Facts on Hydraulic Fracturing

Exploring Chemicals

Water storage for completion operation in Colorado.

January 2015
Part 1
Introduction

The oil and natural gas industry has been using the technique of hydraulic fracturing, or fracking as it is more commonly known, for decades in order to economically produce oil and natural gas found in dense subsurface rock formations. Hydraulic fracturing opens microscopic pathways that enable natural gas and oil to pass through the tight rock formations into the wellbore and ultimately be collected in a safe, cost-effective, and timely manner at the surface. The process requires significant amounts of water and relatively small amounts of additives, or chemicals. Some environmental and public concerns have been raised regarding the use of chemical additives. The industry recognizes the need for better understanding transparency and continuing education regarding the use of these chemicals and hydraulic fracturing technology.

Just as hydraulic fracturing is essential to producing oil and natural gas from tight rock, chemical additives play vital roles and are necessary to the hydraulic fracturing process. There are only a limited number of chemicals that are routinely used, although there are many chemicals that service companies could use as additives. Through regulatory measures, voluntary actions and appropriate management practices, the oil and natural gas industry implements the necessary measures to mitigate and manage risks posed by shale gas operations.

Key Facts:

1. Additives are necessary for the successful placement of the fracture treatment and to enhance safe and efficient production of oil and natural gas from dense rock formations including shale.

2. The relative volume and concentration of additives used in hydraulic fracturing is low, less than 1 percent of total volume in most applications.

3. Additives used in hydraulic fracturing fluids generally consist of chemicals used in other public and household applications.

4. Industry has been a driving force to develop forums to publicly share the ingredients used in hydraulic fracturing programs worldwide.

5. There are existing rules, regulations, best practices and industry guidelines that have proven effective to safely manage chemicals and avoid spills.

6. Under U.S. law “Trade Secrets” legal protection applies to nearly all consumer goods and only a very small amount of the total products used in fracturing.
Key Fact 1
Additives are necessary for the successful placement of the fracture treatment and to enhance the safe and efficient production of oil and natural gas from dense rock formations including shale.

The use of chemical additives is key to the safe and effective hydraulic fracturing of dense oil- and natural gas-bearing rock formations. Ranging from limiting the growth of bacteria to the prevention of corrosion of the well casing (protecting the surrounding environment), chemicals are needed to ensure that the fracturing job is effective, efficient, and above all else safe (http://www.fracfocus.org/water-protection/drilling-usage).

The specific chemistry of hydraulic fracturing fluid is engineered to successfully place sand in a fracture in order to recover oil and natural gas from a particular geological formation, increase production in the well, and protect the integrity of the wellbore and associated equipment. A typical hydraulic fracturing fluid is primarily water and sand with less than one percent concentrations of between one and 12 additives, depending on the characteristics of the target formation (http://fracfocus.org/water-protection/drilling-usage). The exact composition of a hydraulic fracturing fluid typically is determined on a case-by-case basis, depending on real-time conditions at the job location and knowledge of the formation being fractured.

The standard industry term “additive” refers to the chemical products typically added to a base fluid to create the fracturing fluid mixture that is pumped down the wellbore in hydraulic fracturing operations. An additive is generally a mixture of chemicals and in fewer cases can be a single chemical substance. The chart on page 5 depicts the generic hydraulic fracturing additives used, the applicability in the process, and the reasons for use. Breakers, biocides, friction reducers, and acid corrosion inhibitors are the most common categories of chemical additives used (http://www.epagov/ogwdw/uic/pdfs/cbmstudy_attach_uic_ch04_hyd_frac_fluids.pdf).

To increase the recovery of natural gas or oil and overall production from a well, additives such as friction reducers, proppant, and biocides may be used in a fracture treatment. It is important for the wellbore to be adequately protected from the formation of scale or corrosive materials to ensure the integrity of the well. To accomplish this, operators use corrosion and scale inhibitors and biocides to protect the steel pipe, also called casing, of a well, in part to protect groundwater aquifers.

