

HELPING TO KEEP YOUR BUSINESS FLOWING

# FLUID HANDLING

## INTERNATIONAL

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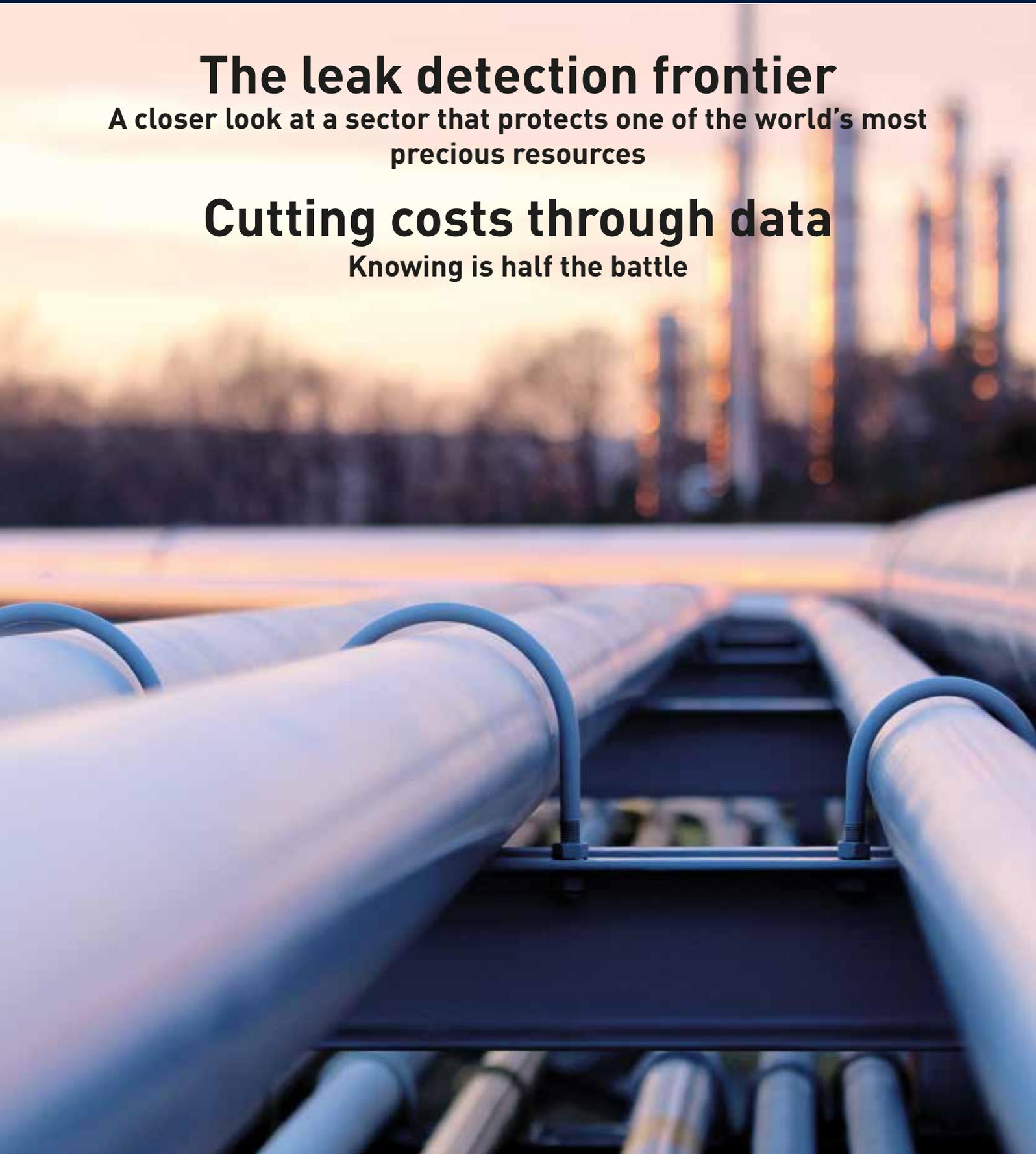
Issue 1 Volume 6

### **The leak detection frontier**

A closer look at a sector that protects one of the world's most precious resources

### **Cutting costs through data**

Knowing is half the battle



# Extracting more oil for less

## New synthetic water treatment media shows big potential to reduce costs of treating produced water from polymer flooding

Continuing oil and gas market pricing pressures keep exploration and production (E&P) operators looking for new ways to extract more oil from existing reserves for less. Typically, they have used enhanced oil recovery (EOR) techniques to tap the majority of oil in a reservoir – 55% to 80% – that cannot be primarily accessed via geological pressures or secondarily via water flooding. A new water treatment media has now been debuted – able to load up to five times more oil – that promises to make EOR even more economical.

