Hydraulic Fracturing Process

Pennsylvania Independent Oil & Gas Association

The hydraulic fracturing process, also known as "well stimulation," is vital to extracting natural gas from the Marcellus and Utica shale, as well as other geological formations in Pennsylvania.
Over the course of nearly 70 years, well stimulation has been researched, advanced and used across the United States as a safe and effective method to create tiny cracks in the targeted formation that allow oil and natural gas to flow freely into a wellbore and up to the earth's surface.

Hydraulic fracturing technology has been used to produce oil and natural gas since 1949. The process involves pumping a mixture made up of 99.5 percent water and sand, along with a minimal amount of additives, into the ground under high pressure. The solution opens tiny fractures in the rock to allow a pathway for the oil and gas to enter the wellbore. It typically takes about a week of round-the clock activity to complete a hydraulic fracturing operation, at which point the equipment is removed to allow the well to enter the final completion and production stage. *(Photo courtesy of Range Resources.)*

The Well Stimulation Process

Operators begin the stimulation process once a well has been drilled to a desired vertical and horizontal depth, with a series of steel pipes, called casing strings, cemented in place along the length of the wellbore. The steel and cement isolates the well from the surrounding geology and groundwater zones found above. Groundwater sources are typically located a mile or more above shale formations in Pennsylvania. A device known as a perforating gun is first lowered into the well to a designated location in the shale, and a charge is fired down the well from a wire at ground surface to perforate the steel casing, cement and the shale formation. This perforation stage creates small cracks, or fractures, in the rock.

A mixture of water, sand and chemicals is then injected into the wellbore under high pressure. The sand holds open the cracks in the rock to allow the well to produce natural gas. Water and sand make up about 99.5 percent of the fluid injected into the well, and the chemicals used in the process – both small in number and dilute in concentration – can be found in many household items.

Once the first producing zone of the well has been perforated and stimulated, a rubber plug is placed near it to isolate that area from the rest of the horizontal wellbore. The perforation and stimulation processes then continue multiple times along the length of the formation to make the well as productive as possible. A drill bit is lowered into the well after the process is completed to drill out the rubber plugs and allow gas to flow to the surface.

Completing the Process

At the completion of the stimulation process, approximately 20-30 percent of the water flows back up the wellbore, where it is collected and held in metal tanks, and then recycled in a subsequent well completion operation. While lined impoundments are often used to hold freshwater used in the well stimulation process, they are not used to store flowback water

Operators in Pennsylvania have pioneered the technology of recycling flowback water, with most achieving a 100 percent recycling rate. Over the productive life of the well, additional "produced" water slowly comes to the surface, where it is collected in on-site storage tanks and transported to permitted treatment facilities.

Protecting Groundwater

Agencies in Pennsylvania enforce stringent regulations to protect groundwater during both the drilling and well stimulation process. Shale wells require multiple, redundant layers of steel casing and cement, and strict quality control procedures for steel and cementing integrity to protect groundwater sources.

State and federal oil and gas regulatory agencies, including the Pennsylvania Department of Environmental Protection, have not documented a case of drinking water contamination related to the stimulation of an oil or natural gas well. In April 2009, the Groundwater Protection Council stated that the chances of groundwater contamination due to this process are as low as 1 in 200,000,000.

Regulation of Water Withdrawals

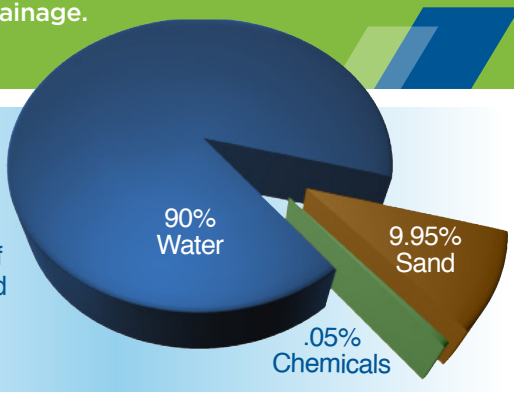
Water use in the well stimulation process is regulated in Pennsylvania either by the state DEP, or the federal Susquehanna River Basin Commission, with approval required for every withdrawal from streams or rivers. These withdrawals are limited to fraction of a waterway's normal flow to protect aquatic life, and stream withdrawals can be halted in the event of low flow conditions. Recycling advancements have reduced total water withdrawals required for well stimulation, and the use of temporary pipeline systems have eliminated significant truck traffic from roadways where drilling activity is taking place.

