PRODUCED WATER MANAGEMENT

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ABSTRACT

In the early days of the oil industry, producers were in the oil business. In today's oil industry, producers are in the produced water management business. The emphasis has changed primarily because the majority of the produced fluid is water.

This paper will deal with one major challenge facing the oil industry today - produced water. Handling produced water is costly; however, by employing good produced water management, additional revenue can be derived. This presentation will include the following: "Evaluating Present Water Equipment," "Internal Tank Designs," "Method of Skimming," "Salable Oil," and "Treating Reclaimed Oil."

INTRODUCTION

Studies indicate that there are over seven billion barrels of produced water per year, compared to less than three billion barrels of oil per year. If the average produced water has an oil carry-over of over 150 ppm and a solids carry-over of approximately 70 mg/l, over one million barrels of oil are lost annually. Although this is a tremendous loss in revenue to the industry, the cost involved in the 53 kilo tons of solids per year which are injected or disposed of creates an astronomical expense. Through proper produced water management techniques, over half of this oil could be salvaged and sold, thus providing immediate additional revenue. The problem faced by the industry, however, is not only in recovering salable oil, but in effectively reducing the tons of solids which are creating additional expense in waterfloods and disposal systems. This paper will address some of these problems and the methods involved in solving them.

Benefits derived as a result of reduced solids include the following: (1) improved effectiveness of a waterflood program, (2) decrease in chemical costs in a water system, (3) reduced expense in disposal well cleanout and injection well workovers, (4) increased effectiveness of tertiary recovery programs, and (5) elimination of permanent formation damage.

Increased Profits through Reclaimed Oil

Produced water management can increase profits through additional salable oil and decrease expenses on injection well workovers. The expense involved in the workover of injection and disposal wells continues to rise. In some cases, the expense in water well workovers exceeds the expense in produced well workovers.

Properly and effectively managing produced water involves three basic steps: (1) evaluating present equipment, (2) internal tank designs, and (3) skimming and treating reclaimed oil.

EVALUATING PRESENT EQUIPMENT

In initiating equipment evaluation, a flow diagram of all equipment in use is a necessity. Sample points should be installed at water outlets of all equipment such as free-water knockouts, oil treaters, and water-treating equipment. Samples should be obtained at all water outlets throughout a system in order to provide background information over an extended period of time. Analyses run on these samples should include ppm of oil to determine the amount of oil carry-over, and millipore filter analysis to determine the amount and type of solids carry-over. Reviewing these analyses and visual inspection of water samples can be a tremendous asset in evaluating the equipment presently in use. In some instances additional retention time, if needed, can be obtained by adding baffles to the free-water knockout.

Water-Treating Equipment

Most water systems are equipped with water-treating tanks for oil/water separation. The primary water clarification process begins here, and acceptable water quality can be obtained, provided water-treating tanks are operating at peak efficiency. Additional equipment such as filters, wimco units, etc. are often used to "polish" the water in its final stages of preparation for injection. The performance of the polishing equipment is directly related to the effectiveness of the water-treating tanks.

The majority of problems encountered in water clarification will occur in the water-treating tanks. Lack of retention time is the number-one problem in a water-treating tank. Basically, two factors contribute to this problem -- <u>overloading the tank and inadequate internal tank design</u>. In most cases, redesigning the tank internally will drastically improve the retention time and may alleviate the need for additional equipment.

Once the tank size and produced water reach a point exceeding a 1:5 ratio, turbulence within the tank will increase, dead spots will become more prevalent, and acceptable water quality may be difficult to obtain. There are exceptions, however, depending on the quality of water entering the tank and the amount of solids and free oil present in the incoming water. The author knows of one 10,000-barrel tank handling 190,000 barrels of water and the system is operating within acceptable ranges.

Retention Time

Retention time is a measurement of the length of time it takes for produced water to go from the inlet to the outlet of a water tank. Normal practice to determine retention time has been to monitor the amount of fluid going through the tank versus tank size. This practice, however, does not take into account the flow of the fluid going through the tank which is related to the placement of the water inlet and water outlet. Inadequate retention time plays a significant role in determining what additional equipment is needed to provide acceptable water and chemical application.

The various methods used in running retention studies basically revolve around injecting a predetermined traceable material ahead of the equipment to be tested. Samples, taken at fixed intervals, will determine the exact time it takes the tracer to travel through the system. Plotting these results on a graph will give some indication of the movement in the system and will help identify dead spots or short currents in the system.