The oil and natural gas industry demonstrates a commitment to continuous improvement in hydraulic fracturing technology, including how and what chemical additives are used. Industry is reducing the use of certain chemicals and developing new chemicals that combine operational efficiency with improved environmental performance. For example, companies are evaluating additives that have a faster degradation timeframe and chemistries that breakdown into benign substances in the environment or into a form that naturally occurs in the environment (The Modern Practices of Hydraulic Fracturing: A Focus on Canadian Resources).
<table>
<thead>
<tr>
<th>Additive</th>
<th>Purpose</th>
<th>Downhole Result</th>
<th>Other Common Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid</td>
<td>Helps dissolve minerals and initiate cracks in the rock</td>
<td>Reacts with minerals present in the formation to create salts, water and carbon dioxide</td>
<td>Swimming pools, chemical cleaners</td>
</tr>
<tr>
<td>Corrosion Inhibitor</td>
<td>Protects casing from corrosion</td>
<td>Bonds to metal surfaces (pipe), any remaining product not bonded is broken down by micro-organisms and consumed or returned in produced water</td>
<td>Pharmaceuticals, acrylic fibres and plastics</td>
</tr>
<tr>
<td>Biocide</td>
<td>Eliminates bacteria in the water that can cause corrosive by-products</td>
<td>Reacts with micro-organisms that may be present in the treatment fluid and formation</td>
<td>Disinfectant, sterilizer for medical and dental equipment</td>
</tr>
<tr>
<td>Breaker</td>
<td>Allows a delayed breakdown of gels</td>
<td>Reacts with the crosslinker and gel once in the formation, reaction produces ammonia and sulfate salts</td>
<td>Hair colouring, disinfectant, manufacture of common household plastics</td>
</tr>
<tr>
<td>Clay Stabiliser</td>
<td>Temporary or permanent clay stabiliser to lock down clays in the shale structure</td>
<td>Reacts with clays in the formation through a sodium-potassium exchange, reaction results in sodium chloride (salt)</td>
<td>Low sodium table salt substitute, medicines, intervenous fluids</td>
</tr>
<tr>
<td>Crosslinker</td>
<td>Maintains viscosity as temperature increases</td>
<td>Combines with the breaker in the formation to create salts</td>
<td>Laundry detergents, hand soaps, cosmetics</td>
</tr>
<tr>
<td>Friction Reducer</td>
<td>Reduces friction effects between the water and the pipe</td>
<td>Remains in formation where temperature and exposure to breaker allows micro-organisms to consume</td>
<td>Cosmetics, make-up, nail and skin products</td>
</tr>
<tr>
<td>Gel</td>
<td>Thickens the water in order to suspend the proppant and sand</td>
<td>Combines with breaker in the formation to enhance fluid return to the borehole</td>
<td>Cosmetics, baked goods, ice cream, toothpaste, sauces, salad dressings</td>
</tr>
<tr>
<td>Iron Control</td>
<td>Helps to prevent precipitation of metal oxides</td>
<td>Reacts with the minerals in the formation to create simple salts, carbon dioxide and water which, are returned in produced water</td>
<td>Food additive, beverages, lemon juice</td>
</tr>
<tr>
<td>Non-Emulsifier</td>
<td>Used to break or separate oil and water mixtures</td>
<td>Generally returns in produced water; in some shale formations, can return via produced natural gas</td>
<td>Laundry detergents, dishwasher detergents, carpet cleaners</td>
</tr>
<tr>
<td>pH Adjusting Agent</td>
<td>Maintains effectiveness of other additives such as crosslinkers</td>
<td>Reacts with acidic agents in the treatment fluid to maintain a neutral (non-acidic, non-alkaline) pH, produces salts, water and carbon dioxide, returns in produced water</td>
<td>Detergent, washing soda, water softener, soap</td>
</tr>
<tr>
<td>Scale Inhibitor</td>
<td>Prevents build-up of scale in pipe and formation</td>
<td>Product attached to the formation, majority of the product returns with produced water, remainder consumed by micro-organisms</td>
<td>Household cleaners, de-icers, paints</td>
</tr>
<tr>
<td>Surfactant</td>
<td>Reduces surface tension of the treatment fluid in the formation and helps improve fluid recovery from the well post stimulation</td>
<td>Some made to react with the formation, some to be returned with produced water; or some enter the produced natural gas</td>
<td>Glass cleaner, multi-surface cleaner, antiperspirant, deodorants, hair-colour</td>
</tr>
</tbody>
</table>
Key Fact 2
The relative volume and concentration of additives used in hydraulic fracturing is low, less than 1 percent of total volume in most applications.

The design of a hydraulic fracture job takes into consideration the type of geologic formation being fractured, anticipated well spacing, and the selection of proppant material. Other considerations include the formation temperature and pressure, length of the productive interval to be fractured, reservoir depth, and the formation, and underlying and overlying rock properties.

