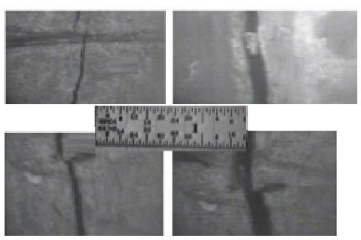
The Basics of Wells – Hydraulic Fracturing: What is it?

Hydraulic fracturing is a highly established, sixty-year old well stimulation technique that has been used an estimated six million times worldwide. Fracturing stimulation is critical to today's U.S. production of most oil and gas resources. The need for hydraulic fracturing depends on the natural flow capacity or permeability of the formation. Economic flow from the earliest wells depended on the wellbore contacting formations with high natural flow capacity, but as hydrocarbon reserves in these high permeability formations ran low, attention turned to technologies that could accelerate hydrocarbon flow from lower permeability formations.

Oil and gas well fracturing, in the most simple of terms, creates a crack or fracture through hydrocarbon bearing rock using pressure and an injected water, oil or gas-based fluid to overcome rock tensile strength and formation stresses. The objective is to create a fracture that may grow vertically and laterally outward from the well. After the fracture is initiated at the wellbore and widened by increasing injection rate, a proppant material, usually sand or man-made ceramic, is carried into the fracture by the injected fluid, packing the fracture with sufficient proppant to maintain a stable flow path along the fracture after the hydraulic fracturing pressure is released. Fracture shape varies with the specific conditions but is usually in the range of a few hundred feet along vertical and horizontal planes within the rock. At depths greater than about a thousand feet, fractures are vertical. Downhole camera pictures of fractures at about 4500 ft. show that fractures are usually very narrow and may close completely if sufficient proppant is not placed to offset the closure stresses in the rock.



Downhole video images of hydraulically created fractures in open hole, vertical producing wells in west Texas San Andreas formation at depths of about 4500 ft (1370m).
Top Left: narrow vertical fractures stopped by thin shale beds.
Top Right: a Wider fracture propped open by a rock fragment.
Lower Left: an unpropped fracture at low pressure.
Lower Right: the same fracture during fluid injection (700 psi higher pressure).

Fracture growth is limited by both natural and applied forces and factors. Changing depositional environments have shaped the rock strata for millennia, creating rock layers with different characteristics, many of which cannot easily be fractured. These formations are natural barriers to fracture height growth. The natural containment barriers in reservoirs are extremely strong; proven by the fact that much of the low density oil and gas remained trapped there even after millions of years of major earthquakes. As a fracture grows outward from the well, some of the injected fluid is continually lost to the permeable formation, reducing the pressure in the fracture and eventually stopping fracture growth when the total leak-off rate equals the injected rate. Fracture barriers and rock stresses control the extent to which a fracture can develop. Typical fracture heights from top to bottom are about three hundred feet and unusually tall induced fractures beyond seven hundred feet are not known.

Formation permeability is the ability to flow fluids through pores and natural fractures in the rock. As hydrocarbon reserves have declined, low initial permeability shale formations, part of the vast shale belts of the world, have become the oil and gas reserves for the future. Hydraulic fracturing in these ultra-low permeability formations is a flow enabling technology and production would not be possible without it.

Pollution from wells and the associated processing and distribution systems has been demonstrated to be preventable if the companies and governments that are involved in production will operate in a responsible manner. The fracturing process, using fresh or salt water, with proppant and chemicals to control bacteria and reduce friction, is routinely modified to fit the geology of the well. Most problems in actual field studies have been identified as transport (moderate to minor) and well construction (minor). Potential for pollution by fracturing can exist in rare cases but has been rated as a very low risk by numerous third-party studies and US national lab run studies, particularly when safer chemicals are used to reduce transport or spill risks and the wells are designed to operate successfully during and after the fracturing treatment.

Fracturing has developed from a curiosity in the late 1940's to the dominant stimulation mechanism for shales and other low conductivity reservoirs that hold massive volumes of oil and gas. Fracturing is routinely used for wells that are thousands of feet deeper than any local fresh water occurrence. Well design requirements for hydraulically fractured wells includes stronger pipe and additional cement.

Photos- Left: The first Stanolin Oil fracture job near Hugoton, Kansas, in 1947. Right: Apache Frac near Snook, Texas, in 2015. 1947 photo by Stanolin Oil Company. 2015 photo coutesy of Sam Pittman.

One of the most frequently voiced concerns about hydraulic fracturing is that fracturing would contaminate groundwater with chemicals, methane gas or oil. Potential to fracture into water sands from deep hydrocarbon zones is exceptionally low as shown by microseismic monitoring data that established the distance between the "top" of fractures and the bottom of the deepest water zones in thousands of fracture treatments in the Barnett Shale and other formations.

Fracture Height-Growth - Examples of fracture height in Four Major Plays (Pinnacle data)						
Shale	Number of Fracs with Microseismic Data	Primary Oil or Gas Pay Zone Depth	Fresh Water Depth [Typical] (Deepest)	Typical Distance between top of Fracture and Deepest Water		Closest Approach of Top of Fracture in Shallowest Oil & Gas Pay to Deepest Fresh Water
Barnett (TX)	3000+	4700' to 8000'	[500'] (1200')	4800'		2800'
Eagle Ford (TX)	300+	8000' to 13,000'	[200'] (400')	7000'		6,000'
Marcellus (PA)	300+	5000' to 8500'	[600'] (1000')	3800'		3800'
Woodford (OK)	200+	4400' to 10,000'	[200'] (600')	7500'		4000'

Disclosure: George E. King is a Texas Registered Professional Engineer with over 44 years oilfield experience. His technical background includes fracturing, workovers, chemicals, acidizing, well integrity and horizontal wells.
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