



## CO<sub>2</sub> Huff n' Puff Services for Stimulating Oil Wells



Linde's cyclical Huff n' Puff services stimulate aging oil wells with CO<sub>2</sub> to recover residual oil. In this process, CO<sub>2</sub> is injected into a single well. The well is shut-in for a designated soaking period to allow CO<sub>2</sub> to dissolve into the oil to cause swelling, increased saturation and permeability, and reduced viscosity. Oil is then produced back from the stimulated well typically at a higher rate than before treatment. CO<sub>2</sub> injection helps suppress water production from coning and helps with reservoirs containing paraffin.

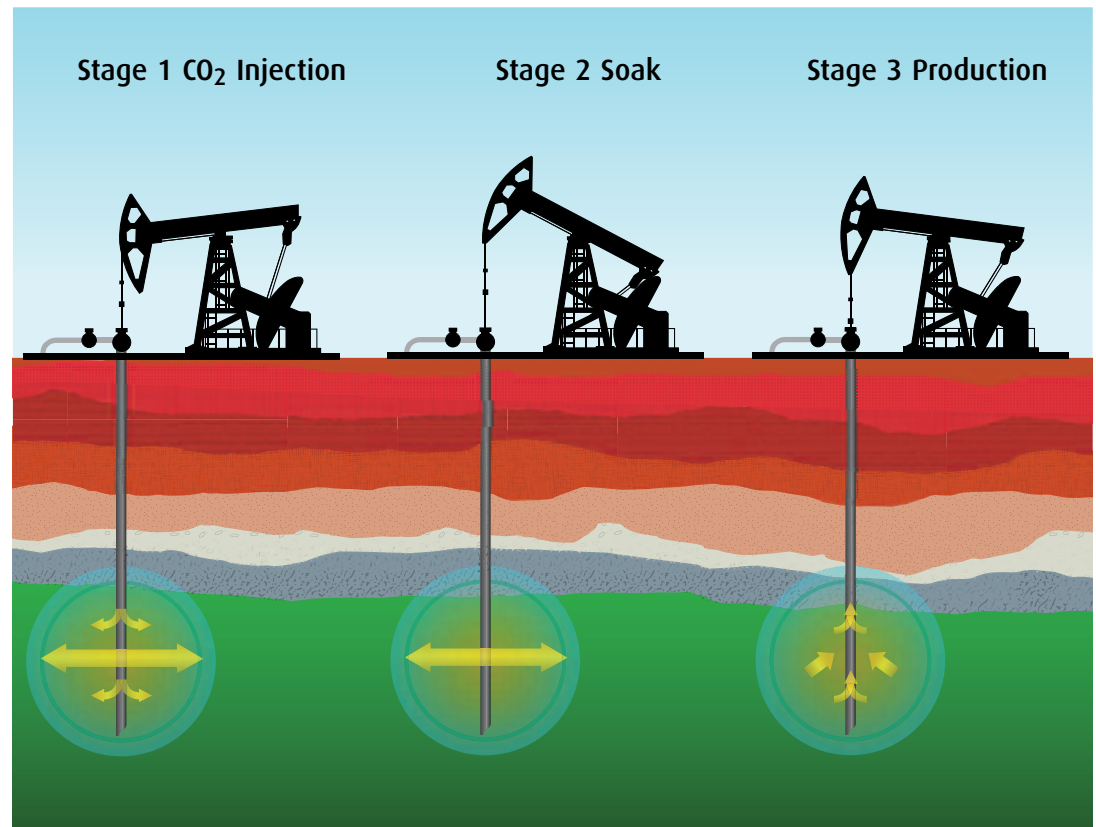
Stimulation with CO<sub>2</sub> Huff n' Puff is utilized in formations that are not amenable to full scale CO<sub>2</sub> enhanced oil recovery (EOR) floods. Favorable response has been seen in:

- Production wells with confinement near the well bore and minimal fracture network.
- Formations with compartmentalization and water drive support.

Successful projects produced in reservoirs in the following ranges:

- API oil gravities ranging from 10-40°
- Porosities ranging from 10-35%
- Depth from 1,000 to 13,000 ft
- Zone thickness from 5 to 225 ft
- Permeability ranging from 10 to 2500 md

