Treating Water for Water Floods

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INTRODUCTION

The purpose of this paper is to give a general report of water treatment as it applies to secondary oil recovery by water repressuring. It is not meant to be technical but rather informative, explaining the general considerations to be given to the treatment of water. It is also meant to assist in coordinating the efforts of the different departments involved in the planning and operation of a water treating system.

PURPOSE OF WATER TREATING

The purpose of water treating is to prepare the available water or waters to make them the least destructive to equipment, and to yield a water of optimum clarity, compatibility, and stability at the face of the formation in the injection well. It is necessary to contend with extremely varied circumstances from water to water; consequently, each water is an individual problem. A majority of these circumstances require physical and/or chemical treatment of the water, but every effort should be made to minimize the necessary treatment and still accomplish the ultimate goal. The initial construction of the treating plant should be based on the chemical and biological characteristics of the water but designed in such a manner so as to allow adjustments to obtaining maximum efficiency from the treating procedure. This also allows for adjustments when and if any changes occur in the water.

Compatibilities

A major consideration that should be investigated thoroughly at the onset of a water treating program is that of compatibilities. This term refers to the absence of any detrimental development as a result of mixing two materials. This includes two or more sources of injection water; the injection water and the medium of the formation into which it is to be injected; the water and gas or oil seals to be used; the water and the chemicals to be used; and the chemicals, if more than one is to be applied.

The most common incompatibilities encountered between two waters are the subsequent combination of hydrogen sulfide and a soluble metal, oxygen and hydrogen sulfide or a soluble metal, and barium and sulfate. These conditions can best be identified by laboratory procedure, but in many instances field observations will result in the detection of an undesirable incompatibility. These usually show up in the field in the form of black water, rusty water, gyp deposits, overloaded filters, plugged screens, significant decrease in injection rates or increase in pressures, and other less obvious conditions. These situations can be corrected, in most instances, by some method of treatment if the condition is detected early in the planning of the treating system.

Types of Water Systems

There are two general types of water systems which are usually referred to as "closed" and "open". The closed system is designed to eliminate all oxygen contamination from the air. Traces of oxygen are not always significantly destructive, but can be extremely detrimental in some systems. Therefore, it is vital that a closed system be maintained under very close observation. Many other factors must be considered in the decision of complete enclosure. These include such items as nature and amount of turbidity in the raw water, incompatibilities, oil content, chemical stability, and bacterial activity.

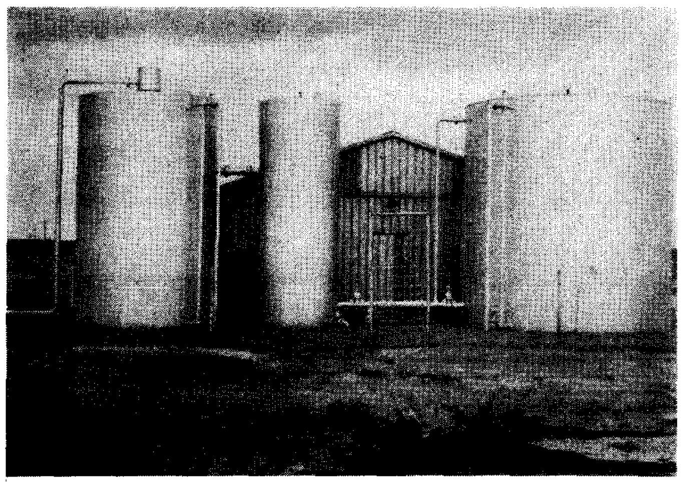

Fig. 1 CLOSED SYSTEM

If the closed system can be effectively utilized, it is usually more desirable from an economical standpoint. Corrosiveness of a water often can be vastly reduced by handling it through a closed system. This is not meant to indicate that oxygen is always corrosive; aeration is actually utilized to prevent corrosion in some instances. Essentially the same conditions must be given an open system as is given a closed system. The nature of these considerations is the major guiding element in making a choice between systems. Aeration is often required to accomplish reasonable filter runs, effective sedimentation, stabilization of incompatible waters, cooling, and many other less significant treating advantages.

