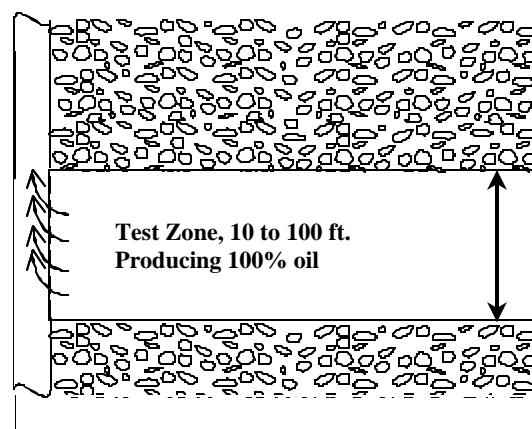


Technical Bulletin

Connate Water Testing

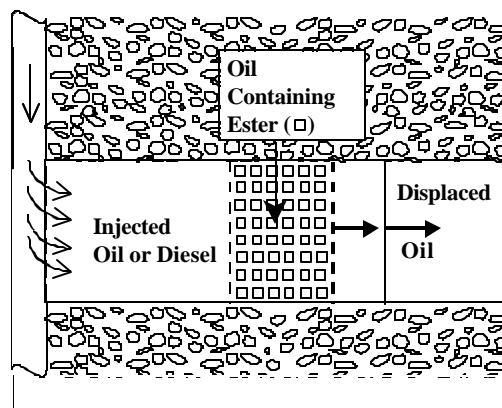
Connate water SWCT tests are carried out on wells that produce 100% oil. With a 100% oil cut, the reservoir pore space is generally at or very near connate water saturation (relative permeability of water is zero). In this fluid setting, the oil is the mobile phase sharing the pore space with a stationary, (connate) water phase. Figure 1 illustrates the test zone.

Figure 1
Test zone producing
100% oil



To perform the single well connate water (S_{WC}) test, a volume of oil or diesel containing the partitioning ester, (such as isopropyl formate) is injected into the target zone of the test well. A larger volume of oil without the ester is then injected to push the ester bank until it reaches a position ten to fifteen feet from the well bore. Figure 2 shows the position of the ester carrying oil bank during injection

Figure 2
Ester position
during injection

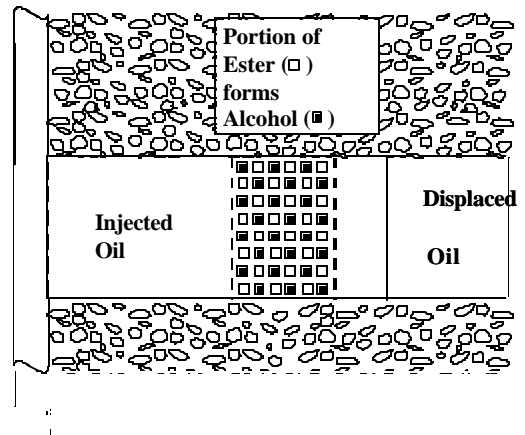


Total injected volume is based on known porosity, test zone thickness and test well production rate. The total volume injected is labeled with a non-reactive, non-partitioning material balance tracer, to differentiate it from displaced oil.

During a shut-in period of two to ten days, a portion of the ester reacts with the connate water to form the secondary tracer, an alcohol. Figure 3 shows the ester and corresponding product alcohol formed during the shut-in period.

At the beginning of the production step, as shown in figure 3, the remaining isopropyl formate and IPA tracers are superimposed, located 10 - 15 feet from the test well bore. After the shut in period, the well is produced. The produced fluid is accurately measured, periodically sampled at the wellhead, and each sample immediately analyzed for content of the un-reacted ester; the product tracer and the material balance tracer.

Figure 3
Some of the Ester forms
an alcohol during the
shut-in period



The un-reacted ester tracer, which is not very soluble in connate water, flows back to the well at very near the same speed as the oil. The secondary tracer is much more soluble in the connate water than in the mobile oil phase. Since the secondary alcohol spends much of its time in the stationary water phase, it flows more slowly and hence is produced later than the un-reacted ester tracer. This velocity difference is illustrated in figure 4.

