Pre-Gulf of Mexico field trial
A Permian salt water disposal well (SWD) was selected to test the system under the most adverse conditions: injection of untreated produced water. SWDs are common across West Texas and Oklahoma, disposing of up to 30,000 barrels of water per day (BWPD) per well.

The system was built on 4-1/2” base pipe with an array of 630 NRVs (figure 2). The quantity of valves is a function of the expected injection rate. To minimize flow velocity, and hence erosional concerns, the flow is limited to 40 BWPD per valve. The size and positioning of the valves is critical to be able to mount them flush with the pipe so that a direct wire wrap screen can be manufactured over them without interference.

The test well was completed with the Cascade³ system installed permanently on 4-1/2” production tubing, below a production packer. For the purposes of the test, a single...
injection zone was adequate to observe the effects of the non-return valves to achieve the following downhole test objectives:

- Observe and record water-hammer, with/without check valves
- Prove that check-valves can hold back pressure
- Observe for any evidence of plugging or erosion over an extended time.

The field trial was set up to test several aspects of functionality using multiple downhole memory gauges to record pressures at reservoir depth:

- Baseline step-rate injection test
- Step-rate injection test through valves
- Check test (bleed off tubing pressure, observe annulus pressure)
- Multiple hard shut-in tests to record water-hammer
- Longevity test, continued injection (3-6 months).

The test assembly was positioned at the top of the injection zone, which was completed openhole with approximately 2,000 ft of sandstone pay. With the tubing plugged below the test assembly, and pressure gauges set to record both the tubing and annulus pressures, the test was conducted by pumping down the tubing. A pump truck was brought to location to simulate injection, and portable tanks were tied into the flow line to take any returns.

Evidence of functionality

Multiple hard shut-in tests were done by quickly stopping the surface pumps to record any fluid bounce and/or water-hammer on the downhole pressure gauges. The well was then opened to the surface tanks and tubing pressure was bled off to zero. No flow was observed into the tanks, which indicated that the check valves were effectively isolating the tubing from any back-flow (Figure 3).

Evidence of the technology’s check-valve functionality was clearly visible during the check tests and flow rates and pressures were as expected when pumping through the test assembly. Finally, when the tubing pressure was bled off to zero, the NRVs prevented any back-flow and held annulus pressure constant. This observation verified that the system performed as designed for downhole conditions, checking against flow from the annulus to the tubing.

Continued observation

As of October 2018, the SWD well has been put on full-time water disposal duty for several months. Future plans include running a set of downhole pressure gauges to observe the injection rates and pressures after a sustained period of injection. Offshore plans are currently in progress for the implementation of Cascade3 in an injector well for on a deepwater Gulf of Mexico asset.

References