Treatment of Water for Subsurface Injection

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Subsurface injection for disposal of produced water and for water flood operations is an increasingly common practice in the oil industry, and many of these installations will be made in the future. An important phase of production operations is waterflooding in which water is injected into selected wells of an oil bearing formation to force the oil toward producing wells in that formation. This appears to be a simple operation, but actually there are complications which arise; these complications frequently may be traced to the quality of the water which is injected. Since more wells are subject to plugging, water quality is usually of more concern in the operation of a waterflood than in most saltwater disposal systems.

Water quality is determined according to several factors which must be considered. These include the kind and amount of suspended solids, the corrosivity of the water, the types of bacteria which may be present, the compatibility of the injection water with formation water, and the scale forming tendencies of the injection water.

Tests are made of the various water sources and combinations of water which will be handled in the field installation. After the water characteristics have been determined, it is possible to properly select equipment and treating procedures to obtain the lowest handling cost for the particular water or combinations.

Compatibility is one of the earliest characteristics to be tested. The mixing of injection water with water present in the oil formation may cause a reaction which would plug the injection well beyond repair. If a positive cure could not be provided economically, this water may be used; but its use would result in conditions not desirable in production operations.

Corrosion in waterflood operations (1) not only causes higher maintenance and replacement costs in surface equipment, but the products of corrosion may cause irreparable subsurface damage to the injection wells in the field. Coupon tests or corrosimeter probes may be employed to determine the corrosion rate of the water; a spark plug test (b) will indicate if pitting type corrosion caused by trace amounts of oxygen is prevalent in the system. The gases dissolved in the water are the main corrosive agents in the water injection systems, and oxygen is a worse offender than both hydrogen sulphide and carbon dioxide. For this reason, gas seals are, wherever possible, employed to exclude air from contacting water in the system. In spite of the best field practices, however, the equipment is still subject to corrosion and usually it is necessary to employ protective coatings on many of the metal surfaces. Satisfactory application of these coating requires diligent attention: the surface needs to be sandblasted to white metal and all sharp edges removed before the plastic can be properly applied. Further, forms such as angle iron supports and brackets should be of corrosion resistant materials since an effective coating can seldom be applies to these configurations.

Other factors which cause corrosion are the use of dissimilar metals, the presence of stray currents, and the occurrence of corrosion concentration cells. Some of these factors may be effectively countered by alert attention during the design of the system and others by the instigation of field measures after the system is placed in service.

The suspended solids that may exist in practically all waters consist of oil, sand, silt, clay, iron oxide, iron sulfide, calcium carbonate, calcium sulfate, barium sulfate, strontium sulfate and various types of bacterial, algae, and fungus growths. Oil is a common substance which frequently must be removed from waters in waterflood installations, and it is good practice to use the best available means to extract the oil from produced well streams. Then a coarse-graded filter or an excelsior packed filter may be used to effect coalecense of oil and removal of large particles with some absorbence of the oil. This procedure will remove oil down to a level of about 10 ppm or less.

Algae and fungus growths usually are limited to open-type systems; the effect of sulfate reducing bacteria has lowered the quality of the water in many closed systems. However, growth of these bacteria may be discouraged by designing a system with a minimum of dead spots, and use of corrosion resistant and internally coated equipment. The use of organic bactericidal inhibitors and chlorine has been effective in controlling this growth in a number of installations

Millipore filter tests are used to determine the plugging characteristics of the water and to facilitate indentification of suspended solids which may be responsible. Data from these tests cannot be converted to an injection rate in a formation, but they are particularly helpful in evaluating the performance of filter aid materials being tested under comparable conditions. This test involves merely filtering the water constant pressure through a disc having an 0.45 micron pore opening. The volume of filtrate is measured at timed intervals, and flow rate data is plotted relative to cumulative volume on semi-logrithmic paper. The slope of the resultant straight line is used as a quality index with the best waters ranging from 0 to 0.25. Waters in the next category range from 0.25 to 0.50 while poor quality is indicated by a slope above 1.25.