While EOR has been proven for years to be a financially viable option for extending the life of a well and recovering much more oil from its reservoir, lower oil prices have driven many E&P operators to introduce chemical EOR (CEOR). One of several CEOR techniques called polymer flooding involves the injection into a well reservoir's rock formation of a dilute solution of a water-soluble polymer. The polymer increases the viscosity of the injected water, which improves its sweep efficiency to release more oil from the formation.

In fact, between 40 and 180 tonnes of extra oil can be recovered for every tonne of polymer that's injected. Consequently, CEOR via polymer flooding can have an enormous return on investment. For onshore polymer injection applications, every \$1-3 invested in it can yield an additional barrel of oil. Using \$45 per barrel pricing, that's a return of between 1,500% and 4,500%.

### Challenges of treating produced water from polymer flooding

While polymer flooding can be financially rewarding, it does present E&P operators with some produced water treatment challenges which can add cost and complexity back into the business case. Some of the polymer comes back with the produced water, making it more viscous than produced water without polymer. The viscosity poses some well-known issues for conventional water treatment. Chief among them are:

- Lack of charge neutralisation, due to the increased viscosity. This keeps oil and solids from moving freely in the produced water, making it difficult for droplets and particles to float or sink.
- Lack of oil droplet and particulate movement prevents contact and coalescence, preventing settling, which is a key principle behind conventional water treatment.
- Current polymers are not biodegradable, although recent studies have shown them not to impact the environment, especially living marine organisms.

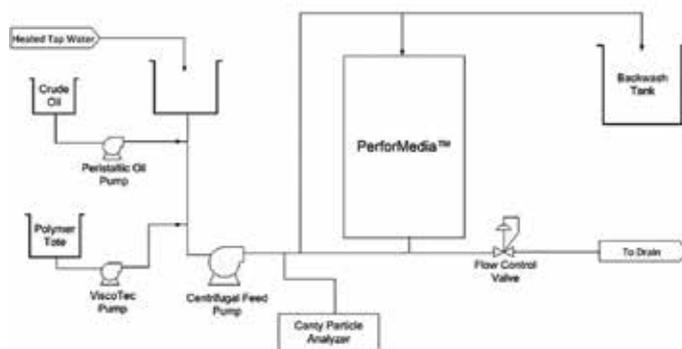


Figure 1: Diagram of proof-of-concept treatment system using synthetic PerforMedia for filtering polymer-flooding produced water

- Cost prohibitive to add enough chemical to re-neutralise the particles.

Extensive research has been done on treating well water produced by polymer flooding with conventional treatment technologies. The results haven't been promising. The increased viscosity causes a commensurate increase in drag, which negatively impacts gravity separation.

In addition, research into secondary water treatment flotation systems shows the approach to be about 40% less efficient than when treating non-polymer water. Stabilised particles won't coalesce or float, and the high viscosity can short-circuit a system. Research has shown that a flotation system can be efficient, but it requires adding a >40 ppm chemical dose, so the cost of the chemicals makes this approach uneconomical.

Then there are issues with using traditional walnut shell filter (WSF) media with highly viscous polymer-flood produced water. The inefficiencies in the upstream treatment systems place a much higher burden on the media filter. This means that a significantly higher amount of oil in water (OiW) and total suspended solids (TSS) must now pass through the hydrocyclones and flotation system. Such an excessive load combined with the viscosity causes traditional WSF systems to require more frequent backwashing (down to a few hours between backwashes) due to hitting high differential pressure (dP) conditions.

Even then, the effluent contains enough oil to require further treatment via granular activated carbon (GAC) columns and/or disposable cartridge filters. While possible to treat polymer-infused produced water, the additional operating expenses

can be considerable, undermining the business case for CEOR using polymer. So the question becomes, what alternative treatment methods could help put its ROI on stronger footing?

### Evaluating synthetic filtration media

To find a solution, Siemens conducted a proof-of-concept investigation into the use of a patented synthetic filtration media called PerforMedia Oil Removal Media. The goal was two-fold: (1) develop a system around this technology that could remove oil and total suspended solid (TSS) content from high-viscosity produced water; and (2) ensure the system would have a flux and footprint that would be acceptable to the E&P industry.