Perhaps the most accurate method of running a retention study is with radioactive tracers. This method can: (1) be measured with a highly sensitive collimated gamma detector which is very accurate; (2) be monitored in the field and can produce an on-site graph which will provide immediate results; and (3) measure retention time without having to gather samples, consequently reducing human error. This radioactive tracer provides the operators an accurate measurement of retention time quickly and on site. It is recommended that a radioactive retention study be conducted before and after redesigning a tank. If so desired, the radioactive tracer can be tagged and injected ahead of the free-water knockout and allowed to follow both the oil and water throughout the entire treating facilities. A complete evaluation of the treating facilities will provide pertinent information on the effectiveness of the free-water knockout, as well as the water-treating tank.

INTERNAL TANK DESIGNS

Tank Design

During the last 25 years, we have experimented with various tank designs, such as baffles, gas rings, tank partitions, and various inlet nozzles. Based on our experience, we advocate two types of designs which are effective and economical.

Figure 1 shows a very popular tank design consisting of a perforated inlet line two-thirds of the way up in the tank and the outlet line two to three feet from the tank bottom. This design has been very effective, but it does have a few drawbacks. The perforations in the line can become plugged if the produced water contains large amounts of solids, and/or has scaling tendencies. Problems could also stem from a low-velocity environment. For instance, if the tank size and produced water have a ratio of less than 1:2, there will be some short currents and dead spots on the tank sides and the retention time will actually be decreased.

Figure 2 shows what is perhaps the most popular and most effective tank design. The inlet is two-thirds of the way up with a 60-degree angle from the inlet pipe directed toward the tank wall, and the inlet line is tilted 14 degrees upward.

The inlet line, directed toward the wall of the tank, will provide greater utilization of the entire tank circumference. The 14-degree upward tilt will direct the flow of the water toward the top of the tank, thus utilizing part of the one-third additional height of the tank. The vortex motion occurring inside the tank will utilize the entire contour of the tank and will provide more retention time with less dead spots. In using this vortex motion design, it is imperative that skimming be done on a daily basis. Should the oil-wet solids and interface build up, the vortex motion will draw this interface down, resulting in unacceptable water quality.

Case History

We were recently contacted by a major oil producer to help provide acceptable water quality in its water-treating system. The system consists of a 10,000-barrel water-treating tank with 190,000 barrels produced water per day. The initial analysis indicated that the problems were a result of high oil and solids carry-over and the accumulation of an excessive amount of oil and interface in the tank. The first course of action was a retention study. Results of the study are graphed in Figure 3. We noticed a breakthrough of traceable material in less than two minutes.

Objective: In evaluating the retention study, the decision was made to redesign the inlet of the 10,000-barrel tank. In reviewing the tank design options, the design illustrated in Figure 2 was implemented. An automatic skimming system was installed as illustrated in Figure 4.

Results: Once the tank was redesigned and put back in service, a retention study was again conducted. Figure 5 is a graph of the retention time which was increased to 18 minutes. Redesigning the tank and installing the automatic skimmer which skimmed on a daily basis, have resulted in additional production of over 11,000 barrels of salable oil annually. Considering the tank/water ratio is 1:19, the results on the tank design were phenomenal and profitable.

In revamping the present equipment, we were able to achieve acceptable injection water and increase profitability inexpensively. This is a typical example of results which can be obtained through produced water management.

SKIMMING AND TREATING SKIMMED MATERIAL

Skimming

Regardless of the retention time, internal design, or water-clarification program used, if proper skimming is not maintained, it will be impossible to have good water quality. The method of skimming and handling of oil and solids can provide a profit if done properly and efficiently.

The numerous methods of manually skimming oil off a working tank require a lot of time and effort on the part of the field personnel. Perhaps the best skimming method available is through a floating oil skimmer as pictured in Figure 4. Regardless of the method used, skimming should be done on a daily basis. During the skimming process, it is imperative that all material floating on top of the water be skimmed. If an interface of oil and solids is allowed to build up, it will eventually result in massive plugging in injection and/or disposal wells.

Treating Skimmed Material

By implementing an effective water management program, the amount of material accumulated for skimming will contain oil, oil-wet solids, and residue from various types of chemicals used in the producing process, such as surfactants, corrosion and scale inhibitors and emulsion breakers. The objective in skimming is to provide the greatest amount of salable oil with minimum expense. Depending on the amount of solids and chemical residue which is skimmed, this material can be put back into the production treating process. Caution: Reprocessing the skimmed material through the production treating equipment can cause severe problems. In most cases, the skimmed material will create an interface buildup in the oil-handling equipment, and will cause water carry-over in the sales tank. The large amount of chemical residue can cause an overtreating effect in the produced oil, and water will be carried over into the sales tank.

