Salt Water Disposal System Design Considerations

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A salt water system should be designed to serve all the wells in the subject area until the last producing well is plugged. To intelligently design such a system the engineer must use all the information available to him and also rely on good common sense. One engineer stated that his lease "would not produce much water" However, if he would have thought to examine the lease before making that statement, he would have found that (1) the bottom-hole pressure had dropped only 20 psi in 20 yr and that (2) his offset operator was setting pumping units capable of moving 500 BPD. Undoubtedly, his lease would make water and in the very near future.

Subject Area

The area to be served by a system should be defined and maps prepared to work on the problem. If it is to be a joint participation project, some prudent operator should initiate the project by calling a meeting to discover who is interested in a system and to secure the leases and wells that will make up the joint ventures Usually, a cooperative project to serve several parties, or even the entire field, is more economical than would be each party going its separate way.

Gathering System

After the subject area is defined, a gathering system should be planned; and to arrive at the design figure, a given quantity of water should be assigned to each well. Bottom hole pressure history, potential tests, and productivity indices should be examined to select the proper design figure so the line sizes can be properly sized. If there is one thing that has been learned in the design of a system, that is the fact that water flows "down-hill"; therefore, a gravity system is the easiest and the cheapest way to move water. The drainage pattern of the ground surface should be studied, and the gathering system designed with the same general pattern. Of course, with closed piping there is some latitude in design, and the water may actually go up-hill for a short distance. But in general, the lines should be laid to "grade" for best performance, and if high points in the lines are inevitable, these points should be adequately vented. A gravity flow line should never be installed at an elevation greater than its designed hydraulic gradient.

Regardless of the precautions used, however, gas will accumulate in the lines because it will come out of solution with the water. Gas will cause blockage in a gathering line; but by installing gas boots at every pressure vessel that discharges water into the system, much of the gas problems can be eliminated before they become troublesome. Simple float-operated gas vents can be installed at known high places in the gathering system.

Salt water and hydrogen sulfide gas, together, in the gathering system are corrosive, and many cases extremely corrosive. All materials used -- including all valves, fittings, and vessels -- should be corrosive resistant. With low pressure gravity lines, asbestos-cement pipe has been used extensively for salt water disposal, and this pipe is especially economical in high volume systems and gives excellent service. Cement-lined steel pipe is also used and is suitable for greater pressures than is asbestos-cement. Plastic pipe is also good, although some plastics are particularly sensitive to heat and its use should be carefully examined. Care should be used in the installation of all types of pipe to insure against damage.

The C factor of 100, as applied in the Hazen-Williams friction formula, should be used in the design of line size. All new pipe of asbestos-cement, cement-lined, or plastic, has a friction factor of higher than 100; but after installation, the accumulation of scale, BS and paraffin deposition severely affect the smoothness of the pipe interior. This accumulation does not mean that the value of C can not be increased above 100, but it becomes impractical and uneconomical to constantly maintain it at a higher value.

Accumulation Facilities

An accumulation tank or tanks should be located adjacent to the disposal well, and the tanks should be sized to provide adequate setting time for suspended solids and to serve to handle any fluctuations in water production. Also, oil will undoubtedly accumulate on the tanks, for no matter how efficient the battery oil treating facilities are supposed to be, some oil will be carried into the gathering system and to the accumulation tanks. A spreader system in the tanks should be installed to reverse the flow of water and decrease its velocity so the solids will settle out. If sufficient settling will not alleviate the suspended solid problem, one may have to use filters which will greatly increase the operating costs.

Redwood tanks make an excellent accumulation facility, for they are corrosion resistant and can be partially buried if the feet of head is needed for gravity flow. Concrete tanks can be used, although their construction is more difficult and costly. Steel tanks, if adequately corrosion protected, can also be used.

A lining of coal-tar epoxy, if properly applied, has proved good in steel tanks. It is usually not necessary to provide a gas blanket on the tanks because as oil accumulates on them -- and it will -- the escaping gas provides an adequate blanket.

The water level in the tanks can be controlled with a float which is linked positively to a butterfly valve on the tank outlet line to the disposal well. Ceramic-lined, monel trim valves provide an excellent control device at this point in the system.

Disposal Well

A properly installed disposal system does not "just happen;" it must be designed in detail and have adequate supervision during installation. The most important single component of any disposal system is the disposal well which is the "heart" of a salt water disposal system and must be well protected, because it should be the last well in an oil pool to be plugged.

If at all possible, a gravity flow injection well should be attained, even though the initial completion cost may be higher than that of a pressure injection well. To pump water into a disposal well results in higher initial cost and is a continual operational problem which may be eliminated at the system beginning if more study is put into the well selection and completion.

The disposal well falls in three catagories: (1) a well drilled specifically for disposal purposes, (2) a dry hole converted for disposal, and (3) an abandoned producing well converted for disposal. A well, drilled specifically for disposal purposes, can be located favorably to take advantage of all available head of the gathering system and at the same time to take advantage of certain geological conditions which affect the porosity and permeability in the disposal area. Also of most importance, the size, weight and setting depth of the casing can be made before the well is drilled and may affect the well's performance. However, the high initial cost of drilling a new disposal well is its principal disadvantage. A dry hole in which the casing has not been set has the advantage of being less expensive for disposal, providing the surface location is suitable and the well bore large enough to accommodate the injection casing. An abandoned producing well offers an advantage of being the cheapest disposal well if the casing is in good shape and if it is favorably located, both geologically and geographically.

For gravity injection, the distance from ground surface to the static fluid level determines the head which is available for 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 condition. In a field which produces fluid in large volumes, usually the same reservoir has characteristics which make it a good prospect for disposal.

To protect the disposal well casing from salt water corrosion it is essential to run a full string of tubing which should be protected by interior plastic coating or cement-lining and should be sized to provide the capacity needed for the disposal system. Plastic tubing is also available, but caution should be used, for there are mechanical limitations for some types of this tubing. Interior plastic linings for tubing are available in epoxies, phenolics, and coal-tar expoxies; and being developed are better materials which should provide more protection for very severe corrosion problems. Cement-lined tubing has given excellent protection where the collars have been adequately sealed with a reinforced rubber sealing ring.

Oil, naphtha, gasoline or sweet oil can be used in the annulus between the tubing and casing to proteot the tubing exterior; and they also provide a means to observe the pressure-volume performance of the disposal well. If the static bottom hole pressure at the bottom of the tubing is determined and if the specific gravity of the disposal brine is brown the correct gravity of hydro-carbon can be placed into this annular space which, under static conditions, can be calculated to reflect a pressure at the surface. Then, as salt water is injected, the formation resistance will cause a pressure increase on the surface gage. This oil in the annulus will enable one to spot troubles such as a tubing or casing leak, formational plugging, or scale deposition in the tubing. By keeping a graph of injection rates and pressures, a prediction can be made for future remedial, cleanout, or acidization work on the injection well.

Operation

After a salt water system has been installed, it should not be forgotten; records should be maintained on water volumes and pressures. Lines should be checked to determine if scale, paraffin or gas is causing or will cause trouble. Any shut-downs should be avoided, for it is the produced oil that pays for the operation of a salt water disposal system.

A well designed salt water disposal system based on good engineering design, proper material selection, and experienced supervision should provide efficient and economical service for the life of the oil field.