Water is the primary component for most hydraulic fracture treatments, representing the majority of the total volume of fluid injected during fracturing operations. The proppant is the next largest constituent of injected material. Proppant is a granular material, usually sand, which is mixed with the fracture fluids to hold or prop open the fractures enabling oil or natural gas to flow into the wellbore and ultimately through production equipment at the surface. Proppant materials are selected based on the strength needed to hold the fractures open after the job is completed with the desired fracture conductivity.
A fracture treatment will typically use low concentrations of between three and 12 chemical additives, with certain formations only needing one to two chemicals. [http://fracfocus.org/water-protection/drilling-usage](http://fracfocus.org/water-protection/drilling-usage)

The ingredients used in fracturing fluids vary according to geology. In general terms, water makes up more than 90 percent of the solution; sand or proppant constitutes approximately nine percent; and additives make up less than one percent of the total volume. The below pie chart, available at FracFocus, shows a general breakout of typical ingredients.

![Average Hydraulic Fracturing Fluid Composition for U.S. Shale Plays](http://fracfocus.org/water-protection/drilling-usage)

Acid is commonly used as a chemical additive in hydraulic fracturing fluids, as well as other common consumer products. In most cases, acids are substantially diluted. In hydraulic fracturing fluid the concentration of the acid when injected into the ground is generally 1,000 times weaker than the concentrated versions presented in product Safety Data Sheets, SDSs, (Halliburton, Inc., Virginia Site Visit, 2001; Schlumberger, Ltd., 2001). ([http://www.epa.gov/ogwdw/uic/pdfs/cbmstudy_attach_uic_ch04_hyd_frac_fluids.pdf](http://www.epa.gov/ogwdw/uic/pdfs/cbmstudy_attach_uic_ch04_hyd_frac_fluids.pdf)) A specific example of the level of dilution of specific additives that occurs is the use of hydrochloric acid (HCl). HCl is a common chemical with many uses including treating swimming pool water systems and is also produced by our bodies to assist with digestion. In hydraulic fracturing, a typical HCl concentration is composed of 85 percent water and 15 percent acid. Once the entire stage of fracturing fluid has been injected, the total volume of acid in an example fracturing fluid from the Fayetteville shale was 0.123 percent. This indicates that the fluid had been diluted by a factor of nearly 1,000 before it was pumped into the formation. At this concentration, according to the U.S. Department of Energy, hydrochloric acid is safe to drink ([http://energy.gov/sites/prod/files/2013/03/f0/ShaleGasPrimer_Online_4-2009.pdf](http://energy.gov/sites/prod/files/2013/03/f0/ShaleGasPrimer_Online_4-2009.pdf)). Furthermore, if this acid comes into contact with carbonate minerals in the subsurface shale formation, it is neutralized ([Modern Shale Gas Development in the United States by the U.S. Department of Energy](http://www.epa.gov/energy/shalegasprimer)).

Although the concentration of chemicals usage is very small in hydraulic fracturing fluids, sometimes measured less than parts per billion, they are critical to safe and successful operations.
Key Fact 3
Additives in hydraulic fracturing fluids generally consist of chemicals used in other public and household applications.

Chemicals, in varying forms and types, play an essential role in today’s modern society. Most commercial processes and household products contain chemicals that can be hazardous in large quantities and concentrations if not handled properly. For example, drinking water treatment plants use large quantities of chlorine to treat the water. When used and handled properly, it is safe for workers and near-by residents and provides clean safe drinking water for the community. Similarly, operators use chemical additives in hydraulic fracturing that are safe when properly handled according to regulations and long-standing industry practices. In addition, many of these additives are common chemicals, which people regularly encounter in everyday life, as depicted in the graph on page 9 and in table on page 5 (http://energy.gov/sites/prod/files/2013/03/f0/ShaleGasPrimer_Online_4-2009.pdf Page 62).
Understanding Fracturing Fluid

The fluid from the hydraulic fracturing process is nearly 99.5% WATER & SAND. 9.5% SAND

90% WATER

Typical Additives Used in Fracturing Fluid and COMMON HOUSEHOLD ITEMS

SODIUM CHLORIDE used in table salt
ETHYLENE GLYCOL used in household cleaners
BORATE SALTS used in cosmetics
SODIUM/POTASSIUM CARBONATE used in detergent
GUAR GUM used in ice cream
ISOPROPANOL used in deodorant

To create productive natural gas wells, companies force fluid thousands of feet below the surface at high pressure to crack shale rock and release trapped natural gas. This extraction technique is called hydraulic fracturing. The fluid used in the process is made up almost entirely of water and sand. However, it also includes a very small percentage of chemical additives that help make the process work.