## Procedure



### Pre-Injection

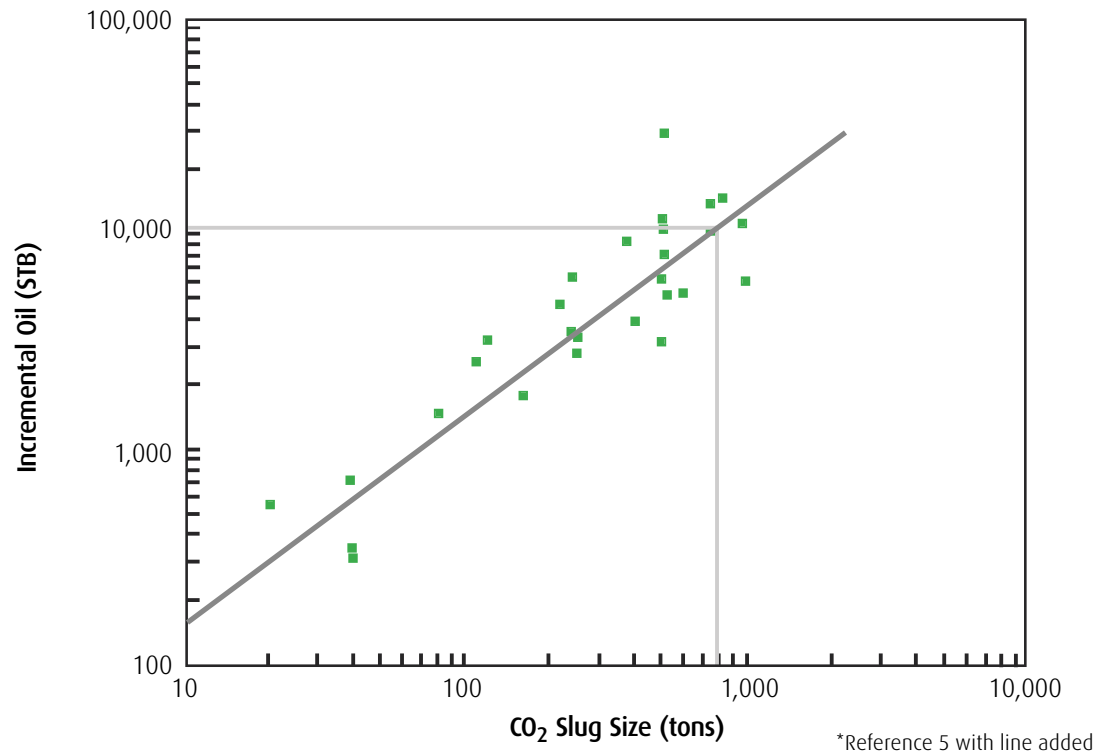
- Confirm integrity of the well tubing
- Confirm suitability for the intended pressure stimulation
- Measure well's current production and reservoir characteristics
- Set supply system

### Injection

**Stage 1:** Inject the desired CO<sub>2</sub> quantity into the well

**Stage 2:** Shut the well for predetermined soak time

**Stage 3:** Resume production, measure oil, gas, water, and CO<sub>2</sub> flows Analyze results, as production declines, consider additional treatments to again stimulate recovery.



This chart shows the relations between incremental oil produced and mass of CO<sub>2</sub> injected for successful cyclic CO<sub>2</sub> field tests. Documented CO<sub>2</sub> Huff n' Puff stimulation results are cited in the references. Example analysis of results is shown in chart.

The standard operating procedure for determining adequate soak time is to observe the initially produced fluids. If the CO<sub>2</sub> has had adequate time to soak, then oil and water production is expected within the first 24 to 48 hours. If only CO<sub>2</sub> is produced within the first 24 to 48 hours, then additional soak time is required to allow enough time for CO<sub>2</sub> to become miscible with the reservoir fluids.

### Technical Specifications

#### Flow Rates

- 0.1 – 2 bpm at 10,000 psig max.
- 0.6 to 6 bpm at 5,000 psig max.

**Pressures:** 0-10,000 psig

**Temperatures:** Up to 150 deg °F

### Linde is a trusted supplier

Linde is a leader in training, safety, and operation of well site injection equipment. Highly trained operations personnel use formal standard operating procedures that have been developed, tested, and refined over years in the field handling well site logistics. For each job, a review is conducted of the job scope, equipment operation and setup to ensure a safe and reliable operation.

Linde has over 30 years of experience providing services in enhanced oil recovery, energized fracturing, and well injection services across the globe including the United States, Mexico, Canada, China, Columbia and United Arab Emirates. As a leading supplier of nitrogen and carbon dioxide, Linde is your one-stop shop for optimizing your oil and gas production.

To learn more about Linde's Huff n' Puff services, go to [www.lindeus.com](http://www.lindeus.com) or call **1.844.44LINDE**.

## Further Information and References

- (1) Mohammed-Singh, L., Petrotrin, and A.K. Singhal, and S. Sim, Alberta Research Council, 2006, Screening Criteria for Carbon Dioxide Huff 'n' Puff Operations. Paper SPE 100044 presented at the SPE/DOE Symposium on Improved Oil Recovery, Tulsa OK 22-26 April 2006.
- (2) Monger, T.G. and J. M. Coma, 1988, A Laboratory and Field Evaluation of the CO<sub>2</sub> Huff 'n' Puff Process for Light-Oil Recovery, SPE 15501, presented at the SPE Annual Technical Conference and Exhibition, New Orleans, LA, 5-8 Oct 1986. Revised May 2, 1988.
- (3) Smith, L.K. and R. C. Surdam, 1992, Cyclic CO<sub>2</sub> Enhanced Oil Recovery in Wyoming Cretaceous Fields, Wyoming Geological Association Forty-Third Field Conference Guidebook, p.145- 166.
- (4) Chen, C., M. Balhoff and K. K. Mohanty 2013, Effect of Reservoir Heterogeneity on Improved Shale Oil Recovery by CO<sub>2</sub> Huff-n-Puff, SPE164553, presented at the SPE Unconventional Resources Conference-USA, The Woodlands, Texas, USA 10-12 April 2013.
- (5) Thomas, G.A., and T. G. Monger-McClure. 1991. Feasibility of Cyclic CO<sub>2</sub> Injection for Light-Oil Recovery. SPE 20208, presented at the SPE/DOE Symposium on Enhanced Oil Recovery, Tulsa OK 22-25 April 1990.