



# Boost productivity from mature reservoirs

## ELEVATE™ Miscible Gas Foam Flood Solutions

### Rising to the challenge for greater oil recovery

For more than half a century, oil and gas operators have used miscible gas floods of supercritical carbon dioxide ( $\text{scCO}_2$ ), Nitrogen ( $\text{N}_2$ ) and hydrocarbon gases to extract additional oil from mature reservoirs after primary and secondary modes have been exhausted. This effective enhanced oil recovery (EOR) technique is relatively simple: The gas is injected into a well, where it “mixes” directly with oil rather than physically forcing the oil up with pressure. This mixing reduces the oil’s viscosity and interfacial tension with the surrounding rock, making it easier to extract.

Recently, there has been an increase interest in gas floods in unconventional reservoirs. In this EOR technique, the gas is injected at high pressure in the fractures with the aim of increasing pressure in the matrix and solubilizing the gas in the matrix; hence, dislodging more oil and increasing production from the well, both in drive and huff and puff configurations.

The popularity of the miscible gas foam flooding process across the industry is founded on its low risk and its low cost. Challenges – such as low sweep efficiencies due to reservoir heterogeneity and gas density or fracture connectivity in unconventional reservoirs – remains, keeping oil recovery efficiency lower than desired.

Dow offers unique field-proven solutions to meet those challenges. By combining the innovative chemistry of ELEVATE™ Foam Conformance Solution with Dow’s proven implementation expertise, producers can reach and recover more oil from existing wells, while simultaneously reducing operating expenditures.

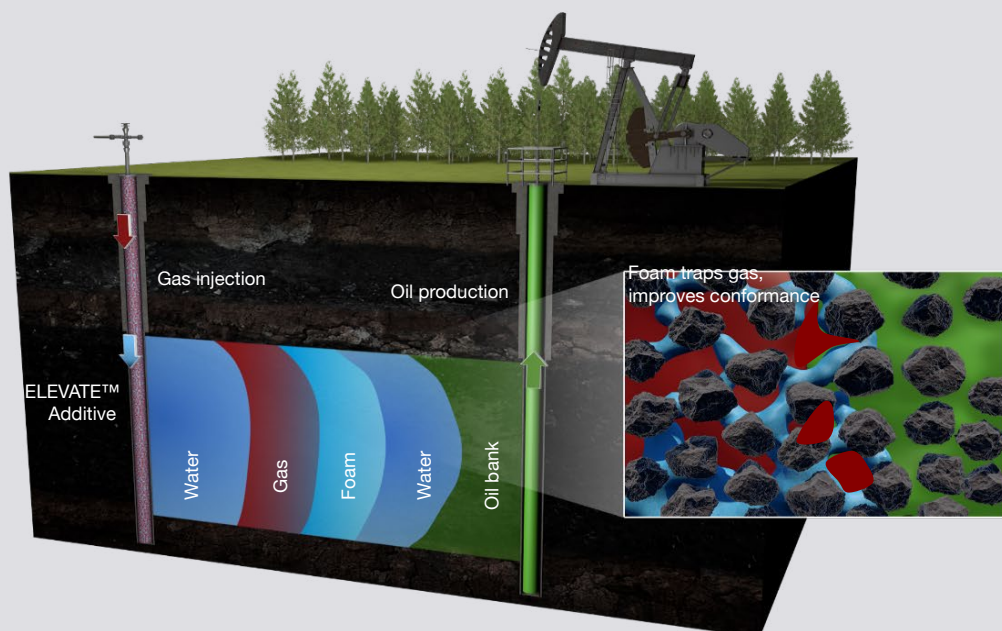


Figure 1. Miscible gas injection sequence

## Balancing mobility and conformance issues for conventional gas floods

ELEVATE™ Foam Conformance Solution generates a “foam” of injected gas and water in the formation to address the two key problems of conventional gas flooding: mobility and conformance control. If there is not enough mobility of the gas, it cannot “sweep” the oil to the production well. However, if the gas is not directed to where residual oil is, the various flow rates throughout the reservoir must conform with each other as closely as possible in order to sweep as much of the oil as possible.

