Applications and Advantages of High-Density Liquid Corrosion Inhibitors

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INTRODUCTION

The need for weighted corrosion inhibitors in the petroleum producing industry has been obvious for some time. This need has been met with varying degrees of success in the past with corrosion sticks or other encapsulated materials. With the development of high-density liquid corrosion inhibitors which are easier to apply, are less expensive, and in most cases are far more efficient than solid inhibitors, this need has been satisfactorily eliminated. The rapid acceptance of high-density liquid corrosion inhibitors attests to their effectiveness in corrosion mitigation work, and to the initiative of the petroleum industry personnel who are continually searching for better or more economical ways of performing their duties. The use of these inhibitors has grown rapidly in the past four years and now accounts for a very significant percentage of the total inhibitor used in petroleum producing wells.

The term high-density corrosion inhibitor is used to designate those formulations that have been coupled with a weighting agent to make them heavier than conventional inhibitors which have a weight between about 7.6 and about 8.2 pounds per gallon. The weighting agent is used to increase the weight so that the inhibitor will fall through the oil column and/or through any water column in the well. Many high-density liquid corrosion inhibitors are compounded so that water releases the inhibitor portion from the weighting agent. Some are released very quickly and some are so compounded that they may remain coupled to the weighting agent for a period of from several hours to a few days before being completely de-coupled. Some of the factors which influence the rate of de-coupling would be the physical and chemical characteristics of the inhibitor and temperature and salinity of the water in which the inhibitor is immersed. Most of the high-density liquid corrosion inhibitors will form a tough film over the metal surface regardless of whether it has or has not been released from the weighting agent.

The high-density liquid corrosion inhibitors can be broadly classified into two types. One type is those products which are heavier than conventional inhibitors but lighter than salt water and are designed to fall through the oil phase and align themselves with the oil/water interface. The other type has a density greater than that of salt water and are designed to fall into, and/or through formation waters found at the bottom of producing wells.

Two important features of all high-density liquid corrosion inhibitors are that they lay down a tenacious film and they are so compounded that they will fall through thousands of feet of oil in a high fluid-level well and arrive at the oil/water interface with essentially the same characteristics as when introduced at the top of the well.

APPLICATIONS OF HIGH-DENSITY LIQUID CORROSION INHIBITORS

High-density liquid corrosion inhibitors were developed and used initially almost exclusively in the Texas, Louisiana Gulf Coast area because it eliminated the need for high priced pumping equipment to effectively treat offshore and inland waterway wells with conventional inhibitors. These inhibitors are now being used in most all producing areas in nearly every type of well due to their effectiveness in problem well treating.

High Fluid Level Pumping Wells: These wells can be effectively treated with a high-density liquid corrosion inhibitor since it will fall through the oil column in the annulus and align itself with the oil/water interface and be picked up with the pump to coat down-hole equipment as it returns to the surface. This eliminates the need in most cases for well circulation.

Low Pressure Gas Wells which are often killed with conventional-type treatments can be treated effectively and economically with high-density liquid corrosion inhibitors. The volume required is not enough normally to kill the well thus eliminating the necessity of swabbing to re-establish flow following treatment.

High Pressure Gas Wells: Equipment and manpower requirement for conventional tubing displacement treatments are quite expensive. These wells can be effectively treated by merely pumping the inhibitor into the top of the tubing and closing the well in for the required period of time to permit the inhibitor to fall, then returning to production.

Flowing Oil Wells With Packers: These wells have been treated previously with stick inhibitors or squeeze-type treatments which were in many cases ineffective or required swabbing to re-establish flow. Treating with high-density liquid inhibitors, the chemical is merely pumped or lubricated into tubing, well is shut-in for required period of time then returned to production. Inhibitor requirement is not enough to kill the well.

Static Water Columns in Casing Strings: This occurs in multi-completioned wells; when the upper zone produces any water, the resultant static water column is normally quite corrosive. High-density liquid inhibitor can be lubricated or pumped into the annulus and the upper zone shut-in long enough to allow the inhibitor to fall. This was one of the first applications of high-density liquid inhibitors in the Permian Basin area and results have been excellent.

