Basic Problems of Salt Water Disposal

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ABSTRACT

The energy provided by salt water in an oil reservoir is one of the best known oil recovery mechanisms. Salt water should be considered a tremendous asset to oil production, rather than a liability, and it should be intelligently handled. Progressive companies recognize the value of salt water, as well as its dangers. Provision for its handling is made in the budget along with other development and operating costs. The most satisfactory method of disposing of large volumes of salt water in inland areas is by subsurface well disposal.

A properly installed system does not "just happen"; it must be designed in detail and have adequate supervision, preferably by experienced personnel, during installation. Because of the corrosive nature of oil field waters, consideration should be given to the economy of corrosion resistant materials. The disposal well is the "heart" of a salt water disposal system and must be well protected, as it should be the last well in an oil pool to be plugged. The cooperative system to serve an entire pool provides for the most efficient handling of salt water disposal.

SALT WATER

Reservoir Energy

Many of the well known oil pools have an active water drive. In other words, the predominant producing energy is furnished by the salt water; at first it pushes the oil to the well bore, and in later stages also flushes the reservoir. The natural water flood is one of the cheapest and most efficient mechanisms for the recovery of oil. In those cases where sufficient natural water drive is not available, the oil operator often goes to great expense to secure and inject water to institute an artificial water flood.

It is very difficult to understand why salt water should be considered as a liability in an oil field. It is, perhaps, because many people have not learned how to handle salt water. It is a human tendency to reap the benefits of its energy and attempt to disregard its dangers.

Pollution

One of our great resources is fresh water. Everyone has a moral obligation to prevent pollution of these resources. Salt water produced in an oil field must be properly handled to keep pollution to a minimum.

The potency of salt water in causing pollution of fresh waters is often not fully comprehended. It is generally considered that potable water should not contain more than 250 ppm of chlorides. On this basis, one barrel of salt water containing 50,000 ppm chlorides would contaminate 200 barrels of essentially chloride free fresh water; thus, an oil pool producing 10,000 bbl/day of such brine would render 2,000,000 bbl/day of fresh water unfit for human consumption. This would be equivalent to the volume of water contained in 20 acres of a 50 foot thick formation having a porosity of 25 percent. It also becomes apparent that in many areas where fresh water is scarce, the pollution problem may become more acute.

Our rapidly expanding population demands water for modern living habits, irrigation and increased industrialization; the public will also demand, and alert management will provide, adequate salt water disposal as a wise investment.

Disposal Methods

There has been considerable recent discussion of means to convert salt water into a usable fresh water. Among the processes mentioned are vapor compression, flash evaporation, freezing, solvent precipitation, electro-filtration. Also mentioned are methods using nuclear and solar power; these are power sources only and should not be confused with purification methods. Some of the above methods are now being used in special cases. However, any large scale economical use will in all probability find its initial success in "brackish water" rather than with brines. While it is expected that great strides will be made with these processes in the immediate future, the "purification" of salt water will also create a by-product problem in residual salts or high concentrate brines which will require disposal or markets.

Pits and/or ponds have found wide use in handling oil field waters. Earthen pits that will handle large volumes

