Questionable Practices Used In Conditioning Waters for Injection Purposes

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Methods of conditioning waters for injection purposes in the oilfield are manifold and encompass virtually every sort of treatment program of merit, and then some. It is this latter portion "and then some" with which this paper deals. However, one should not let this short phrase be misleading, for the number of water floods utilizing poor water treating practices are many and are therefore not uncommon in oilfield water injection operations.

Cases where inadequate or no initial consideration was given to the water conditioning program are discussed. However, to limit somewhat the topics, examples cited will be confined to the handling of saline waters and these examples are meant to point out specific and serious departures from good water treatment practices. But these departures do not mean some of the general attitudes put forth can not be applied to fresh waters.

Approaches to water conditioning are like those of making a car trip to a far removed town. The driver who does not anticipate the best route to travel and follows no guides usually gets lost. Further, the motorist who only observes road signs may miss one and find himself lost, or take a circuitous way. On the other hand, only the person who anticipates the journey by using a map and a carefully chosen course can determine the shortest and best route by which to reach his destination. It will be seen that the approaches to water conditioning programs are similar.

ROUTES LEADING TO THE INITIATION OF POOR WATER CONDITIONING PRACTICES

Mapping the progress of a wayward route is not difficult. A general pattern can usually be traced in the development of poor conditioning concepts which lead to problems.

Economic Nearsightedness

The first step in this pattern is that of economic nearsightedness, or false economy. Causes for the economic squeeze are too numerous to cover here, but the attitudes resulting from it are similar. For instance, it is often reasoned that water conditioning and expenditures for it are minor in comparison with those of major production operations and that, therefore, they merit less time and cost consideration. Such reasoning, however, underestimates the extent to which water problems can develop and cause increased expenditures during the life of the flood.

The outlook is that the first step, anticipation of potential problems, is minimized with expectations that problems will remain insignificant.

It is common that this original outlook is altered after a period of operation to the idea that the first step is minimized with the result that problems become significant.

In other words, the driver has reached a junction only to find he has gone in the wrong direction.

Incomplete Knowledge of Water Problems

This particular route can be a result of the above economic factor or can be born independently of it. In either instance, the job of battling water problems is dumped into the lap of a person uneducated in that field. And quite often this person is a petroleum or reservoir engineer who has surveillance over all production operations, many of which must be performed by outside specialists (well stimulation, logging, etc.). Still, he is usually the one delegated to carry the burden of coping with water problems, also a specialized field and one widely divergent from his own.

This reasoning assumes that an engineer has time, other than that consumed by his regular tasks, to attack the broad field of water treatment. But if the engineer does have some time, road blocks immediately present themselves in the form of sources from which he may extract knowledge for his water conditioning chores.

1. He may gain knowledge from periodicals or publications. However, the papers available are usually too broad, too specific, or too technical to be helpful, so, via reading, the engineer can absorb only spotty facts and limited knowledge, something less than comprehensive. This inadequate reading leads to "a little knowledge is dangerous" situation. Thus, in recognizing and treating any one problem, he may upset several other contributing factors, and this action can introduce new problems not existing initially and not being capable of being solved by the original treatment.
2. A certain amount of "utility" information is available from outside sources such as service companies, chemical salesmen, etc. But with such information an engineer can obtain so many rules of thumb that he is likely to end up all thumbs in his approach to water treatment, and the outcome of trying to correlate several suggested solutions for the same problem is confusion.
3. Another source of information may be a research laboratory which, depending upon how it functions in working with an engineer, can be an asset or a liability. If the research department assumes the responsibility of treating the water and keeps the engineer informed so that a joint effort is made toward water quality control, good results may be obtained. However, the research department is often times well removed from the location of the operation, and this separation lends to poor coordination in getting a job done. In addition, most of a research department's time is devoted to pure research so that cooperation with the engineer is neglected. If the research department submits desk-derived theories and recommendations to the engineer, little useful knowledge or real help is being supplied. Other less used or less accessible sources of information no doubt exist. The point is that the engineer usually ends up allocating considerable time procuring what

amounts to unorganized and incomplete water conditioning information. This step falls into the pattern as one of the poor routes mentioned in the original analogy.

Therefore, economic nearsightedness and lack of information have considerable influence on the difficulty with which the destination of good water quality control is reached.

At this juncture, troubles can and usually do exist, though they may not necessarily be recognized until they are out of hand. Analogically, the driver (operator, engineer) is lost or has encountered a dead end; and to get back on the main highway to the objective of effective water treatment, he must back track, take short cuts, or pursue side roads.

MISGUIDED WATER TREATMENT ROUTES

The overall pattern progresses by one of the following paths:

No Treatment

This path abandons the journey by rationalizing about the destination of good water quality control: "You can not get there from here."

With no treatment and under the premise that induced or inherent water troubles are present, the operator may open the door to any of the multitude of problems that water envelops.

Semi-Treatment

This category implements two faulty treating practices. The first is treating for one problem and not another; the second is introducing problems by way of a treatment.

