Handling Operating Problems

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For discussion purposes: handling operating problems has been divided into 4 topics (1) Injection system, (2) produced water system, (3) record keeping and (4) costs. In actual operation of a water flood the 4 topics are inseparable.

INJECTION SYSTEM

Principal handling problems in the water injection system are corrosion of the metal surfaces and plugging of the injection wells. The former often is the more difficult and costly problem.

Corrosion

Corrosion of metal surfaces can be stopped or at least retarded by 1 or more of the following 6 methods.

1. Separation of the corrosive water and the metal by use of cement or plastic linings as physical barriers. The most economical application of lined pipe is in systems with a high injection rate per well.
2. Addition of chemicals (corrosion inhibitors) which will provide the required physical barrier in separating the corrosive water and the metal. The most economical application of this method is where the condition is reverse of that for No. 1, that is, where a large number of low injection rate wells are involved.
3. Alteration of the chemical makeup of the water. Removal of dissolved oxygen or hydrogen sulfide are examples of this type of corrosion control.
4. Reduction of bacterial activity in those cases where the organisms are producing significant quantities of sulfide. Bactericide treatment usually is applied as the remedy but physical changes which may be an economical supplement or even replacement for the bactericide treatment often are overlooked or ignored.
5. Electrically reversing the flow of current at the anodic locations on metal surfaces (cathodic protection). This is a practical means of reducing corrosion inside steel tanks, filter shells and on the outside of buried pipe. The required current can be supplied by installation of sacrificial magnesium anodes or by rectifier installations depending upon which is more economical for the particular application.
6. Substitution of noncorrosive metals or other materials for steel. This is commonly done in pumps, valves, meters and low pressure piping.

All the foregoing 6 methods should be considered in each water flood. If all possibilities are not examined, the operator will be inviting uneconomical or higher than necessary corrosion control costs.

Plugging

Reduction of injection rate or increase of the injection pressure can be caused by screening out of suspended solids from the injection fluid at the sand face in the injection well bore. However, plugging in the producing wells and normal buildup of reservoir pressure also can cause increased injection pressures. It must not be concluded that plugging in the injection well bore is taking place simply because injection pressures are rising. Significant plugging occurs only in the vicinity of the injection or oil well bores, not in the formation between wells. Injection well bore plugging may be caused by one or more of the following items:

1. Mixing of 2 or more chemically incompatible waters on the surface prior to injection. Solution to this problem may be either separation of the waters or application of chemical treatment.
2. Chemical instability in 1 water. Precipitation of calcium carbonate and/or iron compounds is the most common problem encountered.
3. Accumulation of corrosion products, either iron sulfide or iron hydroxide. This is closely related to water stability.
4. Organic growths and slime materials. Organic materials rarely are the primary cause of plugging, but they may contribute to plugging caused by other materials.
5. Oil carryover. Oil from the produced water often acts as a binder for precipitated solids. This is especially true in the case of iron sulfide precipitation. The combination of iron sulfide and oil probably is the worst plugging agent normally found in water flood operations.

The numerous types of plugging materials and the big variety of causes for plugging should make it obvious that filtration is not necessarily the most economical solution to a plugging problem. Many oil field waters can be injected without filtration with only minor treatment. If suspended particles are small enough to require diatomaceous earth filtration for removal, they are small enough in many cases to enter the formation without significant plugging.

PRODUCED WATER

Reinjection Versus Disposal

Mixing of produced water with the makeup water may create 1 or more of 3 problems:

1 Oil contamination, (2) chemical incompatibility and (3), if the makeup water is fresh, bacterial instability. As mentioned earlier, oil contamination usually is not a problem unless significant suspended solids are present. Some types of chemical incompatibility problems can be solved economically with chemical treatment if they are not too severe. Included in this group are the mineral scales, calcium carbonate, barium or calcium sulfate. Others, such as iron sulfide or iron hydroxide, cannot be controlled economically by chemical treatment unless the rate of deposition is very low.

Of the 3 problems which may be created upon mixing of produced water with a fresh makeup water, bacterial instability often is the most difficult to control. The most severe sulfate reducer problems usually occur in fresh-salt water mixtures. These bacteria produce considerable hydrogen sulfide causing pitting type corrosion and/or iron sulfide plugging.

Corrosion

The operator has no selection of waters in the oil gathering system. He must handle all of the water produced with the oil. Corrosion protection must be derived from chemical treatment, protective linings or from use of corrosion resistant materials. Economics permit higher concentrations of corrosion inhibitors than those used in injection systems. Proper application is as important as selection of the proper chemical.

