



# Renew Production of Depleted Oil Wells. CO<sub>2</sub> Huff `n Puff Well Stimulation Increases Oil Recovery.



## Stimulate depleted wells

Huff `n Puff is a proven single-well stimulation method that can dramatically increase production from stripper, depleted or low-pressure oil wells. Since the early 1990s, Linde has deployed Huff `n Puff technology to inject carbon dioxide (CO<sub>2</sub>) into depleted wells, with results of incremental oil production. Studies have shown CO<sub>2</sub> Huff `n Puff can increase oil recovery, boost short-term production, and provide important information on injectivity and pressure communication with adjacent wells.<sup>1</sup>

## How it works

Linde's Huff `n Puff trailer-mounted pumping package, equipped with pump, operator's room, well-piping storage and fuel tank, injects liquid CO<sub>2</sub> at predetermined pressure into the well hole at immiscible conditions. The CO<sub>2</sub> is shut-in according to bottom-hole pressure, then flowed back to the surface – usually with a dramatic increase in oil production. The injected CO<sub>2</sub> causes oil to swell, lowering its viscosity and interfacial tension. Energy stored in the CO<sub>2</sub> works as a drive mechanism to move fluids to the producing wells.

## Why Huff-n-Puff

Huff `n Puff is the ideal, affordable solution for depleted single wells that are not yet ready for refracturing. For significantly less than the cost of a refracture, Huff `n Puff provides energy to give hydrocarbons in low-pressure zones the necessary lift to get them flowing to the wellbore. When subjected to normal well stimulation pressures, CO<sub>2</sub> exhibits a hydrostatic head equal to or greater than fresh water, lowering treating pressures and horsepower costs.

## Benefits

EOR well treatment & pilot floods, remove water, frac hit mitigation

## Unit specification

Minimum output pressure:	300 psig
Maximum output pressure:	2400 psi
Minimum Flow rate*:	0.5 bpm
Maximum Flow rate:	3 bpm
Minimum operating temperature :	-20°F
Maximum operation temperature (Heater):	200°F

\*varies with discharge pressure

## Linde for CO<sub>2</sub>

As the world's leading industrial gases company and the largest supplier of CO<sub>2</sub> in North America, Linde provides high quality CO<sub>2</sub> on a national scale, yet with local service. We provide energized fluid solutions for oil and gas customers in every major basin in North America, and back that up with field support by our team of highly trained field engineering and pump specialists.

<sup>1</sup> Mohammed-Singh, L., Petronin, and Singhal, A.K. and Sim, S., 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.

**Safety**

There is no higher priority in Linde than the safety of people, property and the environment. Managing risks is a vital component in achieving our goal of zero accidents and achieving our vision: "At Linde we do not want to harm people or the environment." Linde has performed comprehensive risk assessments to evaluate and determine the necessary safeguards to protect our customers, contractors and employees. These safeguards are designed into our equipment and work procedures.

Linde offers the following recommendations and guidelines based on two decades' experience with Huff 'n Puff well stimulation.

**Shut-in recommendations**

	Low Energy Reservoirs	Moderate Energy Reservoirs	High Energy Reservoirs
psi	<400	400-1,000	1,000-2,400
Shut-in	5-8 days	10-14 days	15-30 days
Comments	Produce well as soon as evidence exists that water or oil flowed back to the wellbore	A good deal of swelling takes place at this pressure range	High pressure realizes a large oil swelling benefit when CO <sub>2</sub> is introduced

**Well selection guidelines**

- The well should be mechanically sound; tubulars in the well should be in good shape and recently tested. The well head should be rated to the corresponding treatment pressure.
- Wells with evidence of thief zones and extensive fractures are not good candidates for Huff 'n Puff. Confinement of CO<sub>2</sub> around the well bore is paramount to a successful job.
- Oil wells with good initial production rates are preferred. Current oil production rate is not particularly important, as long as total fluid rate is high.

**Production equipment requirements**

- For non-producing wells, turn well on until CO<sub>2</sub> injection has started. This tests the existing production equipment prior to injection.
- Candidate wells should be equipped with a pumping system that does not use casing gas for fuel. CO<sub>2</sub> makes the casing gas incombustible.
- For wells with a rod pump, a gas anchor is recommended. Otherwise, a gas-tolerant pump can be used, or the pump can be positioned below the perforations.

**CO<sub>2</sub> injection guidelines**

- Pressure-test the casing before CO<sub>2</sub> injection. Test the stuffing box for anticipated tubing pressure during injection.
- Inject CO<sub>2</sub> down the annulus with pump in place; this preserves the well for pump installation after CO<sub>2</sub> is in the formation.
- If using injection string, position compression-set or lock-set packer as close to the perforations as possible. The backside should be filled with fluid prior to injection and casing pressure monitored throughout injection to test for packer leaks.

**Talk to Linde**

We'll help you determine if Huff 'n Puff is the right technology for your wells, design the treatment and operate the stimulation to renew production from depleted wells.

Learn more at [www.linde-gas.com](http://www.linde-gas.com).

**Additional references**

- Wells Stimulated by Huff-n-Puff:**  
 SPE 15502-PA – An Evaluation of CO<sub>2</sub> Huff 'n Puff Tests in Texas  
 SPE 15501-PA  
 SPE 27656  
 EERC Williston Basin Huff 'n Puff

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