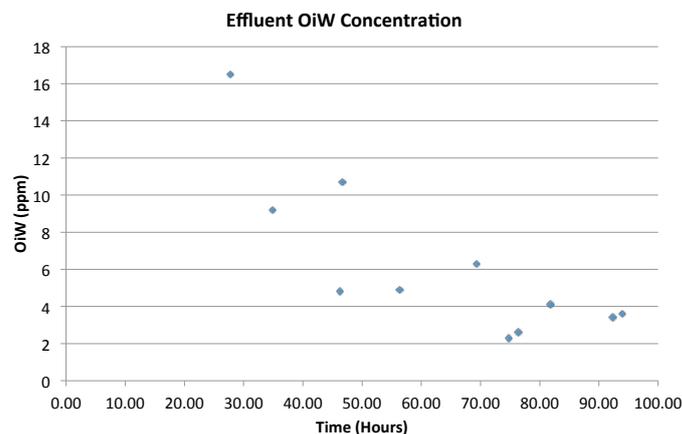
Other important considerations were that the solution would not degrade the CEOR polymer water treatment and other water clarification chemicals would not be required for operation or cleaning.

For its research, Siemens enlisted the help of SNF Floerger, the global leader in the production of water-soluble polyacrylamide polymers used in CEOR injections as well as in other industrial applications. The company provided its AN 934 BPM polymer (a copolymer acrylamide/acrylic acid polymer) for testing. This polymer has a lower molecular weight, giving it properties similar to those found in post-injection produced water, which would typically have spent time in the reservoir and also have been pumped several times.

Figure 1 provides a schematic of the test system, which featured a high-viscosity pump and an automated flow control subsystem for managing and monitoring filtration and backwash. A Canty particle analyser was used to ensure a representative oil droplet distribution of 10–100 microns. All testing was done at 70°C with feed-oil concentrations of 250–500 ppm and polymer concentrations of 500–1,000 ppm. The feed oil was obtained from an active polymer-flood site in Canada and had an API of 21.6.

As mentioned, filtration used synthetic PerforMedia. This proprietary media is able to reduce oil concentrations from 500 ppm to 10 ppm or less, and it can combine the oil removal capacity of secondary (flotation) and tertiary (media filtration) treatment into a single economic step. Compared to conventional WSF media, it can load up to five times more oil. This helps eliminate upstream flotation treatment, saving CAPEX (capital expenditure) and OPEX (operational expenditure). It can also handle feed oil and grease concentrations of up to 500 mg/L with oil spikes >1,000 mg/L versus 100 mg/L or less for standard WSF media.

PerforMedia can handle high feed TSS concentrations, too. As a physically larger media, it is not as prone to plugging as conventional media. This helps to lower backwash frequency, further saving costs by reducing the volume of backwash water sent to downstream treatment. Compared to conventional media, PerforMedia has an attrition rate of <5% per year. This reduces recurring yearly expenses and downtime to replace the lost media.



**Figure 2. Results of a representative test run of the Siemens treatment system with PerforMedia as filtration for produced water from polymer flooding**

Researchers conducted a series of test runs of the proof-of-concept system, with each run spanning three backwash cycles. The following test conditions were representative of the trials:

- **Flux:** 24.4 m<sup>3</sup>/hr/m<sup>2</sup>
- **Feed OiW:** 241 ppm
- **Feed polymer:** 493 ppm

Figure 2 shows the results of this test run, with the best results showing an average 97.4% oil removal resulting in an effluent OiW levels of 6.2 PPM. Notably, the system dP did not increase over time. The test also validated that the backwash system is effective at regenerating the media.

This proof-of-concept treatment for produced water from CEOR polymer-flood applications confirmed that, unlike conventional produced water treatment technologies, a system using the synthetic PerforMedia material can provide a highly efficient approach to:

- Removing OiW in polymer-flood produced water feeds with concentrations as high as 500 PPM to <10 ppm in the effluent
- Eliminating requirements for additional chemicals
- Keeping the polymer unchanged during treatment, making it available for re-injection and minimising additional make-up polymer requirements

The next stage in the Siemens investigation is finding E&P industry partners to take part in field pilot testing. The goal would be to further validate this synthetic media approach in real-world conditions, especially with suspended solids and variability in the feed streams of polymer-flooded produced water. Two models of skid-mounted, safety-rated pilot units are available, each scaled for approximately 100 and 2,500 barrels per day production levels. ■

#### For more information:

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