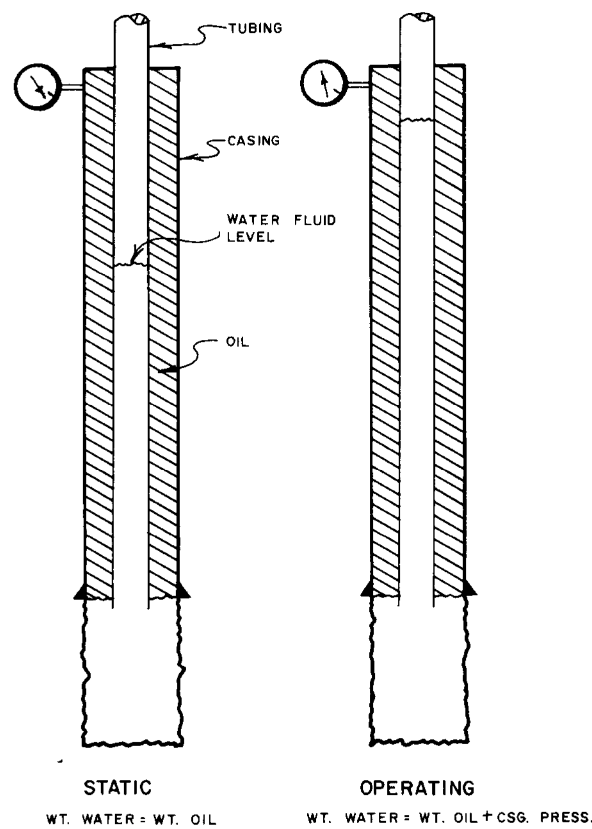

FIG. 1 OIL BALANCE METHOD OF LOADING ANNULUS OF SALT WATER DISPOSAL WELL

of produced water are invariably in porous alluvial soil or sand and disposal is largely due to downward seepage rather than evaporation. Pits dug in impervious soils usually fill with water, unless the volume handled is quite small. Lined or sealed pits can be used for small volumes of water, when the water can actually be evaporated.

In an area where the average annual evaporation rate is 52 inches and the annual rainfall 18 inches, the net evaporation will amount to 34 inches (2.8 feet) per year. By converting this net evaporation rate to barrels, it is found that roughly 2 square feet of pond surface is required per barrel of water produced per year. Thus, a well producing 60 barrels of water per day (21,900 bbl/yr) would require a pond of one acre in areal extent.

There are many factors which will further affect these calculations; the weather is probably the greatest single factor. A cool, rainy summer could, in effect, cut the capacity of a pond in half. A film of oil on a pond would greatly reduce the rate of evaporation, and the escape of oil to a pit is not an uncommon occurance. The salt content also adversely effects the evaporation rate of water. One of the greatest disadvantages of evaporation is that only water is removed and the salt content of the remaining water is increased. Therefore, until the salts are actually removed from a sealed pit, the disposal problem has not been solved.

To facilitate evaporation of water from sealed pits, the use of natural gas flares, burners or jets have been used. This still leaves the probelm of disposing of the salt or concentrated brine solutions. Further, if the full BTU content of the natural gas were utilized, it would require approximately 1 cubic foot of gas to evaporate 1 pound of water. At a field value of 10¢/MCF the cost of natural gas alone to evaporate a barrel of water would amount to more than 3.5¢ depending upon efficiency. It is questionable that this could be considered good conservation practice.

The cost of sealed pits is considerable and except in special circumstances, (i.e., small water volumes, isolated wells, etc.,) they are not considered too satisfactory.

The most satisfactory method of disposing of salt water, and this is particularly true where large volumes have to be considered, is to inject it into deep subsurface salt water bearing formations.

Disposal Well

Water can be injected into many disposal wells by gravity flow. The distance from the ground surface to the static fluid level in a disposal well determines the available head tor gravity injection. This head must be divided into two components.

1. that part which is used in friction in the injection string and
2. the remaining head which is available to force the salt water into the disposal formation.

A porous, permeable reservoir with considerable areal extent and a low fluid level offers the best disposal conditions.

The disposal well should be located at a topographically low point to provide gravity flow from the field to the accumulation facilities at the well. The well can be drilled and cased in a manner similar to oil wells drilled in the general area. However, when water is to be disposed of into a formation that also carries oil, the long string of casing is set 50 feet or more below the oil-well contact. The depth below the contact is influenced by the structure of the oil pool and the character of the porosity and permeability development.

Where large volumes of water are produced from a reservoir, that formation in turn should, in general, have the characteristics required for good disposal.

Normally salt water is corrosive and often extremely corrosive. A disposal well should preferably be tubed with a corrosion resistant material. Cement lined steel has given excellent results when the collar joints are properly sealed as with reinforced rubber seal which is now available.

Plastic lined steel tubing has application when properly used. Many of the plastic linings are inferior for severe corrosion conditions, but better materials are being developed. The modified epoxy thermosetting linings are showing considerable promise and one coal tar epoxy lining has been in use in corrosive water for 2-1/2 years without any evidence of failure. Plastic tubing has been used with varying degrees of success. The material is entirely corrosion resistant but has failed mechanically. Special applications may be justified.

Where tubing is used, the outside of the tubing and the inside of the casing may be protected with oil. This is done by using the "oil balance method" wherein the annular space is filled with oil balanced against the water in the tubing. The gravity of the oil to be used will depend upon the setting depth of the casing, the static water fluid level (or bottom hole pressure) and the specific gravity of the water. This method provides a casing head pressure which is very valuable in determining the condition of the disposal formation and the injection tubing (see Fig. 1). Any change in well conditions are immediately reflected by the casing pressure. This can often result in planned prosecution of work rather than proceeding on an emergency basis.

