

Full steam ahead for greater production

High-temperature additives
for improving thermal
enhanced oil recovery

DOW

®



Improving efficiency of thermal processes with ELEVATE™

Heavy oil and bitumen are one of the most abundant, but most difficult-to-recover hydrocarbon sources. With heavy oil viscosities in the thousands of centipoises and bitumen viscosities over 1 million centipoise in-situ, these oils need to be heated to be produced.

Thermal systems, including hot water and steam, have been used for many years to lower the viscosity of these oils so that they can flow to producing wells. Steam floods, cyclic steam stimulation, and steam-assisted gravity drainage (SAGD) processes continue to be implemented in many parts of the world. While it is considered very effective in recovering heavy oil, thermal EOR is still energy intensive and in most cases, not efficient, with steam-oil ratios (SORs) as high as 10 in some cases.

Thermal enhanced oil recovery (EOR), particularly steam processes, suffer from similar issues to other displacement processes – conformance and mobility control. In addition, the condensed water is not a good solvent for oil and therefore does not fully recover the oil trapped in tighter and smaller pores.

Dow has developed solutions to combat both problems – ELEVATE™ SF Conformance Control Additives to control conformance issues in steam floods and hot spots in SAGD, as well as ELEVATE™ SL Volatile Additives to improve the efficiency of SAGD operations. These additives help increase oil production rate, increase total oil recovery over time and decrease SOR. Combined with Dow's implementation expertise, backed by decades of experience in additives for use in oil production, these products will help recover more oil while significantly reducing water and energy use. Dow's additives have been specifically designed for high temperatures. They have also been tested and show no adverse effects on the formation or any downhole or topside equipment, with minimal effect on separation, water treatment, or water recycling operations.

Proven productivity improvement

ELEVATE™ SF Conformance Control Additives are injected with steam to form dense foams in-situ, at the rock face. The foam effectively viscosifies the steam, reducing its mobility in high

permeability or de-saturated zones. This forces the steam into the oil-rich areas not yet reached (Figure 1). Injection strategy is typically through campaigns or in batches to optimize usage of the ELEVATE™ SF additives. In SAGD wells, these additives could also be used to mitigate “hot spots”.

ELEVATE™ SL Volatile Additives have been designed to be transported with the steam towards the condensing front and assist the in-situ emulsification of oil in water mixtures, enhancing oil production (Figure 2 for a SAGD chamber). The additive is produced back with oil and water and does not pose any issues in the surface separation process.

ELEVATE™ thermal oil recovery solutions

- **Better performance** – ELEVATE™ SL Volatile Additives and SF Conformance Control Additives have proved to **increase oil production** under gravity drainage.
- **High actives, winterization** – Additives have +95% active content. High Actives Concentration **enables savings in logistics** and storage. Winterization down to -40 °C available with environmentally friendly solvents (percentage actives between 40-80%).
- **Sustainable impact** – Injection of additives to steam could **increase energy efficiency** (hence reduce GHG impact) by 30-50%. Products are typically biodegradable, pose no bioaccumulation, and have low to no toxicity.
- **Product stability and safety** – 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.

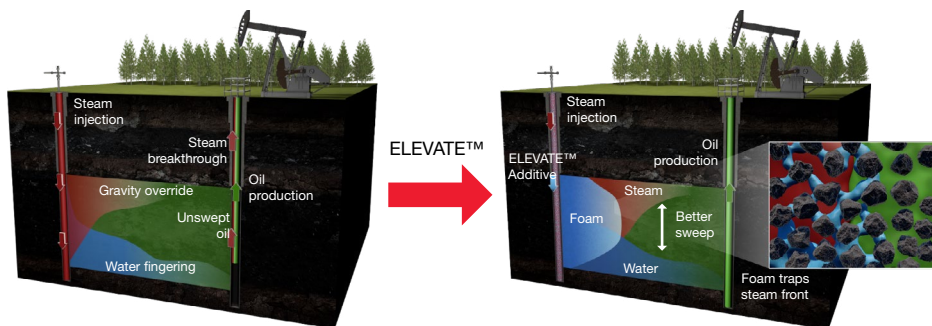


Figure 1. Steam foams generated with ELEVATE™ SF Conformance Control Additives can reach oil bypassed by initial methods.

