WHY IS WATER QUALITY IMPORTANT?
HOW DO YOU MONITOR WATER QUALITY?

Ron Matthews, Bobby Hunt, Paul Mason and Beth Hall
Rockwater Energy Solutions

Water is typically present in oil and gas production operations. Producing oil and gas necessarily means having to manage water. What components are present in that water, whether dissolved or dispersed, affect the function of the water and its effectiveness in the desired operation. "Water quality" is a measurement of how well the water conforms to the requirements of the specific application. Since most of the water handled in the oil industry is re-injected back into the ground, the makeup of the formation will determine the water quality needed for that field.

WHY IS WATER QUALITY IMPORTANT?

With more water being produced and re-injected, water quality becomes a big factor in water injection systems, as well as water disposal systems.

Two issues are of particular interest. First, poor water quality creates plugging and as a result, a loss of injectivity. Water quality can be a primary measurement used for injection purposes to help evaluate the water injection process. Areas of concern with water quality should include water analysis of any makeup water, membrane filter testing, oil carryover, oxygen measurements and bacteria testing. These will be discussed in more detail later.

It follows to mention how poor water quality affects an oilfield formation in ways that are detrimental to oil production. The first is "well-bore narrowing." This event occurs when the solids form a filter cake on the formation face at well bore. The second effect involves "formation invasion." This happens when the solids form an internal filter cake bridging off the formation. A third effect is "well bore fill up," when the solids settle to the bottom of the well by gravity and decrease the net zone height.

As part of determining whether a system has poor water quality, we need to evaluate the non-dissolved substances that exist within the injected waters. This includes iron sulfides, iron oxides, precipitated carbonate and sulfate scales, sands and silts, oil, paraffin, asphaltenes, and any materials from a biological origin – all of which can contribute to the effects discussed above. Thus, evaluating water quality can help extend the life of a waterflood or water disposal system.

Another issue involving water quality that is of immediate concern to the producer is a loss of revenue due to re-injection of hydrocarbons. This is illustrated in Table 1, showing actual production data.

WHAT SHOULD BE MONITORED FOR WATER QUALITY AND HOW?

It is of primary importance to understand the operation of the water system, whether injection or disposal. For example, one needs to know if there are proper storage facilities, closed systems, correct fluid levels within the system, or gas blankets on the system. All play a role when evaluating water quality. Within this evaluation, the need for correct water testing locations also helps in the evaluation process. It should be noted that the goal of sampling and testing is to determine how the whole system is performing.

Suspended Solids

Not surprisingly, the amount of suspended solids is routinely assessed as a water quality parameter. Suspended solids are defined as the non-water, non-dissolved substances that exist in water, normally measured in milligrams per liter of water (mg/l). These solids typically include iron compounds, precipitated carbonates and sulfates, sand, silt, oil, paraffins, asphaltenes, and materials of biological origin. They cause problems by creating plugging in the formation and loss of injectivity, as well as loss of revenue due to re-injection of hydrocarbons.

There are no absolute guidelines for the maximum amount of suspended solids which can be tolerated without plugging the formation, although the American Petroleum Institute (API) has issued a recommended guideline, given in Table 2. For the most part, experience in the field is the best guideline. Particle size distribution, along with the nature and composition of the solids, has important influence on the plugging tendency of water. This information can also set the parameters of filter selection if filtration is required.

Suspended solids in injection waters are measured by using membrane filters, commonly referred to as "millipore filters." They are porous disks composed of pure and biologically inert cellulose esters, and the most commonly used membrane filter is "0.45 micron," which indicates a mean pore size of 0.45 micrometers (microns or µm). The filter has a diameter of 47 mm, a thickness of 15 microns, and an average total pore volume of approximately 80% of the total filter volume. The suspended solids from several liters of water are collected on a membrane filter in a manner that permits larger, more representative samples than those contained from bottle samples. Typically, the millipore filter test measures how much water can be passed through the filter within a five-minute period.