One of the most common chemical additives used in hydraulic fracturing is biocide. A biocide is a substance or microorganism that inhibits or controls the growth of living organisms, such as bacteria. One of the most readily used biocides in hydraulic fracturing is Bronopol (2-Bromo-2-nitro-1,3-propanediol, CAS# 52-51-7), a white crystalline powder. Bronopol is listed in both the U.S. and the E.U. as an approved cosmetic preservative at levels up to 0.1 percent. Bronopol is an excellent preservative for both leave-on and rinse-off products such as creams, lotions, shampoos, rinses, wipes and towelettes. Additionally, Bronopol is regularly used in applications such as:

- Household, institutional, and industrial – product preservation;
- Metalworking fluids;
- Natural gas and oil operations;
- Pulp, paper mills – pulping operations, wet-end additives;
- Water-based paints, inks, and adhesives; and
- Water treatment – cooling-tower water, water baths, air conditioning/humidification systems, recirculating heating/cooling systems, oil-field muds and injection water.

Another example of an additive that is used for hydraulic fracturing is surfactants. Surfactants reduce the surface tension between water and oil, allowing for more oil to be extracted from porous rock underground.

In a study published in the journal *Analytical Chemistry* (http://pubs.acs.org/doi/abs/10.1021/ac502163k), the research team identified the surfactants found in fluid samples from hydraulic fracturing operations in Colorado, Louisiana, Nevada, Pennsylvania and Texas. The “surfactant” chemicals found in fracturing fluid were analysed and reported to be no more harmful than substances commonly found in homes, according to the University of Colorado Boulder, 2014.

Examples of other uses of chemicals typically found in hydraulic fracturing fluid are listed below (AXPC Real Facts about Fracture Stimulation, 2010):

- **Antibacterial Agent:** Disinfectant, Used to Sterilize Medical Equipment
- **Breaker:** Hair Cosmetics, Household Plastics
- **Corrosion Inhibitor:** Pharmaceuticals, Plastics
- **Crosslinker:** Soaps, Laundry Detergent
- **Diluted Acid:** Household Cleaner, Swimming Pool Cleaner
- **Friction Reducer:** Water Treatment, Candy, Make-up Remover
- **Gelling Agent:** Toothpaste, Baking Goods, Ice Cream, Sauces, Cosmetics
- **Iron Control:** Food Additive, Lemon Juice, Flavoring in Food & Beverage
- **pH Adjusting Agent:** Detergents, Washing Soda, Water Softener, Soap
- **Potassium Chloride:** Low Sodium Table Salt Substitute
- **Scale Inhibitor:** Household Cleaners, Deicing Agent
- **Surfactant:** Glass Cleaner, Antiperspirant, Hair Color
Key Fact 4
Industry has been a driving force to develop forums to publicly share the ingredients used in hydraulic fracturing programs worldwide.

The oil and natural gas industry recognizes the need for greater transparency regarding the chemicals used in hydraulic fracturing and its responsibility to openly share information. In the U.S., industry entered into discussions with states through the Ground Water Protection Council (GWPC) and Interstate Oil and Gas Compact Commissions (IOGCC), two organizations whose missions revolve around conservation and environmental protection. As a result of their collaborative efforts, a system was designed that provides a single consistent location for industry to publicly share detailed information regarding the components of hydraulic fracturing additives, information about the well, volume of water used, and the concentrations of chemicals included in the additives. The program was named FracFocus (www.fracfocus.org). The primary purpose of this site is to provide factual information concerning hydraulic fracturing and groundwater protection (http://www.fracfocus.org/welcome). Additionally, the site provides educational information to the public on the topic of hydraulic fracturing and enables public searches by location, well information, date, chemical name, and chemical identification number.

This comprehensive online registry provides detailed and readily accessible information on chemicals used in hydraulic fracturing. As the success of FracFocus grew, states in the U.S. started evaluating the need for regulations around the public disclosure of additives used in the fracturing process. To date, the majority of oil and natural gas producing states have adopted disclosure regulations that require or encourage the use of FracFocus as the reporting mechanism. The U.S. Environmental Protection Agency (EPA) stated that FracFocus “has become widely accepted as the national hydraulic fracturing chemical registry” and “has become one of the largest sources of data and information on chemicals used in hydraulic fracturing.” Since FracFocus first went into operation on April 11, 2011 the FracFocus system has recorded information on more than over 80,000 wells from a total of more than 1,000 participating companies. During the same period, the FracFocus website had been visited more than 3 million times (http://www.fracfocus.org/).

In addition, Canada and the International Association of Oil and Gas Producers (IOGP) have adopted a disclosure regime similar to FracFocus.
Key Fact 5
Proper surface management of additives is paramount to minimizing potential impacts of oil and natural gas development.

Responsible management practices are employed to mitigate or manage the risks posed by shale gas operations. The U.K. Royal Society and the Royal Academy of Engineering concluded in June 2012 that the health, safety and environmental risks associated with hydraulic fracturing can be effectively managed through a combination of sound regulation and modern technology.

