EFFECTIVE APPLICATION OF A CORROSION INHIBITOR FOR ROD PUMPING OIL WELLS

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ABSTRACT

An effective corrosion-control program depends upon well conditions (fluid levels, gas blowing by the casing, well pound, casing gas venting), manner of inhibitor application and the awareness of the personnel responsible for treating the wells.

Preventative programs are valuable for wells producing highly corrosive fluids, and test wells are important for evaluating inhibitors and their application. Such tests have been very valuable for the inhibitor manufacturer as he works with the producer in developing improved products.

Keeping corrosion-control programs current is very important. Well characteristics such as type of production, WOR, and fluid levels change, and the corrosion-control program should change with them if pulling jobs are to be minimized, equipment replacement is to be reduced, and costs kept down. This paper discusses one such approach to optimizing corrosion inhibitor treatments.

INTRODUCTION

Corrosion chemicals can do an effective job in preventing corrosion in rod-pumping wells and decreasing pulling costs. This may sound like an exaggerated statement when you consider that in 1977 oil producers spent approximately $750 million on the repair of tubing, rods, pumps, etc., because of corrosion. It is also estimated that in 1977 oil producers spent in excess of $50 million on corrosion-control programs to help eliminate these high costs. Why, then, is the industry not getting more effective results from the dollars spent on corrosion inhibition?

If a producer has the same number of pulling jobs in 1977 as he had in 1976, perhaps it is time to determine why the corrosion-control program used has not been effective. Probable causes are outside interferences such as solids, scale, paraffin, etc.; ineffective products; or ineffective product application. It is practically impossible to get 100% protection from any corrosion-control program; however, if the most effective product is properly applied, the result should be a reduction in pulling jobs.

This paper deals with the practical means of getting the corrosion chemical to the problem. This may sound like an easy task, and at times it is; but for the most part, it is complicated and can be accomplished only through mutual cooperation between the oil producer and the chemical supplier. In reality, regardless of how good the product is or how much the service representative is involved in setting up a program, if the product does not get directly to the problem, there will be no effective corrosion program.

HOW FILM-FORMING CORROSION INHIBITORS WORK

The film-forming corrosion inhibitors are substances that are added to corrosive fluids specifically to absorb onto metal surfaces in order to form barriers that insulate the metal surfaces from the electrolyte. They create a hydrophobic layer on the metal surface that will actually prevent the electrolyte (water) from contacting the metal surface intimately enough to allow corrosion reactions to proceed. The film-forming inhibitors are organic substances. They are comprised of molecules containing functional parts that are attracted to metal surfaces and that repel water. The process of bond formation is called chemisorption, and the water-repelling surfaces are termed hydrophobic. Examples of the bond-forming functional parts are basic nitrogen groups, like amines; sulfur-containing groups, like sulfonates; and oxygen-containing groups, like fatty acids, phosphorus products, etc. That portion of each inhibitor molecule that sticks out from the metal surface to repel water is generally just hydrocarbon and usually a straight chain hydrocarbon, so it can stick out far enough to keep water as far from the metal surface as possible. The longer these hydrocarbon tails are, the better they are in preventing water contact, but beyond a given length or molecular weight, solubility and/or physical property problems arise. Monomolecular film (one molecule thick) of a film-forming corrosion inhibitor composed of an absorbing head and a water-repellent tail about the same length as kerosene-weight hydrocarbons will prevent corrosion even though the film is visible only because the surface appears oily. Thicker visible films are built up by the very high molecular weight inhibitors, but the thicker films only provide extra inhibitor, which is more resistant to removal, permitting less frequent treatment.

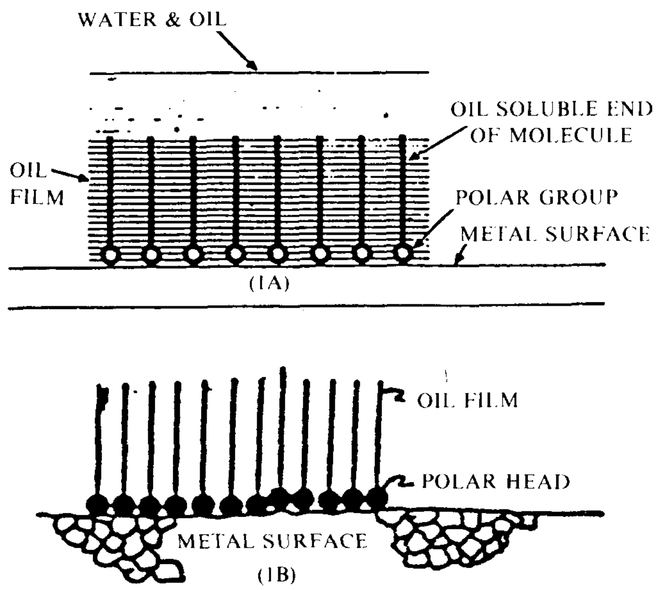

FIGURE 1A, B—SIMPLIFIED VIEW OF INHIBITOR MECHANISM

It is important to understand that inhibitor films are not permanent even in the absence of erosion. Inhibitor molecules do not wear out, but there is a continuing equilibrium system in which some inhibitor molecules are absorbing and some desorbing. Molecules that do leave the surface at one point are able to refilm at some other site in the system. Thus, in the absence of the thick, visible, persistent films designed to obtain continuing long-term protection, inhibitor must be available from the fluids to repair the film as inhibitor molecules desorb.