ELEVATE™ Foam Conformance Solutions help producers strike the balance between efficiency and production. Unlike other foam systems, the ELEVATE™ Foam Conformance Solution provides a high level of partitioning in the  $\text{scCO}_2$  foam, allowing it to be carried to previously unreachable reservoir depths for better aerial and vertical sweep.

While gas mobility is important to fluids production, inefficient use due to their natural heterogeneity or geological complexity can lead to high recycle rates and low Gas-to-Oil Ratios (GOR). In other cases, the low relative density of gas can create gravity override, a condition where gas tends to migrate toward the upper part of the oil producer, and miss a significant portion of recoverable oil.

ELEVATE™ Foam Conformance Solutions help generate just the right foam texture to overcome these conformance issues, resulting in increased oil recovery. At the same time, they minimize gas injection requirements, helping minimize costs of operation and re-compression energy, thus increasing the sustainability of operation.

## Conformance control for unconventional reservoirs

Dow also offers an ELEVATE™ line of foaming agents that reduce gas mobility in the fractures of unconventional reservoir wells. As with the conventional offering, the foam diverts gas into fractures that are not suffering from inter-connectivity issues and hence help improve the gas sweeping efficiency of the EOR process (Figure 3).

## ELEVATE™ Miscible Gas EOR Solutions

<b>Better performance</b>	ELEVATE™ Conformance solutions for miscible gas floods have proved to increase oil production and increase efficiency of conventional and unconventional gas floods, in the laboratory and in the field.
<b>High actives, winterization</b>	Additives have high actives concentration which enables savings in logistics and storage. Winterization down to $-40^\circ\text{C}$ available with environmentally friendly solvents (percentage actives between 20-40%).
<b>Sustainable impact</b>	Injection of additives to gas floods increase energy efficiency (hence reduce GHG impact) by 30-50%. Products are typically biodegradable, pose no bioaccumulation, and have low to no toxicity.
<b>Product stability and safety</b>	Additives do not generate stable emulsions when back-produced and have no negative effects on corrosion or elastomer stability, posing no risk to surface facilities. Additives are also safe to handle and load/unload under normal PPE protection