“We know that natural gas can safely be developed, and to the credit of the industry there are many companies that are leaning into this challenge and promoting best practices for safer and efficient production. That’s not always widely noticed or appreciated, but it’s a fact.”

Heather Zichal
President Obama’s top energy and climate adviser (2012)

There is a commonly shared value between communities and companies to respect and protect the safety and health of the public, workers and environment. In the U.S., local and regional authorities, stakeholders, and companies have worked together for more than a decade to better understand the concerns and actual risks of shale operations. Current operational practices and legislation are regularly evaluated and modified, new technology is developed, and control measures are further refined to continuously improve operations and further minimize risks from shale gas operations.

There are several examples of processes to review and determine whether existing rules, guidelines, and legislation related to shale gas activities are suitable to safely and appropriately manage specific activities. The U.S. State Review Process (STRONGER, http://www.strongerinc.org/, latest revision May 2013) has systematically evaluated state regulations and provided recommendation for improvements. The independent review for the European Commission in 2011 by law firm Philippe & Partners was used to assess whether the existing laws in Europe adequately cover shale gas (http://ec.europa.eu/energy/studies/doc/2012_unconventional_gas_in_europe.pdf).

In addition to regulatory controls, industry and other organizations have developed ‘Recommended Practices’ to protect ground and surface water during shale gas operations. The most frequently implemented guidelines are summarized below. A more comprehensive list of recommended practices is found in Appendix A.

- Groundwater Protection Council: FracFocus (www.fracfocus.org): a program whereby oil and natural gas companies can report products used in hydraulic fracturing.


- The American Petroleum Institute (API) has a large portfolio of industry practices and guidelines supporting shale operations: http://www.api.org/~/media/Files/Policy/Exploration/Hydraulic_Fracturing_InfoSheet.pdf.
Key Fact 6
Under U.S. law “Trade Secrets” legal protection applies to nearly all consumer goods and only a very small amount of the total products used in fracturing.

“Trade Secret” legal protection applies to nearly all consumer goods under U.S. law, and only a very small amount of the total products used in fracturing. It is an exception that is provided under U.S. law for service companies that seek legal protection for a product’s proprietary recipe.

Trade secret laws are designed to protect intellectual property or technological and commercial information against unauthorized commercial use by others. The primary policy consideration underlying trade secret protection is the desire to encourage research and development by providing protection to the originator of business information. A company’s trade secrets can be among its most important assets – the key intellectual property that allows it to maintain market position for its products or services and provide value to its shareholders.

Approximately 99.5 percent of the contents of most hydraulic fracturing fluid systems are well-known and widely disclosed: water (90 percent) and sand (9.5 percent). Trade secret legal protection is focused on materials that are approximately 0.5 percent of hydraulic fracturing fluid. These materials consist of additives formulated to improve the performance and longevity of the fracture, reduce friction, and prevent corrosion and buildup of scale. As discussed above, the additives most often found in this 0.5 percent of hydraulic fracturing fluid systems are commonly used and can be found in food, cosmetics, and detergents.

The trade secret information is most accurately measured in fractions of a percent. In most countries, the legal protection for a specific “recipe” of a product is provided to companies in any business sector, and in narrow circumstances companies lawfully seek to protect their proprietary interests.

Companies in a variety of industries avail themselves of the benefits of trade secret protection for exactly the same reasons as oil and gas service companies. Some of the most famous examples are Coca-Cola’s secret formula, Google’s search algorithm, the herbs and spices in Kentucky Fried Chicken’s fried chicken, and the methodology for determining the New York Times’ Best Seller List.

As required by safety and emergency response regulations, companies that handle and use materials in their processes are required to maintain Safety Data Sheets (SDS) on location. The SDS documents are developed by the manufacturer of the product as a technical document, which provides comprehensive information on a product related to:

- Emergency procedures;
- Hazard evaluation related to the handling, storage or use of the product;
- Health effects of exposure to the products; and
- Measures to protect works at risk of exposure.

The oil and natural gas industry has been actively developing ways to introduce greater transparency about the chemicals used in the hydraulic fracturing process without jeopardizing incentives to innovate. As previously mentioned, the development of FracFocus was an important step in providing greater access to chemical additive information for any member of the public.
Appendix A – Additional Information


FracFocus: www.fracfocus.org

The International Association for Oil and Gas Producer’s chemical disclosure forum NGS FACTS: http://www.ngsfacts.org/

Energy from Shale: http://www.energyfromshale.org/americas-energy/environment


Completion operation with water storage tanks (foreground).
Water storage tanks and associated piping.