Non-Prorated Pumping Wells: These wells, either high or low fluid level, can be economically treated with high-density liquid corrosion inhibitors without the necessity of circulating the well with resultant loss of production.

Other Uses: Earlier usage of high-density liquid corrosion inhibitors was limited to treating wells which were difficult or impossible to treat effectively with conventional inhibitors. The easier application, plus better film life, however, has caused this type of inhibitor to be in far greater demand than originally seemed possible. The treatment of low fluid level pumping wells and high water-producing wells with submergible pumps are examples of this expanded usage.

ADVANTAGES OF HIGH-DENSITY LIQUID CORROSION INHIBITORS

The rapid acceptance of high-density corrosion inhibitors is due to the advantages these materials provided the petroleum industry. The physical and chemical characteristics of the high-density corrosion inhibitors have provided the petroleum producing industry with an effective, economical means of treating wells that were previously difficult or impossible to treat with conventional corrosion inhibitors. These inhibitors are available in a wide range of densities for gas wells and oil wells, flowing wells and pumping wells, and for both sweet and sour well fluids. Following are some of the specific advantages of high-density liquid corrosion inhibitors.

Cut Equipment Costs: The only equipment required for treating with high-density inhibitor is a pump capable of pumping against the wellhead pressure. Less preparation is required as no flush fluids or bulk handling equipment is required as for tubing-displacement type of treating. Conventional corrosion treating in many cases utilizes expensive pumping equipment over a long period of time; the only time required for treating with high-density liquid corrosion inhibitor is the time needed to pump the inhibitor into the top of the well.

Eliminates Emulsion Problems: Many good conventional corrosion inhibitors now available tend to cause emulsion problems in some areas. The excellent de-emulsifying characteristics of the high-density inhibitors virtually assure no emulsion problems following inhibitor treatment.

Eliminates Swabbing Expense: Many low-pressure gas wells and flowing oil wells are killed with conventional squeeze or tubing-displacement type treating. Batch treatments made with high-density corrosion inhibitors do not significantly affect flow from these wells, eliminating the necessity of swabbing to re-establish flowing with the resultant loss of at least a portion of the inhibitor film. A batch-type treatment with high-density liquid corrosion inhibitor will usually provide at least the equivalent protection normally provided by a squeeze treatment of conventional corrosion inhibitor.

Cut Circulation Requirements of Pumping Wells: These inhibitors are so compounded that they will fall through the column of fluid in the casing annulus to the bottom of the well. The procedure frequently used is to briefly circulate the well production down the casing annulus to wet the annular area then lubricate the inhibitor down the annulus and switch well back down flowline. No production is lost due to long circulation periods following treatment.

Cut Frequency Requirements for Treatment: The tenacity of the film of the high-density corrosion inhibitors usually provides greater film life than do the conventional corrosion inhibitors. In some instances the better film life has permitted corrosion inhibitor treatments to be extended to semi-monthly or monthly treatments instead of weekly, as with conventional corrosion inhibitors. In gas well treating, in nearly every instance, high-density liquid corrosion inhibitors have given longer protection than conventional inhibitors.

Prevent Formation Damage Done by Squeeze-Type Treatments: It has been proven, by resultant flow rates, in some cases and suspected in many cases that conventional inhibitor squeeze-type treatments cause damage to gas-producing formations. Many operators will not now allow squeeze-type treatment into gas-producing zones. The high-density liquid corrosion inhibitors will normally provide at least the equivalent protection of a conventional corrosion inhibitor squeeze and the inhibitor required is usually about one-half as much.

TREATING PROCEDURES

High Pressure Gas Wells, Low Pressure Gas Wells, and Flowing Oil Wells are frequently treated with from 25 to 110 gallons high-density liquid corrosion inhibitor pumped, or lubricated, into the top of the tubing then closing the well in for a period of 12 to 48 hours to permit the inhibitor to fall to the bottom of the well. Following the shut-in period, the well is ready to resume normal production. The amount of high-density inhibitor required and shut-in time is determined by depth of well and size of tubing and/or casing to be treated. Wtih most of the high-density liquid corrosion inhibitors, water should not be used to flush inhibitor out of lines of treating equipment.