Mechanical treatment such as filtration is often only half effective because it amounts to semi-treatment. Filters may operate efficiently, but results may be ineffective because water is unstable at the point of filtration. This situation can occur during the filtration of waters containing both soluble iron and oxygen. And after filtration there is a continued reaction between iron and oxygen to form rust-colored, suspended, hydrated iron oxide.

The same effect occurs when filtering a water that is unstable to the deposition of iron sulfide. Again, the reaction between soluble iron and sulfide ions continues after filtration to form black iron sulfide. Hence, filtration is not serving the purpose for which it was intended: it is only half effective.

It frequently happens that filters are installed at a project only to be by-passed or abandoned because of sub-par performance. Ordinarily, inefficient filtration in graded bed filters is caused by cementation, channeling, oil coating of the media, or the like; or in the cases of diatomaceous earth filters, ineffective filtration can be due to poor precoating, improper slurry feed, etc. Thus, loss of money caused by abandoning a costly piece of filtering equipment is actually due to a lack of consideration for problematic characteristics of the water. Also, protection and maintenance procedures most conducive to satisfactory filter operation are neglected.

One case of semi-treatment may be offered which incorporates several faulty facets.

An operator realized the need for filtration by visually observing or "eyeballing" a source water sample which turned black on standing. Because of this reaction, a graded bed filter was installed, but did not prove adequate, and the same blackening of .he water occurred after filtration.

About the same time, full attention was demanded for leaks experienced in unprotected distribution lines. To inhibit corrosion, a continuous chemical feed was initiated prior to filtration. However, it happened that the corrosion inhibitor used was only partly soluble in the source brine; and as a consequence, the media became coated with the insoluble, gummy portion of the inhibitor. So in a short time the filter was plugged and not able to be backwashed.

Here the operator back tracked, but not far enough. The filter media was replaced and the same inhibitor was added after filtration. But this move was inconsistent, for if the inhibitor were filterable as shown, why should one risk experiencing the same effect at a more critical place in the system?

Under these circumstances, plugging of flow lines and intake wells by iron sulfide and/or inhibitor would likely occur. And such was the case.

Upon an investigation of this system, the picture became more complex. The soft inhibitor-iron sulfide flow line scale was found to contain appreciable amounts of calcium carbonate deposition and was also found to be harboring high populations of sulface-reducing bacteria.

Therefore, scaling and plugging were due to at least three major constituents: iron sulfide, inhibitor, and calcium carbonate. Corrosion was caused by acid gas attack accentuated by bacterial action, while anaerobic conditions conducive to bacterial growth were supplied by the inhibitor.

All of the resulting problems could have been anticipated. Corrosiveness of the brine, scale formation with respect to calcium carbonate, instability of soluble iron and sulfide ions after filtration, presence of bacteria, incompatibility of the brine and corrosion inhibitor — all could have been recognized. And once recognized, these troubles could have been more suitably corrected mechanically and/or chemically.

A second example of a misguided route to water treatment in the form of semi-treatment places emphasis on different factors.

The addition of a chemical for pH adjustment in a fresh water system is common and requires careful control. On the other hand, control of pH by chemical addition is more difficult to economically justify in brine problems.

For instance, hydrochloric acid is used to combat calcium carbonate scaling problems by pH control. Such an approach is rarely economical because high carbonate and bicarbonate (alkalinity) contents react with and expend considerable amounts of acid. Therefore, the contribution of a certain degree of buffering character generally inherent in the brine must likewise be considered. The sum of the two can add up to an excessive volume of acid addition necessary to relieve the supersaturated condition with respect to calcium carbonate.

For instance, one could consider a water flood project that maintained air free conditions, employed protected or corrosion resistant flow lines and equipment, and used muriatic acid for calcium carbonate scale control in a single brine source.

The economic advisability of this treatment was questionable to begin with, but scale was apparently controlled in the early stages of the flood. Later, it became necessary to mix with the source water produced water which was a high brine containing over 1000 milligrams per liter of both alkalinity and hydrogen sulfide and which introduced a substantial change in the calcium carbonate equilibrium. Consequently, calcium carbonate deposition began to occur; nevertheless, the volume of acid addition was not changed because the enhanced problem would have required even more acid. This move would have elevated chemical costs considerably above the existing 5 plus mils per barrel.

As if this situation were not discouraging enough, the produced water introduced a calcium sulfate (gypsum) problem upon which the acid had little or no preventive action. The increased corrosiveness of the brine caused by acid addition induced intake well casing corrosion, and consequently an iron sulfide plugging problem of the same wells resulted.

Yet, even though the initial treatment was economically doubtful, was ineffective of its original intent, offered no compensation for an additional problem, and caused another — it was still employed!

Blind Treatment

This malpractice entails treating the results or expected results of a water trouble, rather than the cause.

A basis for the practice is second hand information, i.e., water conditioning action may be taken before or after a problem is encountered. The action pursued rests upon the experiences of a neighboring operator's recommendation or present practice. Another arbitrary prerequisite is that the waters being handled are from the same horizons.