The deposition of destructive scale in a treating system can usually be detected by laboratory and field testing, but the most effective detection is by periodic inspection of equipment. Scaling tendencies by water are not always obvious until the scaling has proceeded to the extent of causing damage. The periodic internal inspection of lines, tanks, and other equipment will almost always identify significant scaling before it

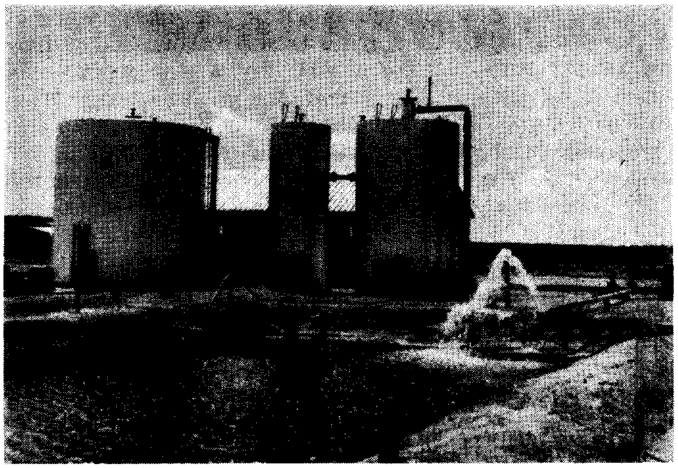

Fig. 2 OPEN SYSTEM

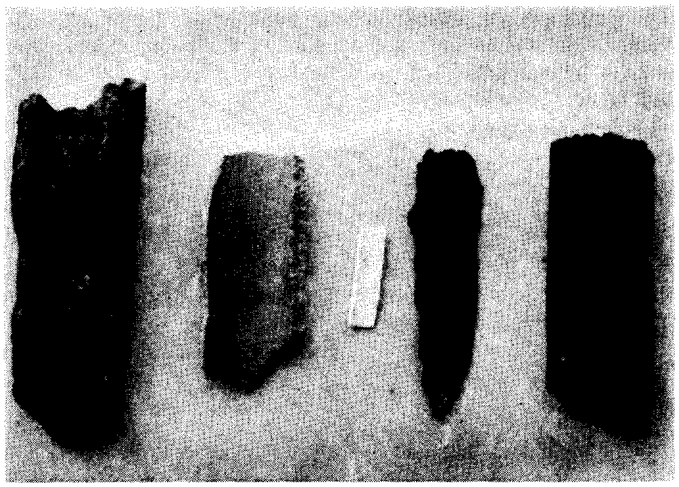

Fig. 3 VARIED SCALES

has proceeded to the extent of requiring physical or chemical removal. Scale can almost always be effectively prevented by chemical and/or physical treatment. Therefore, it is vitally important that field personnel set up an inspection program, especially at the onset of a project or when a new water is added to a system.

Corrosion is inevitable to some extent when a metallic surface is exposed to water. The degree of corrosion determines the necessity of preventive or control measures. It is, therefore, vital to a water treating program to have a routine of continuous determinations of the extent of corrosion in a water system. All personnel affiliated in any way with a water injection system can play a significant role in corrosion detection. The field personnel and the laboratory can combine their efforts in the installation of corrosion coupons and test nipples to determine the extent of destruction of these supplementary metal surfaces. It is important to obtain accurate initial and final weights, but it is actually more important to obtain proper installations and accurate records in the field.

The use of iron as an indicator is a significant application in corrosion detection. This indicator is used by determinations of increasing iron as the water progresses through the system, iron contents of line flushings and back flowed injection wells, and iron content collected on wellhead filter elements. Other conditions must be taken into consideration in utilizing this indicator; volume of water, exposed metal surfaces, and content of raw water, for example. These can be combined to give invaluable supplementary information to the other detection procedures. Another invaluable program in corrosion detection is inspection of the condition of equipment and the maintenance of accurate records of failure of equipment. There are other methods that are also used, such as electrical instruments. The above steps are primarily taken to give confirmation of the indications revealed by analytical records of the chemical and biological condition of the water.

Protective Linings

Some changes have been made in recent years in the general practices of corrosion prevention. Protective linings are becoming progressively more common and effective in the prevention of corrosion. There is also more common usage of nonmetallic equipment to avoid the corrosive tendencies of water. The application and installation of protective linings is extremely vital in the use of this preventive measure. Many failures of linings, which have been accredited to the ineffectiveness of these practices, have actually been caused by incorrect methods and careless installation. More recent developments have eliminated many of the causes of failure.