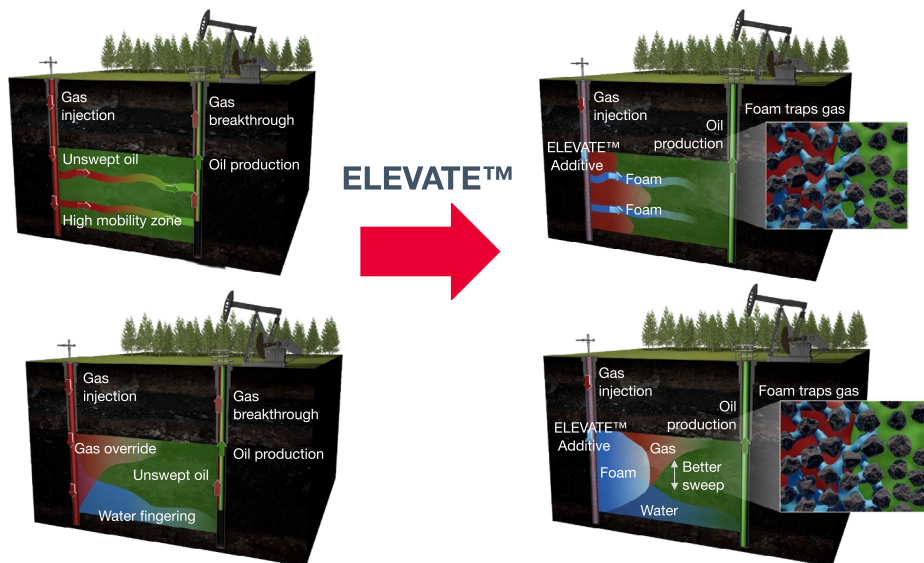


Figure 2. Miscible gas injection flood



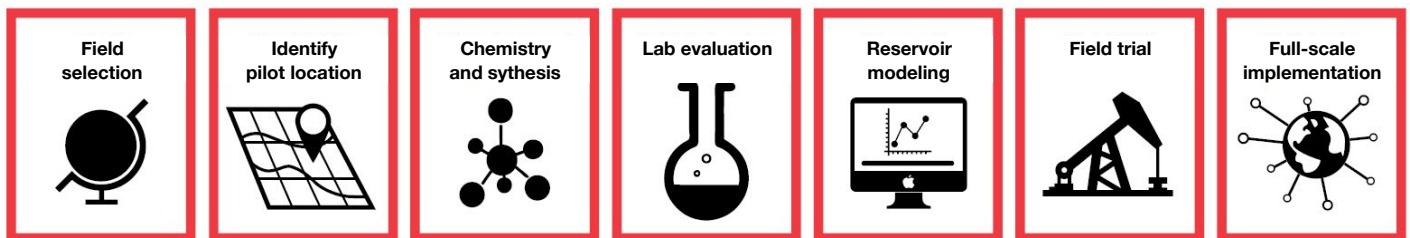
Figure 3. Unconventional foam conformance

## Our proven implementation expertise streamlines your operation

In an operation as complex as gas flooding with water-alternating gas EOR, ELEVATE™ Foam Conformance Control Solution performance depends on many variables. With access to our team of experts who understand the mechanics of oil extraction, you can minimize the risks and maximize effectiveness.

Once a problematic field is pinpointed, our team will work closely with you to select a foam pilot area based on well injectivity, pattern size, current oil saturation, gas-to-oil ratio and gas utilization ratio.

Following an analysis of the geologic and reservoir simulation models, Dow will recommend a foaming solution. After laboratory testing of the foam design recommendation using reservoir rock and fluid samples, a foam model is built to incorporate into reservoir simulations. Dow experts can then provide a baseline extraction forecast to let you know how much additional oil is likely to be extractable.