FAST FACTS

- A 2009 study by the Groundwater Protection Council, a non-profit organization of state groundwater regulators, found the chance for contamination of drinking water sources from the well stimulation process to be one in 200 million.
- The use of temporary water lines for well stimulation operations can greatly reduce truck traffic and their related emissions, as has the increased use of natural gas in place of diesel to power well stimulation equipment.
- Well stimulation has been practiced in drilling oil and natural gas wells in the U.S. since 1949, without a reported incident of groundwater contamination. The well stimulation process is required to produce oil and gas from almost every well drilled around the world.
- Companies in Pennsylvania are developing technologies to recycle flowback water and utilize "least quality" water sources for well stimulation, such as water impacted by abandoned mine drainage.

According to an analysis by the Susquehanna River Basin Commission, Marcellus Shale development at its anticipated peak levels of production in the Susquehanna River watershed would require the use of 60 million gallons of water a day. This amount is less than half of what is needed for recreational purposes, such as irrigating golf courses or making snow at ski resorts.

Water and sand make up about 99.5 percent of the solution used in hydraulic fracturing, with a small number of dilute chemicals added for specific purposes, as summarized below.



New Technologies

The companies developing Appalachian shale formations are also advancing a range of new technologies that will improve the environment, reduce demands on roadways and save energy. Companies have successfully converted both drilling rigs and hydraulic fracturing engines from diesel fuel to a mix that include almost 70 percent natural gas, a technological advance that will save millions of gallons of diesel fuel and reduce air emissions. Pennsylvania has also moved to use water impaired by acid mine drainage and other "lesser quality" water sources for hydraulic fracturing operations.

An equal amount of work is taking place to research the use of additives that are biodegradable and do not bioaccumulate in the environment, including ingredients found in many foods. Guar gum, a thickener used in dairy products, baked goods and ketchup, is used as a friction reducer in the well stimulation process, while citric acid, used in the production of soft drinks and wine, is effective in controlling iron in a wellbore.

Pennsylvania's winters have also led to the discovery of environmentally friendly additives required to prevent water from freezing during cold weather well stimulation, with the increased use of glycerin and potassium formate rather than material such as methanol, which is found in windshield cleaning solutions. Research is ongoing to find ways to enhance recycling capabilities, identify effective biodegradable additives and improve the well stimulation process.

COMMON WELL STIMULATION ADDITIVES

Between five and ten additives are commonly used to stimulate a shale gas well, making up between .05 and .5 percent of the total injection into the well, depending on a well's geological conditions. The list below identifies many of them; the right column lists their common uses.

CHEMICAL	PURPOSE	COMMON HOUSEHOLD PRODUCT
Acids	Helps dissolve minerals and initiate fissure in rock (pre-fracture)	Swimming pool cleaner
Glutaraldehyde	Eliminates bacteria in the water	Disinfectant; Sterilizer for medical and dental equipment
Sodium Chloride	Allows a delayed break down of the gel polymer chains	Table Salt
N, n-Dimethyl formamide	Prevents the corrosion of the pipe	Used in pharmaceuticals, acrylic fibers and plastics
Borate salts	Maintains fluid viscosity as temperature increases	Used in laundry detergents, hand soaps and cosmetics
Polyacrylamide	Minimizes friction between fluid and pipe	Water treatment, soil conditioner
Petroleum distillates	"Slicks" the water to minimize friction	Make-up remover, laxatives, and candy
Guar gum	Thickens the water to suspend the sand	Thickener used in cosmetics, baked goods, ice cream, toothpaste, sauces, and salad dressing
Citric Acid	Prevents precipitation of metal oxides	Food additive; food and beverages; lemon juice
Potassium chloride	Creates a brine carrier fluid	Low sodium table salt substitute
Ammonium bisulfite	Removes oxygen from the water to protect the pipe from corrosion	Cosmetics, food and beverage processing, water treatment
Sodium or potassium carbonate	Maintains the effectiveness of other components, such as crosslinkers	Washing soda, detergents, soap, water softener, glass and ceramics
Proppant	Allows the fissures to remain open so the gas can escape	Drinking water filtration, play sand
Ethylene glycol	Prevents scale deposits in the pipe	Automotive antifreeze, household cleansers, deicing, and caulk
Isopropanol	Used to increase the viscosity of the fracture fluid	Glass cleaner, antiperspirant, and hair color