The application of inhibitors has accomplished very satisfactory results in many treating systems. However, evaluation of the inhibitor before and after application should be carried out with extreme care. Many of these compounds are not satisfactory, as they fail to adequately protect against corrosion and/or result in secondary detrimental effects. Some of these effects are gumming of filters, accelerated bacterial growth, and separation from the water. A few of these compounds show desirable effects against the activity of sulfate reducing bacteria but are commonly ineffective against the control of aerobic bacterial growth. The capacity of effective inhibitors has been known to reduce corrosion rates by as much as 97%.

A water which has the necessary chemical characteristics can be made to deposit a thin protective scale. This is usually accomplished by controlled aeration and/or chemical treatment, of which there are various applications. Some waters can be made to deposit this protective scale by controlled caustic soda treatment. These types of applications must be very carefully controlled to avoid undesirable secondary developments. The control of this treatment can be assisted by the routine scale inspection. Properly controlled application can almost entirely eliminate the corrosion of equipment. More rigid control of this type treatment is necessary when the injection wells take water on a vacuum over a long period of time.

The most thoroughly studied bacteria in relation to corrosion are those groups commonly referred to as sulfate reducing bacteria. These organisms produce hydrogen sulfide as a product of their life process. They are also considered by many to be responsible for aggravating corrosion in a water that naturally carries a high hydrogen sulfide content. They accomplish this by utilizing hydrogen and, thereby, accelerating depolarization of the corroded surface. This results in a more accelerated corrosion cycle. These organisms are especially destructive in lines and tank sediments. Inspection reveals this as a local corrosion on the bottom of lines and tanks. The control of these organisms is accomplished by chemical treatment, the nature of which is dependent on the chemical characteristics of the water. The activity of other bacteria in corrosion is controversial, but work that has been done on the subject is very limited.

Though water is the universal solvent and is always corrosive to some extent, it should not be taken to mean that these waters are always significantly corrosive. Many water plants operate very satisfactorily with no protective linings or corrosion prevention measures. However, in planning, the lining of equipment should be very carefully studied, especially if there is any possibility of using different waters in the system.

INSOLUBLE PLUGGING

The insoluble plugging constituents in a water are referred to collectively as turbidity. This is reported in terms of parts per million. Though there is an extreme variation in the requirements on different floods, a rule for explanatory purposes would be that a turbidity of 1 ppm is completely satisfactory; whereas a turbidity of 20 ppm would be very undesirable. The detection of turbidity and other potential plugging conditions is primarily the task of the water control laboratories. However, the existence of these destructive conditions can very readily show on injection rates and pressures and, thereby, be detected by field and engineering personnel. The identification of the causative condition is the responsibility of laboratories, but the corrective measures applied require the coordinated effort of all concerned with the water system.

The correction and control of potential plugging characteristics of the injection water is closely interwoven with all aspects of its treatment and handling. The major detrimental aspect of corrosion is its plugging capacity when the products of corrosion are insoluble. The corrosion control methods must also be studied for possible secondary plugging effects.

The choice of an open or closed system is closely related to the control of the plugging potentials of a water. Iron often enters into this choice by virtue of the fact that naturally soluble iron compounds can drop out of the water to form turbidity when the water is exposed to oxygen. An example of such a condition was a system which carried a turbidity of 15.2 ppm. The enclosure of this system decreased this to 2.0 ppm. This same system was then continuously treated with citric acid to dissolve the existing insoluble iron and simultaneously assist in retaining the natural iron in solution. This same situation has been encountered where hydrogen sulfide is present in the water. One such example is the reduction of the turbidity from 10.1 ppm to 2.2 ppm by virtue of correcting a faulty closed system.

