Oasis
Filter International Ltd.

2525 Macleod Trail SW
Calgary, Alberta, Canada T2G 5J4
Phone: (1) 403-269-1555
Fax: (1) 403-264-6244
info@oasisfilter.com
www.oasisfilter.com

Treatment of Frac Flow-Back Water

David H. Manz, Ph. D., P. Eng., P. Ag.
VP Marketing and Product Development
Pure Filtered Water International Ltd.
Oasis Filter International Ltd.

January 12, 2011

Background

Until recently (the last few years), all natural gas was extracted from porous rock formations (conventional gas reserves) using vertically drilled wells and an after-drilling production enhancement process, known as 'hydro-fracturing' or 'fracturing', which allows maximum extraction of the available natural gas from the rock formation. With the development of horizontal drilling techniques most natural gas development is now taking place in rock formations that have very low porosity, described as tight formations, such as shale, (one of several types of unconventional gas reserves). The gas production is achieved using new, efficient and cost effective fracturing processes. The exploitable natural gas reserves in tight formations are geographically extensive and many times larger than that in porous formations. Whereas the fracturing process was considered a natural gas reserves production enhancement in porous rock formations, it is an essential first step in exploiting natural gas in tight rock formations.

The fracturing process requires the injection of very large volumes of water (several millions of gallons per operation for development of tight formation unconventional reserves) under high pressure into the rock formations producing complex networks of cracks or fissures in the formation (releasing the natural gas) enabling the placement of small rocks or rock-like particles known as proppant which prevent the cracks from closing. Many different chemicals might be used to force the very large volumes of water into the rock and to facilitate proppant transport concurrently minimizing the risks of limiting natural gas production after the fracturing process is completed. Chemicals used at the completion phase of a fracturing process are often intended to destroy the effects of chemicals used at the beginning of the process. A significant fraction of the water forced into the formation may be returned after the pressure is released and it is allowed to return to the surface – as much as 50%. This water, known as flow-back

water, has very different chemical and physical composition than the initial water used in the fracturing process and it is not easily treated to a condition allowing its release into the environment. It is also difficult to reuse the flow-back in the same type of fracturing process without treatment. Where possible and economical the flow-back water is disposed of into nearby injection wells, a process known as deep-well injection.

Fracturing Systems

Three common basic systems for fracturing or fracing conventional and unconventional gas bearing rock formations are known as gel based, slickwater and hybrid.

The gel based system requires the liquid (mostly water) be made very viscous to allow transportation and positioning of the proppant into rock fissures before it can settle. The gel must ultimately be destroyed (to reduce viscosity of the fracturing fluid to that of water) to allow the excess water to be expelled from the gas producing formation once the proppant is properly positioned. The substance that destroys the gel forming chemicals is known as a gel breaker. Numerous other chemicals are added to perform a variety of special functions including disinfection, cleaning, friction reduction, formation preservation, and other uses. Flow back water is captured in special tanks along with excess proppant, a variety of other solids are also in the water such as those produced during the initial drilling and development of the well, and hydrocarbons, water and chemicals from the rock formation itself. Gel based fracing requires tens to hundreds of thousands of gallons of water per operation. The percentage of water initially injected that returns as flow-back is in the order of fifty per cent but varies considerably with formation characteristics and methods used by the service company performing the fracing operation. Due to the presence of the gel breaking chemicals it is very difficult to simply clarify and remove suspended particles from the frac flow-back from this type of fracturing process and reuse it. The quality of the flow-back water from gel based fracs will vary widely with formation, drilling company and service company performing the fracs.

Slickwater or slick water fracturing is a system of hydro-fracturing which involves adding chemicals known as friction reducers to the water to economically increase the velocity of frac fluid flow. Biocides are added to prevent organisms from clogging the fissures and fouling the piping systems. Surfactants are added to help keep the proppant suspended but do not develop a gel based fracturing system. The transport and positioning of the proppant depends on the high velocity of water. Scale inhibitors are used to prevent sealing of gas producing cracks and fissures. Slickwater fracturing typically uses more water than gel based fracturing methods - between one and five million gallons for each fracing operation. Flow-back water is captured in a similar manner to gel based fracturing operations using many similar chemical

and physical characteristics. The percentage of water that returns as flow-back is in the order of thirty to forty percent but varies considerably with formation characteristics and methods used by the service company performing the operation. An important distinction of a slickwater fracturing system is the flow-back water `might` not contain chemicals that would seriously constrain its reuse in subsequent fracturing operations. It has been reported that flow-back water from slickwater fracturing operations can be clarified, diluted with fresh water, and reused.