Pumping Wells are treated by briefly circulating the well production to wet the annular area. Inhibitor is then injected into annulus and well switched back down flowline. No production is lost due to long circulating periods during the treatment. The inhibitor falls through the fluid in the casing annulus to the bottom of the well where it will enter the tubing and be forced, along with the produced fluid, to the top of the well. Treatment usually consists of an initial treatment of 10 gallons of inhibitor followed with maintenance treatments consisting of the equivalent of 25 ppm of inhibitor based on total liquid produced during the time interval before the next treatment. With most of the high-density liquid inhibitors, the well should not be circulated either during or immediately after the addition of the inhibitor.

Static Water Columns: In multi-completioned wells where static water columns are present, the treatment frequently used is to pump or lubricate the required amount of inhibitor down the annulus and shut the upper zone in until the inhibitor has had sufficient time to fall. Amount of inhibitor required is based on area to be protected.

Non-Prorated Pumping Wells: Another place where high-density corrosion inhibitors are being used is on wells that are not on proration. (The extra cost of the higher priced inhibitor is more than offset by the increase in production and savings in personnel time required to treat and circulate the wells with a conventional inhibitor.)

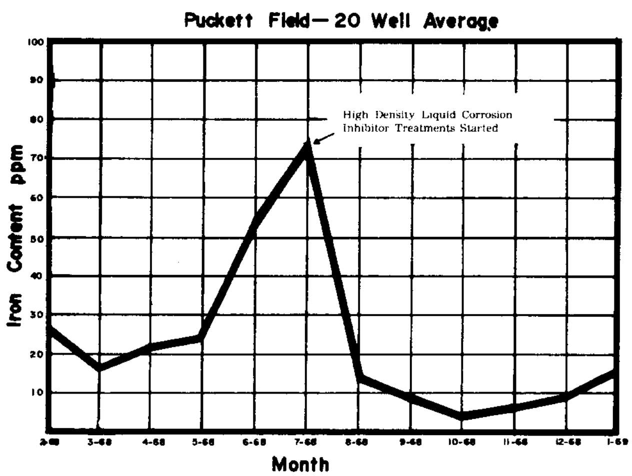
FIELD USAGE

Contrary to what was first believed, that high-density liquid corrosion inhibitors would be limited to gas well treating in the Gulf Coast area and primarily in wells in inland waterways or on offshore platforms, its application has been expanded to include almost all facets of oil field down-hole corrosion mitigation work. The results obtained show that in almost every instance the high-density liquid corrosion inhibitors have performed better than the previous inhibitor used. In some cases the improvement has been modest; in many cases the improvement has been significant. The following is a listing of a few of the cases where high-density liquid inhibitors have performed well in corrosion mitigation.

Puckett Field: Most of the gas wells in the

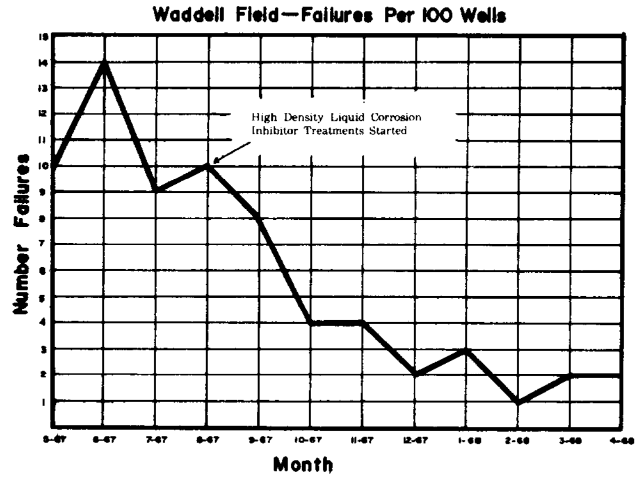
Puckett Field have been treated with conventional inhibitors for some time with satisfactory results. The Ellenberger zone is the most corrosive with its high percentage of CO_2. Iron content in the produced water of untreated wells averages from 150 to 200 ppm. Most operators in this field have now changed to high-density liquid corrosion inhibitors. This change was brought about primarily due to decline in pressures to a point where conventional treating killed the wells, necessitating swabbing to restore flowing. The savings in time and equipment costs realized by use of high-density liquid corrosion inhibitors have been substantial. Results with high-density inhibitors have been very good. Fig. 1 shows the average iron content in ppm for 20 Ellenberger wells which were originally treated with conventional corrosion inhibitors, and then changed to high-density liquid inhibitor.