Bacteria

Monitoring of bacteria is extremely important, since their presence can cause corrosion or plugging of equipment of the injection wellbore. Bacteria that are detrimental in oil-producing systems are sulfate reducing bacteria (SRB's) and acid producing bacteria (APB's). Both of these types of bacteria are sessile in nature, meaning that they prefer to attach to solid surfaces rather than being planktonic or flowing with the water. Planktonic bacteria can become sessile bacteria by adhering to a surface.

Sessile bacteria produce a polysaccharide gel – biomass – that is permeable to water, in which they live. Beneath this biomass, the pH at the surface of the steel can be less than 1.0 and produce considerable iron loss. It becomes important to remove the biomass and kill the bacteria to prevent the corrosion.

It should be noted, however, that the simple presence of bacteria in a system does not necessarily indicate that they are causing a problem. In addition, bacterial populations causing problems in one situation, or system, may be harmless in another. Therefore, "action" concentrations for bacterial contamination cannot be given, but treating is recommended where equipment from a failure indicates that bacteria were the root cause, no matter what the cultures indicate as to the infestation levels.

Oil Carryover

Evaluation of any produced water should be evaluated for oil content, as oil in the water will result in decreased injectivity. Oil interacts with the suspended solids and becomes a sticky mess. Iron sulfide and scales often attract the oil, resulting in plugged field equipment including meters, filters and perforations. The oil carryover test extracts any hydrocarbon that is in the injection waters, and the result is measured in parts per million (ppm).

Oxygen

Oxygen accelerates corrosion drastically under most circumstances. As oxygen combines with ferrous ions to form ferric ions, it forms an insoluble solid which precipitates from solution, increasing the suspended solids content. Evaluation of oxygen content is taken to help identify possible problems with insoluble solids that can become plugging agents in the injection wells.

The API and the National Association of Corrosion Engineers (NACE) have developed standard test methods and recommended practices for testing and evaluating water quality. NACE Standard TM0173-2005 provides details on test procedures using membrane filters. Table 2 lists API recommended limits used in evaluating water quality.

SUMMARY

Water quality is important for the success of a waterflood. Monitoring and water quality goals for the producer are critical to extend the life of the waterflood or water disposal system.

Monitoring of suspended solids can be indicative of corrosion, scale formation, oil carryover or bacteria growth. Water quality evaluation defines potential problem areas that may affect water injectivity. Reducing oil carryover can effectively reduce suspended solids which will aid in reducing plugging.

By design, an effective water quality program can aid in achieving fewer equipment failures, cleaner injection wellbores and better injectivity. The final results are economical savings which translate into greater profit for the producer.

REFERENCES

1. API Recommended Practice 45, “Recommended Practice for Analysis of Oilfield Waters,” Washington, D.C., Third Edition, August 1998.
2. NACE Standard TM0194-2004, “Standard Test Method - Field Monitoring of Bacterial Growth in Oil and Gas Systems,” NACE International, Houston, TX, Revised 2004.
3. NACE Standard TM0173-2005, “Standard Test Method – Methods for Determining Quality of Subsurface Injection Water Using Membrane Filters,” NACE International, Houston, TX, Reaffirmed 2005.

Table 1
What Is The Effect of Oil/Water Carryover on Water Quality?

Oil Carryover (ppm)	Barrels of Water Injected Per Day	Barrels of Oil Injected Per Day	Barrels of Oil Injected Per Month	Production Loss Per Month ($)
1237	600	0.72	21.8	1,853.00
25	18,259	0.45	13.7	1,165.00
36	6,280	0.23	6.9	586.00

Table 2
API Recommended Standards

Total Suspended Solids	< 25 mg/l
Throughput of Millipore (0.45 µm)	1000 ml for 5 minutes
Oxygen	< 50 ppb
Oil Carryover	< 50 ppm