The disadvantage of the slickwater system is the uncertainty that the proppant will in fact be properly located. This has resulted in the development of so-called hybrid systems where the fracturing operation starts with a slickwater frac and uses a form of gel based frac to help locate the proppant. The volumes of water used and recovered as flow-back are similar to those of a slickwater frac. The quality of the flow-back, however, might be changed during the process to attain a fluid that is not easily reused by simple clarification alone.

Flow-back from any type of fracing operation is recovered very rapidly over a short period of time and must be stored, at least temporarily. In the case of the very large fracturing operations associated with the slickwater and hybrid systems, it involves management of several millions of gallons of water in lined pits or in dedicated surface tanks. The preferred method for disposal of frac flow-back from any of the fracturing systems is separation of fluids and solids, disposal of fluids by deep-well injection, and the stabilization and land-filling of the solids.

Business opportunity

Acquisition of sufficient volumes of fresh water for fracturing operations and the release or disposal of flow-back water has become a serious water management issue in Canada and the United States. Each new gas well developed may use several million gallons of water and tens of thousands of wells are being drilled each year in locations that are environmentally sensitive, have limited supplies of fresh water, or limited opportunities for deep-well injection disposal. During its life time each gas well will require several more fracturing operations. A considerable amount of flow-back water is being stored in lined and covered pits awaiting some method of disposal or treatment to allow release into the environment or for reuse. For a number of reasons, including liability, long term storage of flow-back water is not an acceptable option for operating companies. Operating companies are aware that inadequate water management solutions associated with fracturing operations may become a limiting factor in exploitation and development of unconventional gas reserves.

Techniques to allow 100% release of treated flow-back water to the environment are typically very expensive and impractical in many circumstances. While the quality of some of the water produced is very good not all of the water can be treated economically in which case deep-well injection is required to dispose of any remaining fluids.

Treatment of flow back water for reuse in future fracturing operations does not require the same level of treatment as that required for its release into the environment. Service providers performing the fracturing operations are able to alter their fracturing process to use treated flow back water mixed with new water – the ratio of treated to new water depends on the percentage of flow-back water recovered when the fracturing process is completed. Most important is the use of a flow-back water treatment process that only produces water that is suitable for future fracturing use and a stabilized solid that is readily land filled; that is, there is no wastewater generated that requires further treatment or deep-well disposal.

Flow-back from gel based fracturing systems has been proven to be possible to economically treat by a physical-chemical based system developed by Pure Filtered Water International Ltd. of Calgary, Alberta, Canada. This treatment technology has been proven to be very effective and economical to treat frac flow-back produced during fracturing operations of conventional gas reserves as performed by several different service providers in Alberta, Canada. (The quality of flow-back water received from the different frac service providers varied significantly.) The process comprises chemical –physical clarification, oxidation and final clarification. The final clarification used in proto-type demonstrations involved further chemical-physical clarification but can be improved and made less expensive by replacing it with an appropriate filtering process such as that provided by a related company, Oasis Filter International Ltd., also of Calgary, Alberta, Canada.

Flow-back from slickwater fracturing systems can be treated to an acceptable condition for use in subsequent fracturing operations (and dilution) by simple clarification. The filtration technology provided by Oasis Filter International Ltd. would be ideal for this treatment as it portable, able to treat very large volumes of water, requires very little energy for operation and produces no liquid waste.

Flow-back from hybrid fracturing operations may be treated using a combination of the techniques used to treat flow-back from gel based and slickwater fracs.

Frac flow-back water treated using the methods described results in the water being very well conditioned for further treatment using membrane technologies; that is, if demineralised water is required.

Development of any method for treating flow-back from fracturing operations will require the co-operation of the operating and the service company employed to provide the fracturing operations. The obvious positive outcome of using water diverted for fracturing operations to exhaustion is the significant reduction in volume of new water demand and the elimination of flow-back water disposal (including the costs of transport). The frac flow-back treatment systems available from Pure Filtered Water International Ltd. and the filtering systems available from Oasis Filter International Ltd. promise to provide service companies new options in delivery of fracturing operations to meet their clients and regulatory agency water management objectives.

It is worth noting that operating companies are very concerned about the availability of water supplies for fracturing operations and the management of liquid and solid wastes generated by them. They have encouraged service providers performing fracturing operations to develop methods that allow the use of alternative water supplies that would otherwise be considered unacceptable for use in fracturing operations such as using very saline groundwater or even waste water from mines. These options can be very expensive and the fact that they are being seriously considered suggests that the frac flow-back treatment options developed by Pure Filtered Water Ltd. and Oasis Filter International Ltd. will have significant opportunity for practical use and commercialization.