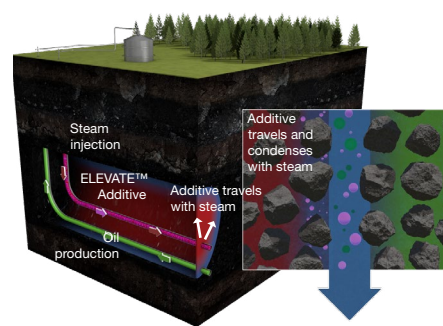
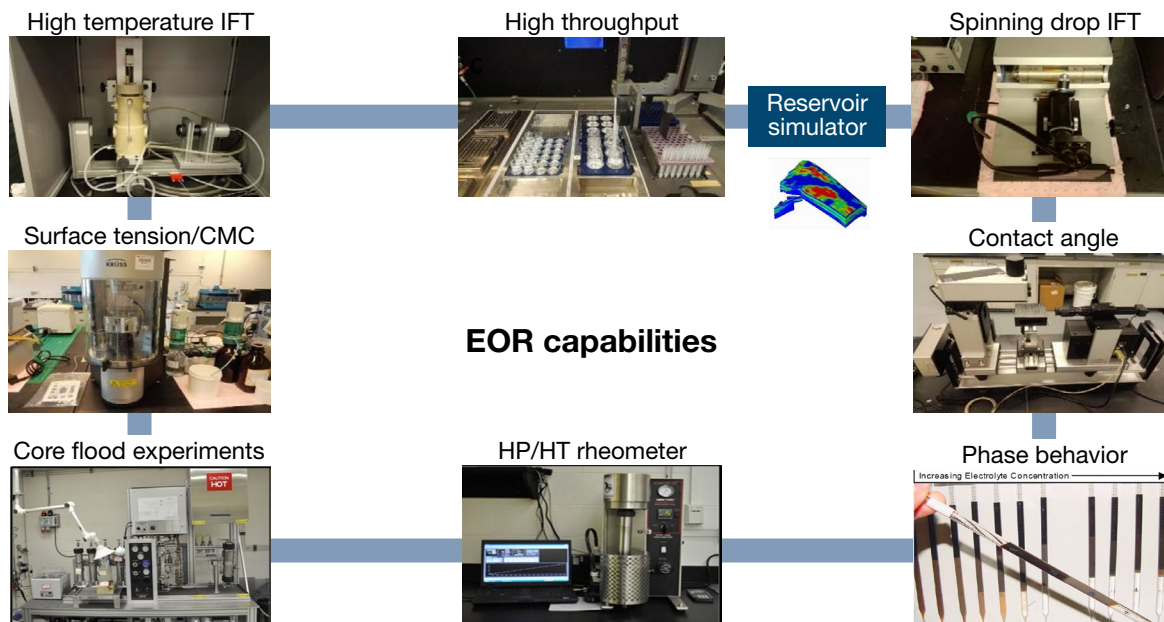


Figure 2. ELEVATE™ SL Volatile Additives travel with steam to improve oil production at chamber edge.

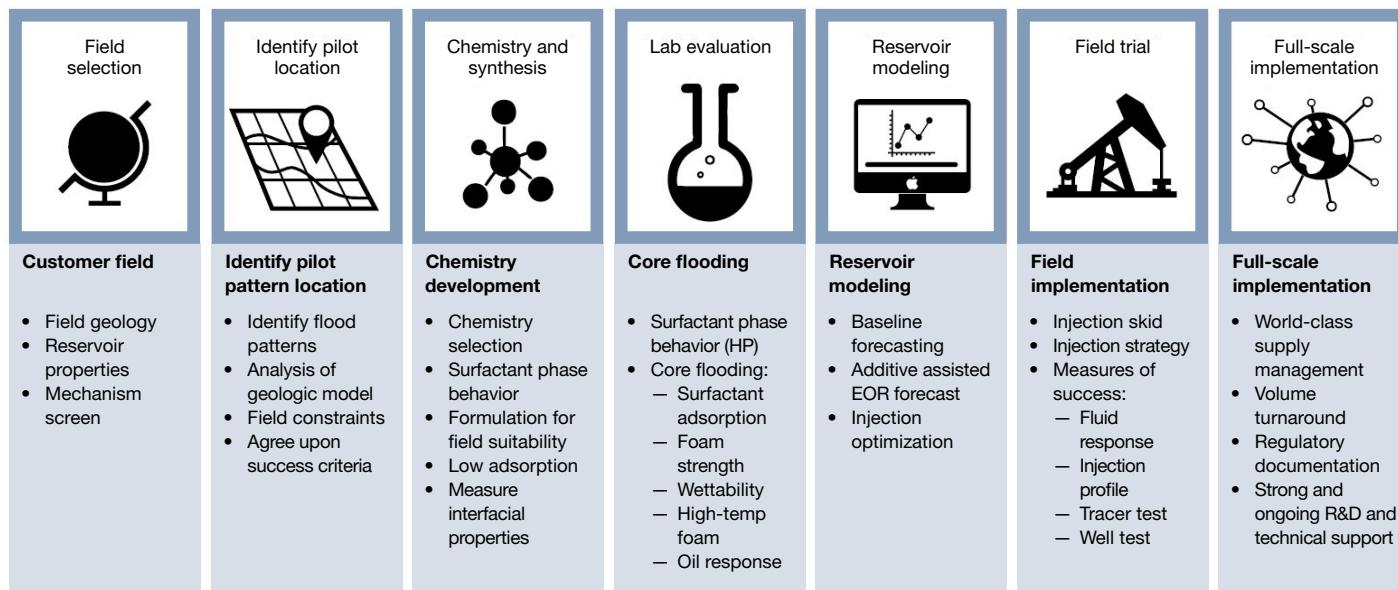
Testing capabilities minimize your risk, maximize your yield

From initial research through lab evaluation, modeling and field trials through full-scale implementation, Dow is at your side to develop a solution that maximizes oil recovery rates in your thermal EOR operation. Dow has developed laboratory evaluation and reservoir simulation capabilities to support field implementation and help customers get more out of previously difficult-to-produce reserves. Dow's EOR lab features extensive capabilities to test multiple core flood set-ups (including various steam configurations) using 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 pressure, temperature and brine concentrations.



Support from lab to field

Dow has an established process to support development of customer-tailored solutions from initial laboratory testing all the way through final field implementation. It begins with rigorous in-house experimental capabilities to test additive performance, de-risk field implementation and meet customer-specific requirements. We work with customers to review or develop new chemistries and perform lab evaluations. Using the customers' conditions and understanding of the process, reservoir modeling is completed. A field trial is then run to make sure the additives perform to desired goals and, once successful, on to full-scale implementation.





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](https://www.dow.com/sustainability).



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 miscible gas floods in conventional and unconventional floods, as well as improve formulations and phase stability for chemical EOR floods such as ASPs. EOR techniques often lead to water treatment issues including mineral scaling, unresolved emulsions and water cleanup. Dow can work with you to find the optimal solution to water treatment needs for EOR.

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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