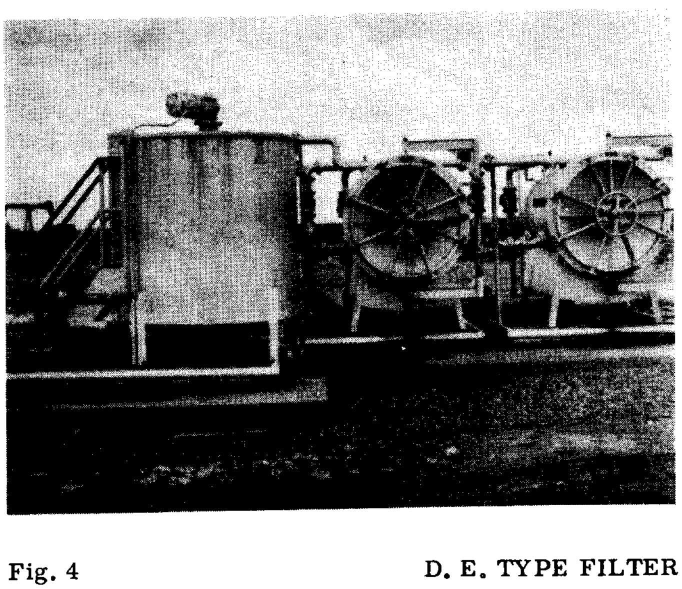

Fig. 4 D. E. TYPE FILTER

Systems which are closed to control such conditions must be watched very closely to insure a complete and effective seal at all times, as even the very slightest periodic air contamination can cause extensive damage. Other situations are encountered in which it is necessary to open a system to correct its potential plugging capacity. This is necessary, for example, when two different incompatible waters are mixed or when the water used carries a natural turbidity that is adequately corrected only by oxidation and sedimentation.

The safeguard and/or correction of existing turbidity is assisted, if not completely accomplished, by filtration. The necessity of filtration is a factor which is relative to many conditions. Some of these are permeability of the formation flooded, the amount and nature of turbidity in the injection water, and the nature of the injection program. A salt water disposal system, for example, can often function satisfactorily without filtration; whereas, the same water would require much more critical treatment and filtration for a secondary recovery project. In cases where a filter would be heavily loaded by the insoluble components of the water, it is often found necessary to precede the filtration with any one or a combination of degasification, aeration, flocculation, sedimentation, and chemical treatment.

Types Of Filters

There are several different types of filters effectively utilized on water flood projects, but they are generally divided into either the sand and gravel type or the diatomaceous earth type. The wellhead filter has more recently come into common and effective useage. It is used most often to supplement the water plant filter in assisting in clarification as the water enters the injection well. However, it has other uses, such as safeguarding against the detection of filter failures and as an indicator and gauge of other undesirable developments in the water system. The choice of a filter on a specific project must include considerations of the physical nature of turbidity, degree of clarity required, and the probable efficiency of maintaining the filtered quality of the water to the face of the formation to be flooded. The D. E. filter gives the better quality effluent if the turbidity particle size is very small; but a reasonably similar quality is obtained with the sand and gravel type filter if the turbidity particle size is medium to large.

The most important factor in a filtering system is the maintenance and efficient operation of the filter. The specifications given by the manufacturer should be carried out in detail after they have been established by the initial operation of the filter. Even slight variations in the operation and maintenance of a filter can often render it useless, and the resulting destruction may not be detected for a long period of time unless rigid water control is being practiced.

A more recent development in the determination of the plugging capacity of a water is the actions of bacteria and their products. Plugging by bacteria and their slime is not readily reflected by injection rates or pressures. It is also not detected by chemical and physical analyses of the water unless the condition is extremely bad. The operation of an injection water system will typically change slowly and, thereby, not clearly indicate the difficulty unless records of bacterial counts are available. If these organisms are not controlled, they will often clog lines, valves, bypasses, and tubing and be very resistant to pressure, due to the sponge effect of the masses. These conditions result in long periods of unchecked growth, and the control of the organisms is especially difficult once they have developed into massive numbers. Control is usually attained by either slug or continuous chemical treatment. Control can also be attained or assisted by physical design of the plant. It is especially important that the continuous chemical treatment be applied in effective amounts and with a minimum of interruption. The longer inadequate or inconsistent treatment is applied, the more difficulty will be encountered in regaining control.

The bacteria that plug by virtue of their masses primarily occur in open systems or contaminated closed systems. In fact, periodic oxygen contamination, not detectable by chemical analysis, can sometimes be detected by bacterial activity. The organisms can often be effectively controlled by accomplishing complete enclosure from atmosphere and/or treating with a chemical oxygen scavenger. This latter application is a very sensitive chemical treatment and must be closely controlled to obtain both the desired results and to avoid secondary detrimental effects. Where oxygen extraction towers are utilized, steps must be taken to avoid slime clogging of the tower in the section where oxygen is still present. The above is not meant to suggest that all waters will support significant bacterial growth, as some waters will give no trouble in this respect. However, the absence of significant counts does not mean they will not adapt to the water and increase in activity. It is impossible to predict this from chemical analysis; consequently, periodic bacterial counts should be made for confirmation control.

There has been considerable controversy as to just what is the most important factor in a water treating system. An extremely important factor, if not the most important, is that of coordination of effort. Management, engineers, operating personnel, and laboratories each play a vital role, but the coordinated effort between each of these is absolutely necessary to attain the ultimate goal in water treatment.