Separate Treating Equipment

The most effective and economical method of treating reclaimed oil is through a separate treating process. Depending upon the pour point of the salvageable oil, a heater treater or gun barrel can be put in service in conjunction with several holding tanks to handle the reclaimed oil. By using a separate treating method, the skimmed material is isolated from the regular treating process, eliminating problems in the day-to-day operation of oil treating, and with proper handling, will increase the amount of oil recovered. In some cases, a chemical program may have to be implemented to obtain the maximum salable oil with the least amount of problems.

SUMMARY

Produced Water Management can provide a profit if approached economically and cautiously by following three basic steps: (1) Evaluate water-treating equipment; (2) Redesign water-treating equipment, if necessary; and (3) Skim and sell recovered oil. The profits derived from this approach to water management will: (1) increase profits through sales of reclaimed oil and (2) decrease expenses by reducing plugging materials in the produced water.

ACKNOWLEDGMENTS

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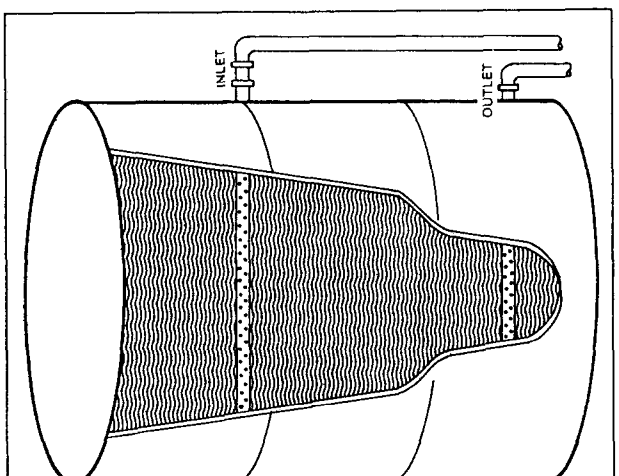