FIGURE 1. — Conventional Inhibitor vs High-Density Liquid Corrosion Inhibitor, PPM Iron Content vs Time, Puckett Field.



<u>Waddell Field—Ector-Crane County, Texas:</u> An operator in this field was experiencing more than normal corrosion problems for this area where wells were under water flood. Fluid levels on most wells were high and in many cases to the surface. Wells were being treated with a conventional corrosion inhibitor which had given satisfactory corrosion protection prior to the time significant change in fluid levels occurred. The problem in this case was obvious; the inhibitor was not getting around. The inhibitor was changed to a high-density liquid corrosion inhibitor. The corrosion rate, as shown by total failures due to corrosion per 100 wells (Fig. 2) and coupon tests, was once more brought under control. Corrosion-associated failures on these wells are still very low for this field.

FIGURE 2. — Conventional Inhibitor vs. High Density Liquid Corrosion Inhibitor, Number of Failures per 100 Wells vs Time, Waddell Field.



<u>Fullerton Field — Andrews County, Texas:</u> A major oil company operating a water flood was experiencing difficulty in achieving corrosion protection with conventional inhibitors on high fluid level wells. Wells were approximately 7000 ft in depth and fluid levels were surface to 3500 ft. A number of wells were put on test with high-density liquid corrosion inhibitors approximately eight months ago, using five gallons inhibitor per well once monthly. Coupon tests and pulling records show corrosion has now been brought under control and the operator reports a projected saving of $844 per well per year due to decreased pulling costs and no loss in production due to circulation. This program has now been expanded.

<u>Goldsmith-TXL Fields, Ector County, Texas:</u> High-density liquid corrosion inhibitors were first used to any great extent in the Permian Basin area in Goldsmith, TXL fields on dual and triple completion wells where static water columns were present. Many of these wells were treated three to four years ago. Wells which have been pulled for various reasons indicate protection has been excellent.

<u>Delaware Basin:</u> The ultra deep, very high-pressure, extremely expensive, very hot wells in

the Delaware Basin are all relatively new and very little information is available on corrosion mitigation at the present time. The principal problem encountered to date is getting conventional inhibitors to fall and tubing displacement under existing pressures is extremely expensive. Several wells have been treated with high-density liquid corrosion inhibitors with all tests indicating excellent results. Some wells which were treated with conventional inhibitors and shut-in for 24 to 72 hours were opened back up only to find the inhibitors were still at the top. These wells were then treated with high-density liquid corrosion inhibitors, shut-in the required period of time, then returned to production with every indication the inhibitor is performing satisfactorily. Possible corrosion problems in this area are being watched very closely due to extremely expensive workover costs. Results obtained in other high pressure hot wells leave little doubt that the high-density liquid corrosion inhibitors will perform well in this area.

Texas Gulf Coast: One operator reported a yearly reduction of more than $50,000 in service charges alone on 46 wells after the replacement of a conventional inhibitor with a high-density inhibitor. These were high fluid level pumping wells. The fluids were considered to be sweet.

SUMMARY

High-density liquid corrosion inhibitors have provided the petroleum producing industry with an effective, economical means of treating corrosion in problem wells. These inhibitors have an excellent film life due to the tenacious film they lay down. These inhibitors simplify well treating by eliminating the need for expensive equipment, fewer treatments per month are required, minimization of emulsion problems, does not kill the flow from the well and no circulation of pumping wells is required. High-density liquid inhibitors are available for sweet and sour well fluids. Some are applicable to either, others are for use only in sweet systems and should not be used in sour wells. High-density liquid corrosion inhibitors could very well eliminate stick corrosion inhibitor treatments, dump bailer treatments and conventional squeeze-type treatments. Overall corrosion mitigation costs have been and will continue to be reduced with the use of high-density liquid corrosion inhibitors.

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