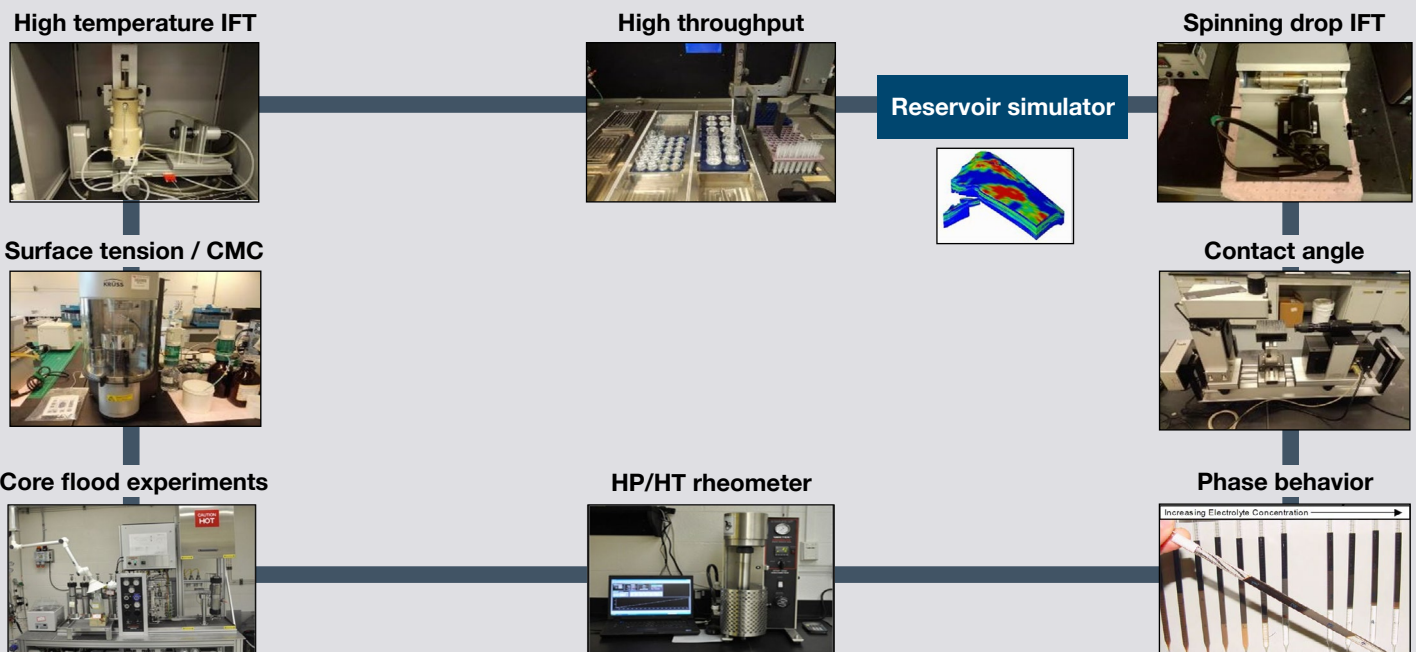


## Testing capabilities minimize risk, maximize yield

Dow has developed a state-of-the-art laboratory evaluation protocol including reservoir simulation capabilities to support field implementation. Dow's EOR lab features capabilities to test multiple core flood set-ups (formation response testers), pressure volume and temperature (PVT) cells, phase behavior

equipment and interfacial tension measurement equipment. All of our testing is done under actual reservoir conditions to determine the best option for your operation and to allow fine-tuning to meet the precise downhole pressure, temperature and brine concentrations.

## EOR capabilities





## Our field experience

A total 30 years of combined experience. Dow's EOR business model is that of technology enabler in strong collaboration with its customer and provide an optimal solution using a holistic approach.

### **Trials: Non-thermal EOR**

- 1 completed - sandstone reservoirs (SPE169166, SPE170729, SPE179635, SPE190312)
- 3 completed/in-progress - carbonate reservoirs
- Field trials are published in open literature (SPE 160016)
- Active in many field trials on wettability alteration for fractured carbonate reservoirs (SPE190397)

### **Trials: Thermal EOR**

- Volatile additives to improve SAGD performance: 2 completed, 1 planning
- Steam foam for steam conformance: 2 planning

### **Expertise**

- Designing of chemistry, lab evaluation, and trial implementation
- Optimizing injection strategy using foam modeling with field scale dynamic reservoir simulation
- Collaboration with customer to design, plan and monitor the field trials

## More EOR solutions from Dow

Dow has additional EOR solutions that can be customized for different EOR strategies. Our ELEVATE™ brand covers additives to improve conformance in steam thermal EOR, as well as improve formulations and phase stability for chemical EOR floods such as ASPs. Dow experts can customize solutions for each field and can help in formulation of complex EOR mixtures.



## Dow's commitment to sustainability

Dow's commitment to sustainability is infused into the very DNA of our Company. In 2006, we launched our 2015 Sustainability Goals, which focused not only on the Company's footprint in our own operations but also our handprint through the positive impact of Dow products and their role in global sustainable development. Now we have introduced our 2025 Sustainability Goals. With these Goals, Dow seeks to advance the wellbeing of humanity by helping lead the transition to a sustainable planet and society. The seven commitments that comprise the 2025 Sustainability Goals represent the next step in our long-term strategic journey. For more information on how sustainability is integrated into all aspects of our business and operations, please visit [dow.com/sustainability](http://dow.com/sustainability).

## Product stewardship and safety

Dow has a fundamental concern for all who make, distribute, and use its products, and for the environment in which we live. This concern is the basis for our product stewardship philosophy by which we assess the safety, health, and environmental information on our products and then take appropriate steps to protect employee and public health and our environment. The success of our product stewardship program rests with each and every individual involved with Dow products – from the initial concept and research, to manufacture, use, sale, disposal, and recycle of each product.

Dow strongly encourages its customers to review both their manufacturing processes and their applications of Dow products from the standpoint of human health and environmental quality to ensure that Dow products are not used in ways for which they are not intended or tested. Dow personnel are available to answer your questions and to provide reasonable technical support. Dow product literature, including safety data sheets, should be consulted prior to use of Dow products. Current safety data sheets are available from Dow.

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