In order for an inhibitor to work in an actual system, it must often possess characteristics in addition to the basic protective-film-formation capability. Thus, for a given system, an inhibitor may need additional ingredients to assist the actual filming ingredients to function, or it may just have to be in the right form (oil soluble, water soluble, etc.). In other words, for a given inhibitor to work, it must get to the surface it is supposed to protect, and it must be able to win out over other substances that are competing with it for the metal surface, such as scale, paraffin, corrosion products, water, and dissolved substances in the water or oil.

CORROSION INHIBITORS

Film-forming inhibitors could be classified according to chemical type; type of system each can be used in, such as crude systems, water systems, etc.; solubilities; the metals they will protect; or even according to the physical properties. Because all of these classification systems would overlap, most people differentiate among inhibitors on the basis of solubility and the environments in which each will inhibit corrosion, and then describe the additional properties each inhibitor possesses on an individual basis.

Because they need to contain relatively long hydrocarbon tails to repel water, the film-forming corrosion inhibitors naturally tend toward oil solubility. A good many of them are truly oil soluble. Though inhibitors do film readily from either oil or water, it is more difficult to make the higher-molecular-weight inhibitor molecules water soluble. Thus, most of the oil-soluble inhibitors have a built-in edge over water-soluble ones in film strength and persistency. The polar head of corrosion inhibitor molecules, in addition to performing the absorption duty, also tend to make the inhibitor water soluble. So, to make an oil-soluble, water-dispersible inhibitor, one can increase the ratio of inhibitor "head" to hydrocarbon tail. This can be done either by adding more head or by shortening the hydrocarbon tail. Alternatively, solubilizing agents can be added. To obtain truly water-soluble inhibitors and inhibitors soluble in high brines, the ratio of head-to-tail must be even higher, or the inhibitor must be made more ionic by making it up as a salt-in-water solution.

Surfactant properties of corrosion inhibitors vary with the type of inhibitor, and extra surfactants are often added to obtain more detergency, solids-dispersing capability, or both. Water-soluble inhibitors tend to be more surface active, but oil-soluble inhibitors can be formulated with added surfactant to approach the properties of the water solubles. The limited-solubility inhibitors are not completely soluble in either hydrocarbon or water. These are very high-molecular-weight materials that are used to form the thick, visible films exhibiting long-term film persistency.

Film-forming corrosion inhibitors used to treat rod pump wells are effective against most of the common corrosions. However, some are much more effective in the presence of one corrodent than another, such as CO_2 or H_2S. Some inhibitors are not effective at all in the presence of oxygen.

CHEMICAL APPLICATION

Corrodents

In initiating an effective corrosion-control program, the most important step is selecting a product designed specifically to handle the particular type of problem involved. The following are some of the more common corrosion problems and the types of products recommended for effective control of them.

CO_2 and H_2S—Very few products on the market today are highly effective in controlling corrosion in both sweet and sour systems. Therefore, it would be advantageous to select separate products for both systems.

FeS—This is one of the more common problems encountered in the Southwest. Iron sulfide can exist in several crystalline forms, some of which are loose and porous, thus promoting attack beneath the iron sulfide layers. In order to prevent hydrogen sulfide embrittlement or blistering, it is important that the corrosion inhibitor be able to compete successfully and adhere to the metal surface. Another problem stemming from FeS is the ability of the iron sulfide solids to absorb large quantities of most corrosion inhibitors. This problem can be attacked in two ways: (1) A corrosion inhibitor with high surfactant properties can be used. This will help remove some of the iron sulfide crystals, thus making the inhibitor more effective. (2) One of the most effective methods of handling this type of problem is through truck treating. A surfactant is injected and then followed by a corrosion inhibitor containing moderate surfactant properties. This will allow the surfactant to strip the solid particles from the metal, thus permitting the corrosion inhibitor to successfully compete and adhere to the metal surface. (Note: An oil-soluble surfactant is more effective than a water-soluble surfactant and will create fewer problems in the oil and water treating systems.)

Paraffin—It is practically impossible for a corrosion inhibitor to adhere to metal surfaces when it competes with paraffin. There are very few, if any, corrosion inhibitors that have been proven effective in removing paraffin from metal surfaces. It is recommended that a paraffin solvent be used ahead of the desired corrosion inhibitor.