Figure 4
Ester separates from alcohol
during production period
depending on amount of
connate water present

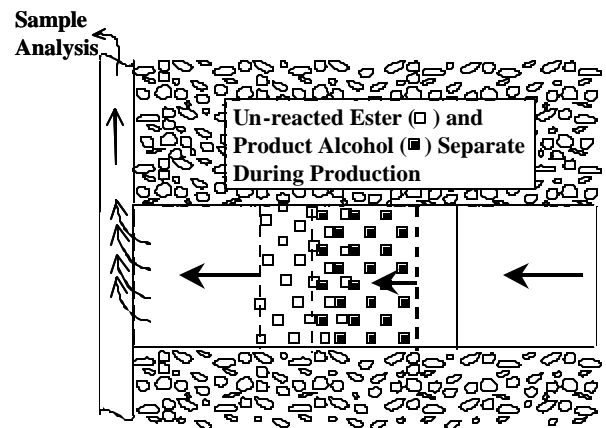


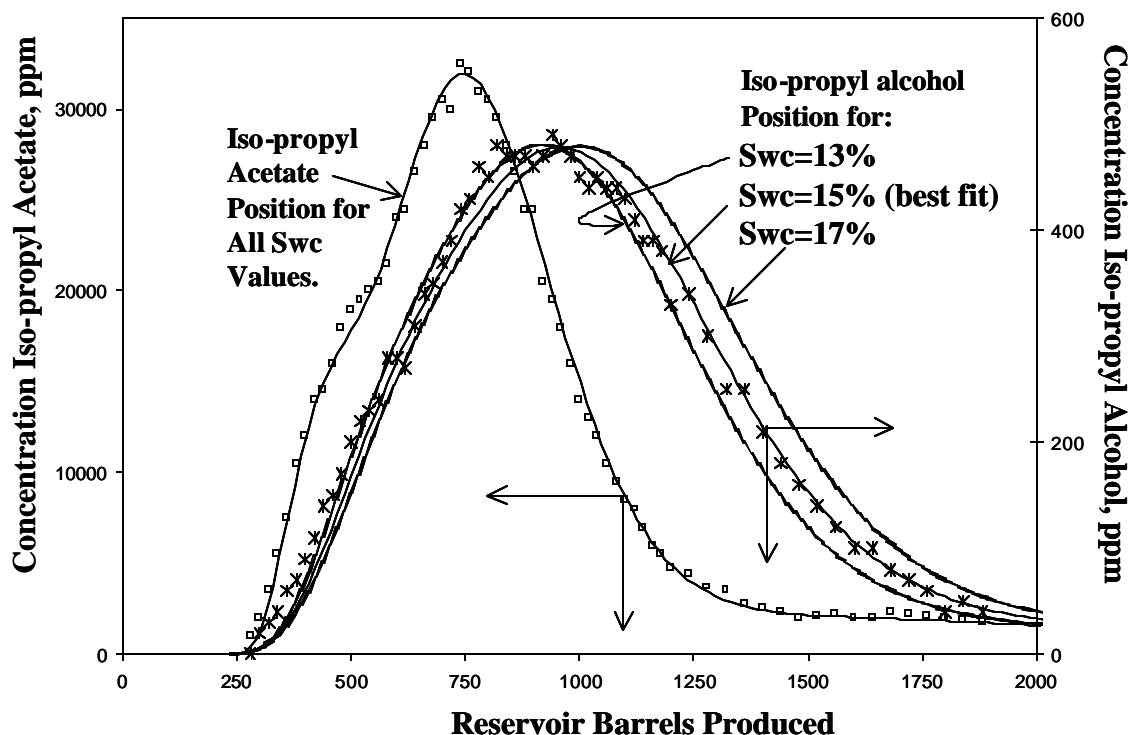
Figure 5 shows a typical connate water test production profile. The profiles of tracer concentration vs. produced volume show the chromatographic separation between the unreacted ester and the secondary alcohol tracer.

In ideal cases, S_{WC} can be calculated directly from field-measured profiles of tracer concentration vs. produced volume, by quantifying the degree of separation between the secondary tracer and ester. However, a more rigorous interpretation can be made using mathematical modeling. Simulated SWCT production profiles are compared to field

SWCT production profiles, and S_{wc} is obtained from the best-fit simulation model. This is shown in Figure 5, a Prudhoe Bay test example. The simulation accounts for ester reaction during the flow period, for K-value concentration dependencies, and for possible flow irreversibilities encountered during the test.

Figure 5

Plotting production data on a profile and simulating a match to each tracer quantifies the ester-alcohol separation and S_{WC} . Data from “Chemical Tracer Studies To Determine Sw, Sadlerochit Reservoir, PBU”, Deans, H.A, and Mut, A. D., SPE Reservoir Engineering (February 1997) 52-57.



Tracer derived S_{WC} data can greatly improve the accuracy of oil in place calculations. The large sample volume of the SWCT test and the porosity independent nature of the measurement allows the reservoir engineer to adjust log derived saturation data and remove doubt caused by water resistivity uncertainties and errors in open hole log porosity measurement.

Contact Charlie Carlisle at CTI (307) 742-0418, cell (307) 351-3629 or visit our website at www.chemtracers.com for more details on this unique in-situ tool for measuring fluid saturations.