Figure 1

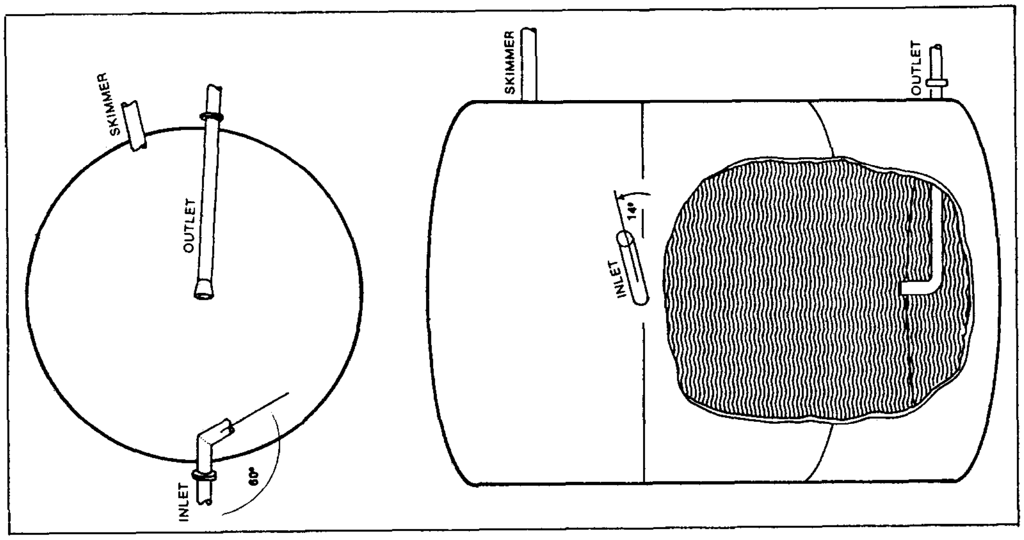

Figure 2

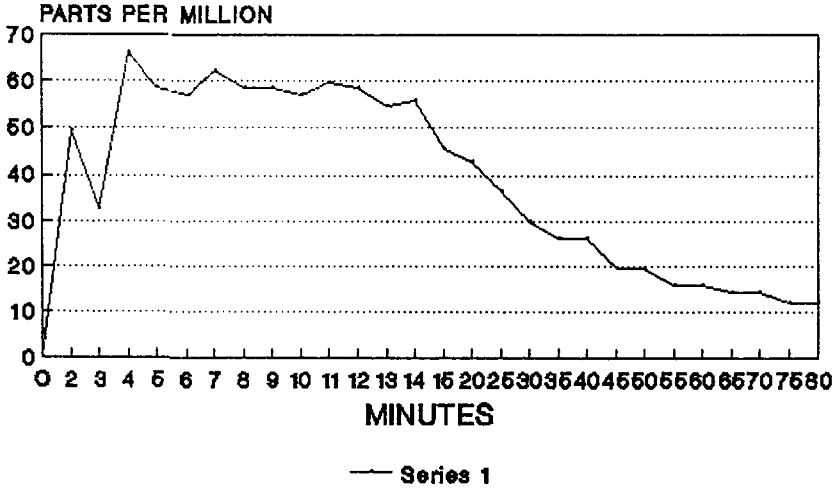

Figure 3 — Time retention study (before)
for SWD Station Tank #1

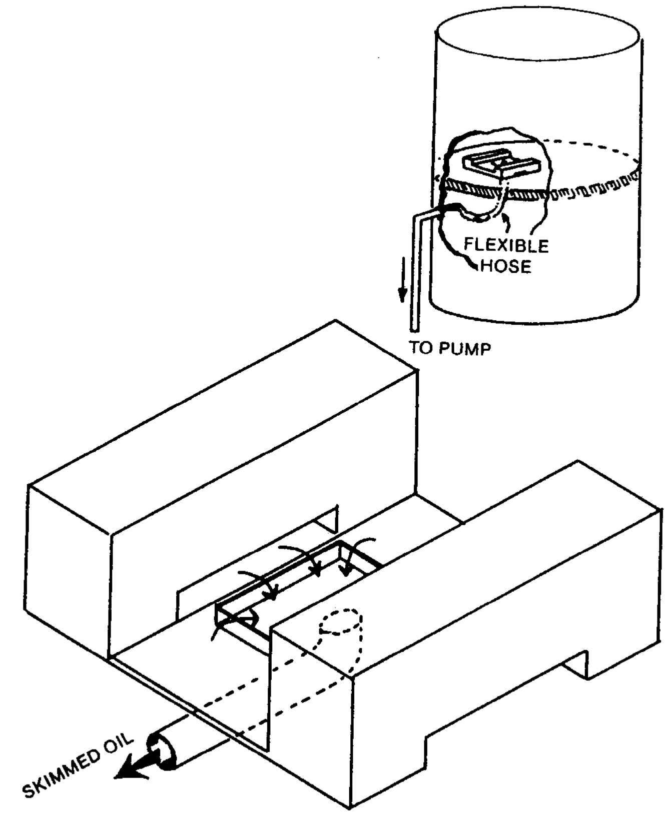

Figure 4 — Floating oil skimmer

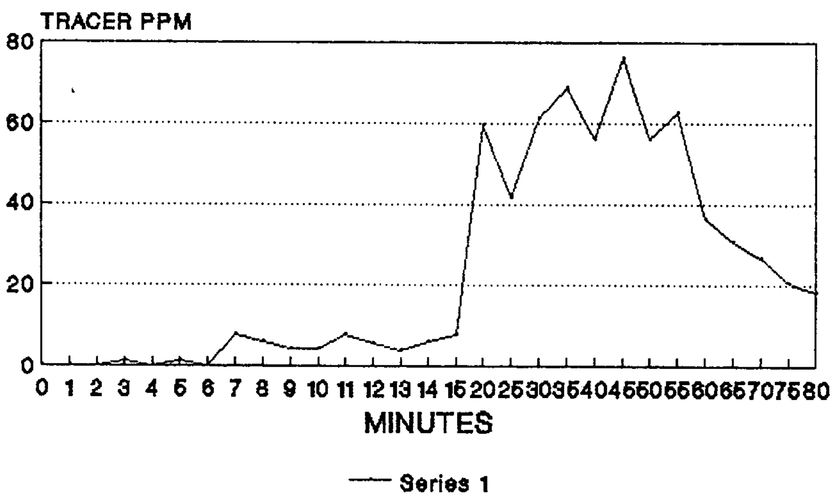

Figure 5 — Time retention study (after)
for SWD Station Tank #1