Hydrogen sulfide is the principal cause of severe corrosion in water flood oil wells.

Plugging or Scale Deposition

Precipitation of solids at or near the sand face in oil wells generally is not a problem. When it is encountered it probably will be most severe at the beginning of water breakthrough. It tends to diminish with increased production of the injected water. One exception to this is iron sulfide precipitation caused by bacterial activity. Sulfide production generally increases with time, causing an increased rate of iron sulfide precipitation.

Downhole chemical treatment is not effective in restoring productivity which has been reduced by scale deposition on the sand face. Acidizing often will provide temporary relief but a frac job with a sand-polyphosphate mixture generally will restore productivity for a much longer period.

A polyphosphate frac job may also provide considerable protection from scale buildup on equipment in oil wells and in the flow lines. However, downhole treatment will provide the same protection more economically and it should be used when scale is depositing on the equipment but not on the sand face.

RECORDING KEEPING

Water treatment and corrosion records are as essential for solving water handling problems as water injection and oil production records are for the intelligent operation of a water flood. Good records are essential for evaluation and control of costs of water handling. Types of records and some of the details needed are as follows:

Chemicals Used

Names of all chemicals, dates started and stopped and concentrations used should be recorded. Treatment location and method of application also are needed.

Injected and Produced Water Rates

Injection rates are required for determination of chemical dosages. Details which should be available to the water treatment engineer include rates of water production for each supply well, method of supply well operation -- that is, continuous or intermittent supply well completion data, produced water rates from the oil wells and injection rates and well head pressures for each input well.

Test Records

Required frequency of water quality testing may range from daily testing to perhaps twice per year depending upon the objectives and urgency of the problems. Water analyses, membrane filter, bacteria and corrosive coupon test results should be followed closely to evaluate water treatment and control. In some cases data should be plotted graphically.

LEAK RECORDS

Recording of leaks or other corrosion failures is an extremely important and often neglected part of record keeping. A chronological record should be kept of all surface line or injection well tubing failures with notations as to the type of corrosion (sharp edge pitting or broad, general corrosion). It also is important to know and to record whether the corrosion attack is from the inside or outside surface.

Similar records are needed for the oil wells. Casing, tubing or rod failures should be recorded.

Leak records should be started from the inception of a water flood. They can be kept by lease personnel so they are relatively inexpensive but they provide invaluable information to the corrosion engineer.

COSTS

All decisions for water handling problems ultimately must be based on estimated costs for the various alternatives. It may be necessary to estimate costs for a period covering the entire future life of a flood, so reliable predictions of future conditions should be obtained.

Corrosion Treatment Costs

In some cases considerable effort is expended in deciding which corrosion inhibitor should be used without adequate investigations as to whether an inhibitor should be used. Costs of living with the corrosion should be compared with costs for chemical treatment and with alternatives such as using protective coatings, modifying the corrosive characteristics of the water or changing water sources.

In some cases corrosion is caused by bacterial activity Decision to treat or not to treat with a bactericide must be based on probable future corrosion damage. Consideration should be given to corrosion inhibitor versus bactericide treatment costs or a combination of the 2.

Costs for Prevention of Plugging

When filtration is required, suspended solids are most economically removed by graded media filters. Installation costs may be approximately $1 for each BPD of injection capacity with operating costs of about 0.5 mill per bbl.

Installation costs for diatomaceous earth filters may be 2 to 5 times higher and operational costs may range up to 5 times higher than those for graded media filters.

Filtration costs are significant enough that filters should not be installed as "insurance".

Produced Water Handling Costs

The most economical method of handling the produced water should be selected by comparing estimated costs for the 3 methods:

(A)	(B)	(C)
Makeup and Produced Waters Mixed and Injected Together into the Oil Reservoir	Makeup and Produced Waters Injected Separately into the Oil Reservoir	Makeup Water Only Injected. Produced Water Disposed of Separately
1. Treatment costs for mixed waters.	1. Treatment costs for each water. 2. Additional equipment and labor costs for separate systems.	1. Treatment cost for makeup water. 2. Cost of additional makeup water equal to cumulative volume of produced water. 3. Disposal system, installation and operating costs.

Although there are many exceptions, method (A) often is most economical for small floods. Method (B) usually is best for medium or large fllods. Method (C) will be most economical in special cases where quality of the produced water is very poor and separate disposal formation or other disposal facilities are readily available.