Suspended solids are not necessarily an objectionable characteristic in injection waters. Some of the fractured limestone formations are not significantly affected by their presence. Tolerance of the quantity of suspended solids and even to the size of solids is governed strictly by the formation receiving the water. For these reasons, our company uses both the sand-type filter and the diatomaceous earth filters and on some occasions no filters are required.

In the Midland area, water is injected in waterflood installations. A number of these require no filtration of injection water; two of the more sizable installations, however, have required the use of diatomaceous earth filters to insure a tolerable size of solids in the injection waters. One of the installations consists of five 600 sq. ft leaftype filters constructed using 316 stainless steel and completely automated. This plant is currently handling only 60,000 bbls of source well water per day. The water being filtered is brackish, mildly corrosive with two to five ppm of sediment. The filters are pre-coated once a week and little filter aid is required to maintain a high quality of water. The system is completely closed to air from source wells to the injection wells. The plant has never operated to capacity because of an inadequate supply of water and no significant operating problems have occurred. In the near future, the amount of water to be handled at this plant will probably be more than tripled using a highly corrosive water when problems in filtering this water are anticipated.

At the Means waterflood the company is injecting approximately 40,000 BWPD which is being filtered through three 600 sq ft leaftype filters at a maximum of one GPM/sq ft. The filter shell is plastic coated and screens are 316 stainless steel construction. The water being filtered contains variable amounts of suspended clay, iron bacteria, and sulfate reducing bacteria. Filter aid capable of removing suspended solids down to one micron in size is used. Shortened intervals between required precoating of filters were experienced after the first few months of operation. Bacteria counts of water from source wells and throughout the gathering and injection system showed sulfate and formation of iron sulfide in filter cake causing increased pressure differential. Also, iron bacteria growth in some of the wells was causing more than the average amount of suspended solids in the water; but periodic chlorination of source wells and addition of HTH to filter aid slurry have prevented the bacterial growth in cake and nearly doubled the filter cycle.

Other problems were experienced in the operation of these filters. A wide variation in flow rates, which is characteristic in most waterflood operations causes uneven buildup of filter cake and shortened filter precoat cycles. It appears quite necessary to use a flow controller on each filter, and a flow indicator to facilitate adjustment is also desirable. Also inadequate flow distribution inside the filters has caused uneven buildup and erosion of the filter cake, and to minimize this problem the use of a flow distribution box inside the filter is being tried.

Plugging of the filter jets with asbestos fibers during precoating also was experienced. It was found that this condition could be alleviated by holding, with the use of a special piping arrangement, the level of the circulating slurry several inches below the jets.

Protective coating on the inside filter shells has required replacement and could have been prevented by proper application as previously discussed.

Filter cake accumulations during backwash were not adequately carried away. To more effectively clean the filter shell on backwash, water jets have been installed at bottom door end of filters and has worked quite well.

Excessive repair to slurry proportioning pumps has been experienced and the use of a jet eductor mixing method is to be tried on some future installations.

Experience with diatomite filtration for conditioning water for flooding has proven quite satisfactory to give the quality of water desired. And since it would be desirable to reduce the costs of installation and operation of these type filters for oil field use, the use of the plastics in construction of filter elements may be a one step to this objective. In the oil field, the filters with decorative effects are not needed, but functional properties are all important.

In our waterflood operations a diatomite filter is needed that will operate without a great amount of attention. Long filter cycles are necessary and failure of equipment needs to be reduced to an absolute minimum. Filters should be designed against corrosion and mechanical failures, and operational features should include a flow controller and method of effective sluicing and precoating.

In the design of a system for subsurface injection it is essential to have factual data on the water to be handled and to employ good practices in process selection and equipment arrangement. This will be a forward step in obtaining a good quality of water.

Maintenance of good quality water requires vigilant attention to system operations with a close surveillance on the water through periodic tests. No two injection systems are exactly alike, and many are subject to changing conditions particularly when waters are mixed, as in the reinjection of more produced water; therefore the need for effective policing of these systems cannot be overstressed.

Bibliography

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