Suspended Solids—Suspended solids in rod-pumped wells create two problems for the engineer trying to inhibit against corrosion. First, the solids absorb large quantities of the corrosion inhibitor. Consequently, larger dosages are required in order to effectively form a protective film on the metal surface. Second, solids which are dispersed require a corrosion inhibitor with some detergent properties to effectively remove the solids and allow the corrosion inhibitor to adhere to the metal surface. If the accumulation of solids becomes very severe, the use of an oil-soluble surfactant may be required.

Oxygen—In the presence of H_2S a trace of oxygen in the system will create a severe corrosion environment. Very few corrosion inhibitors are effective in this type of environment. The most economical and perhaps the most effective way to handle this problem is to eliminate the oxygen which is being introduced into the system. If the oxygen is introduced during truck-treating operations, use of an oxygen scavenger in the flush water may help eliminate the problem.

Once the most effective chemical has been selected to handle a specific probem, a major step has been taken in getting the product to the problem area. The next step, and perhaps the most crucial, is injection of the product into the system. Techniques for application of corrosion inhibitors include continuous injection, automatic chemical feeders, squeeze treatment, circulate-and-park technique, and truck treating. Since approximately 80% of the wells in the Southwest are truck treated, we will explore some of the techniques used in this method.

Outside Factors Influencing Corrosion and Truck Treating

In compiling the information needed for initiating a truck-treating program, we must first identify the corrodents and determine what outside interferences are present. Other pertinent information is the water-oil ratio and the amount of production. Once this information has been compiled and a chemical has been selected, one other factor, a factor which plays an important role in getting the chemical to the problem, must be considered—fluid levels.

Medium Fluid Level—Oil wells that do not pump-off and contain 200-400 ft of fluid column in the annuli above the pump intake are pehaps the easiest wells in which to control corrosion. An effective corrosion-control program can be initiated provided the inhibitor applied is able to combat the corrodents in the well. The fluids in the annulus act as a reservoir for an oil-soluble inhibitor, so it feeds in continuously even when the inhibitor is injected only periodically. Only a small amount of flush is necessary and generally circulation is not required.

Low Fluid Levels—Wells that are kept pumped-down are more difficult to treat for several reasons: (1) They often pump-off and pull in oxygen through leaky casing valves. (2) There is little, if any, reservoir of chemical to feed into the pump intake over any extended period between treatments. If periodic batch treatment with a treating truck is selected as the method of application, the inhibitor must be one of very high film persistency. A small amount of flush water is required. In most cases, treating may be required on a more frequent basis, for instance twice a week.

High Fluid Level—A well containing a high fluid level is perhaps the most difficult to treat of all. It may have several thousand feet of fluid standing in the annulus. If the well can be circulated, an oil-soluble inhibitor can be applied effectively. Very often, circulation is not fesible, and application becomes a problem. Weighted inhibitors are somewhat useful, but the weighing agents drastically reduce the active inhibitor ingredients. A successful method is the use of an oil-soluble, highly water-dispersible chemical with other properties that will assist the product in becoming emulsified with produced water. This emulsion is mixed in the treating truck and the well is treated with the specified amount of active chemical and approximately 5 barrels of flush. Part of the inhibitor will be released in the oil on the way down to the pump intake for continuous feed between treatments. A large amount of the inhibitor will fall all the way to the pump, however, and will immediately begin to form a film on the rods and tubing. Filming with this type of product is accomplished as effectively from the produced water and inhibitor emulsion as it would be from either water or oil solutions.

SUMMARY

Fluid levels are just one of the factors involved in determining the type of product and techniques to be used in initiating an effective corrosion-control program. Other factors are such characteristics as gas blowing by the casing, well pounding, and casing vent to the atmosphere. If truck treating is selected as the most effective method of treating once all factors have been taken into consideration, the next thing to consider is the individual who will actually be responsible for treating the wells. It is imperative that he be familiar with the products and method of application. It is also important that the treater have the ability to recognize problem areas so that pertinent information can be given to the supplier in order that changes in the product or application can be made without delay if necessary.

In a field where an extremely corrosive environment exists, it would be advantageous to the producer if a number of wells were designated for a test program. This will enable the supplier to survey the problems involved in the particular field, and through data gathered from these test wells, special products and techniques could be developed for effectively combating these corrodents. Great progress has been made in developing new products and new methods of application during the past five years. This progress would not have been possible, however, without the cooperation of the oil producers, who allowed the suppliers to test these products under actual field conditions.

The importance of updating corrosion-control programs periodically cannot be overemphasized. Well characteristics such as production, oil-water ratio, fluid levels, etc., are subject to change over a period of time, and the supplier must be constantly aware of these changes in order to maintain an effective treating program. If as little as 1% of the total dollars spent on pulling jobs and replacing equipment due to corrosion can be decreased by an effective corrosion-control program, it will result in tremendous savings to the producer.

In essence, an effective corrosion-control program involves choosing the correct product to combat the specific corrodent and applying it properly in order to get directly to the problem and thus keep the well producing.