes and techniques that were developed along with DuPont StreaMax down-hole coating system development, in order to ensure that the end users can benefit from this technically advanced downhole coating solution. ■