These factors set up blind treatment, and the operator assumes that his problems are the same as those experienced on adjacent projects. After all, the same waters are involved, and the neighbor's chemical treatment seems successful. Nevertheless, some discrepancies exist in this reasoning.

First, the waters may be from the same horizon but may be different in mineral, microbiological, and other characteristics. Any two waters rarely analytically coincide in all of the characters encompassed by the above; thus, differences may exist which render the neighbor's treatment impractical or ineffective in the operator's water.

Secondly, beside inherent differences in the brines, induced problems may result from mechanical variations in handling the waters prior to the application of a chemical.

Thirdly, it is always possible that the neighbor's treatment is not working, a fact that may not be readily apparent for some time if he is not evaluating the chemical. This situation, then, boils down to the blind leading the blind.

As an illustration of some of these ideas, water flooder "A" had a smooth functioning injection program that was successfully administering chemical treatment to the injection brine for a known calcium carbonate instability. It was the practice of water flooder "B" on an offsetting lease to use a soda ash-fresh water solution for corrosion protection between tubing and casing, above packers in intake wells. In following the neighbor's corrosion protection procedure, flooder "A" overlooked two possible complications:

1. Soda ash or sodium carbonate is used for internal treatment of boiler waters primarily to prevent the formation of calcium scales by precipitating calcium carbonate sludge. If the injection brine and the treated fresh water were comingled, a precipitating action would be expected.
2. The area had a questionable history concerning swelling clay problems, so that, if clays were present, a fresh water of high sodium and pH values could likely stimulate a plugging clay problem.

Flooder "A" pulled one intake well for the purpose of cleaning sand from perforations, and the soda ash fluid was circulated. Immediately after this well workover, injection rates dropped to one-fourth of those prior to pulling operations.

Since the intake well already showed an injection rate decline, it was felt that an acid treatment would be beneficial if the problem were that of calcium carbonate deposition. Also, if the problem were because of an aggravation of a swelling or mobile clay condition, acidizing would not implicate any additional congestion.

As it happened, acidizing relieved the situation. However, had it been a clay problem rather than an acid-soluble scale deposition, irreparable damage would likely have occurred. Then workover treatment would have been of a trial and error nature and a costly operation and still might not have alleviated the situation.

Because all intake wells used the same downhole corrosion inhibitor technique, similar results could be predicted when ever the other wells underwent pulling operations. Therefore, considerable risk was taken simply by implementing blind treatment.

Over-Treatment

This category could be explained as making a wrong turn after once being on the right track and is the counterpart of semi- or under-treatment. The basic idea in the process of over-treatment is "If a little bit is good, a lot must be better," but such a water conditioning philosophy admits some technical lapses.

Most chemicals are designed to perform a specific function in a definite dosage range. Some can incorporate two- or three-fold puposes, but still work best in an optimum feed span. Operating below this range will yield poor chemical performance, i.e., it will not give desired results. This point was inferred in the discussion of semi-treatment, while the other extreme, over-treatment, effects a chemical waste, an unnecessary expense.

Further, chemical solubilities can be exceeded; corrosiveness can be accentuated; and scale deposition can be enhanced. Thus, the whole water conditioning picture can be worsened simply by over-treatment.

Unevaluated Treatment

An original assumption made was that at the beginning the motorist chose an unlikely route to successful water conditioning practices.

Most of the aforementioned misguided treatments exhibited one glaring error after the first mistake of not anticipating troubles, and none evaluated the effectiveness of the treatment used. For example, the addition of a corrosion inhibitor does not insure corrosion protection. And neither does the application of a scale preventer automatically minimize scale deposition.

A chemical may not be working because it is the wrong chemical for a certain purpose, because it is incorrectly applied, or because the water characteristics change. However, whatever the reason, a performance evaluation can reveal the job the chemical is doing and can aid the operator in regaining a more successful treating program. Treatment evaluation is a necessity even when the operator has taken a desirable water conditioning path from the start.

CONCLUSION

The evolution of poor water conditioning techniques has as its bases the economic squeeze and a dearth of knowledge of the subject. Unfortunately for the operator, these two factors eliminate the best course for water conditioning: anticipating potential problems, treating for them, evaluating the results, and maintaining a satisfactory control program.

But, because of these factors and because one must contend with water problems, innovations must be made. The result then is the evolution of poor water conditioning programs such as no treatment, semi-treatment, blind treatment, over-treatment, and unevaluated treatment.

Discussions are not intended to imply that all the mentioned treatments are without merit. Neither do they mean to convey the idea that the solution to water problems is always obvious or a cook book procedure in which all the answers are known.

Neither is true.

To second guess specific treatments is unnecessary. It is the foundations for these practices which are questioned. In the oilfield there commonly exist breeches of proved, established water conditioning practices — practices which can and should be fundamental steps toward attaining water quality control.

Poor water treatment programs pacify no problem.

Without recognition of a problem, without knowing its cause and extent, without reckoning a treatment approach with a purpose, without evaluating that treatment, where is there room for attaining the objective: a satisfactory treating program?