When water is injected directly down the casing, it is considered advisable to make some type of a caliper survey of the inside of the casing. The original survey shaould be run before injection is started and periodic reruns made until sufficient history is available to determine if internal corrosion is present. Failure to set up such a control may result in the loss of a disposal well at considerable expense and the disruption of operations.

Accumulation Facilities

A tank should be installed at the well location to provide for the settling of suspended solids, accumulated oil, to provide storage, to allow for fluctuations in production and to permit testing of the well. If sufficient tank capacity is provided and flow properly dispersed and slowed, no other terminal equipment may be required. If the suspended material cannot be sufficiently settled out in this manner, it may be necessary to utilize filters which greatly increase the operating costs.

Redwood tanks have given good service in accumulation facilities since the wood is noncorrosive. The wood tends to dry out, causing leaks, but rubber seals between the staves which help this situation are available on the market. Concrete pits are satisfactory but fairly difficult to install and they are costly. Steel tanks are subject to severe corrosion and should be lined. The same difficulties of obtaining a satisfactory lining in tubing are inherent in tank linings. Usually the tank facilities can be operated as a so called "semienclosed" system. The water in the tanks will carry an oil seal and gas escaping from the oil and water also provides a gas blanket.

The water level in the tank is controlled by a float which actuates a dump handle valve. This gives a positive type control. Ceramic lined butterfly valves and asbestos cement floats have given excellent service.

Gathering System

Just as rain water follows the drainage system in an area, so may a gravity flow gathering system be utilized in an oil field by following the drainage pattern. Since a closed piping system is used, there is some latitude in the design. Lines may actually go uphill for short distances but in general the lines should be laid to grade for best performance. Where high points are necessary in a line it should be adequately vented. A gravity flow line should never be installed at an elevation greater than its designed hydraulic gradient.

It is important that oil and gas be kept out of the gathering system. This is particularly true of gas as it can very effectively block a line. The best solution to the gas problem is to remove the gas by installing gas-boots at the tank batteries that discharge water under pressure. The old maxim -- an ounce of prevention is worth a pound of cure -- is very true in this case.

Corrosion resistant materials should be considered for gathering lines. Materials commonly used include asbestos cement, plastic, plastic lined and cement lined pipe. On low pressure, high volume systems asbestos cement pipe gives excellent service and is most economical in cost. Cement lined steel pipe is well suited for pressure, rock terrain or near surface installations. Plastic and plastic lined pipe also gives good service when caution is used in its application. Plastic pipe is particularly sensitive to heat and its application under such conditions should be carefully designed and installed.

A friction factor of C/100 as applied in the Hazen-Williams Formula is recommended. All the materials mentioned above have a smoother surface when new than after they have been in service. All materials now on the market, when placed in salt water gathering line service, will in time collect material on the pipe surface so that the original smoothness of the pipe material is changed. This does not mean that the value of the C factor can not be increased above 100 but it becomes impractical and uneconomical to constantly maintain it at a higher value.

Operation

When a salt water disposal system can be installed to serve an entire pool, the per well cost can be held to a minimum by eliminating duplication of disposal wells and lines. Also a greater degree of flexibility is provided in operation. Any proposed disposal plan should take the cooperative system into consideration. It is customary to prorate investment costs on a per well basis. The per well basis is also the simplest method of prorating operating costs (per connected well); however, other methods, including the metering of water, may be used.

A well designed system should provide as near continuous operation as possible. Shutdowns of any kind, gas locked lines or inadequate line capacities causing the overflow of water into stock tanks are time consuming and expensive to the oil operator.

Not all operational difficulties of a salt water disposal system are the fault of the system. Quite often poor operating practices of the oil producer cause the trouble. The fault may be the delivery of oil, paraffin and gas to the system along with the water; large heads of water intermittently, instead of a steady flow; and plugged or corroded pipe in the oil treating system which may cause partial delivery of water into the stock tanks instead of into the salt water lines.

A salt water disposal system requires good engineering design, proper material selection and continual experienced supervision in order to give efficient, economical operation throughout the life of an oil field.