Halliburton Company was founded on one of the most profound advancements in protecting the environment from which hydrocarbons are produced. Erle P. Halliburton’s perfection of a highly efficient process to place cement around the steel casing inside a wellbore brought about a step-change improvement in protecting sensitive subterranean formations.

Effective Cementing Enables Fracturing

During the drilling of a well to produce hydrocarbons, (Figure 1) all the formations through which the wellbore passes are protected by steel casing surrounded by cement. Extensive research and development have gone into developing cement blends and procedures that will form a tight, permanent seal both to the casing and to the formation. This casing and cement stabilize and protect the wellbore and, just as importantly, prevent fluids from moving between formation layers.

Halliburton’s cementing process has become the industry standard. Performance measures have been established by the American Petroleum Institute (API) and compliance is monitored and enforced by federal and state regulators. Effectively preventing fluid movement between zones and providing a stable wellbore are critical to the success and environmental performance of fracturing operations.

History of Fracturing Success

Halliburton’s history of fracturing achievement is due to continuous devotion to technology development, extensive training and a global best practices process. Since Halliburton performed the first commercial fracturing treatment in 1949, over 1 million wells have been successfully fractured by the industry in the United States. Operators now fracture about 35,000 wells each year in the U.S. with no record of consequent harm to groundwater.*

Hydrocarbon Bearing Zones are Not Aquifers

The sealed and stabilized wellbore is in place before the fracturing operation begins. All fluids used in fracturing pass down the inside of the steel casing until the fluids reach the zone to be fractured.

The zones to be fractured are several thousand feet into the earth, far below the aquifers from which we all get drinking water. In addition to hydrocarbons (oil and gas), the zones to be fractured usually produce formation fluid consisting of brine (salt water) containing traces of oil and gas and large amounts of minerals. The hydrocarbon reservoirs are sealed by surrounding rock and contain a finite amount of producible material. Once the material is produced, the zone is said to be depleted and another zone must be opened to production, often by drilling another well. Hydrocarbon reservoirs are not replenished.

Aquifers, on the other hand, are replenished (recharged) by rainfall and snowmelt. Aquifers are not normally depleted except in drought conditions. Even then, aquifers can be recharged when precipitation returns. Hydrocarbon production is not related to aquifers except by the sealed wellbore that passes through the water zone on the way to the hydrocarbon zones several thousand feet away.

The Fracturing Process

Today, operators are often faced with more difficult-to-access reservoirs than ever before. Oil and gas are now often found in small deposits that require multiple wellbores to access (Figure 3).

After potentially productive zones are identified, the zones to be produced are perforated (Figure 4).

Aquifers are located relatively near the surface, thousands of feet away from hydrocarbon zones.

Figure 3 – Operators today often must produce hydrocarbons from small, scattered reservoirs.

Figure 4 – Zones to be produced are perforated, usually by using a perforating gun equipped with shaped charges.

Figure 5 – After perforating, fluid is pumped with pressure sufficient to crack (fracture) the reservoir rock.
Once perforating is complete, the zones to be fractured are isolated from the rest of the wellbore and fluid is pumped at high pressure to crack (fracture) the reservoir rock (Figure 5). The pressure required to fracture is usually about 0.5 to 1.0 psi per foot of depth. This is called the “frac gradient” and means that a zone at 10,000 ft vertical depth requires about 10,000 psi pressure to fracture.

These huge pressure requirements necessitate extremely rugged and reliable equipment. Halliburton has found that building equipment specifically for this application has been the best approach. Halliburton is the only service company that builds the vast majority of its equipment used in fracturing treatments.

After the fracture is initiated, fluid carrying propping agent (proppant) is pumped into the formation (Figure 6). The proppant (usually sand) is used to hold the fracture open after pumping stops.

Figures 7 and 8 show the final stages of the fracturing treatment. The created fracture is held open with the proppant to provide a highly conductive path for hydrocarbons to move to the wellbore, then to surface and to market.

At the end of the fracturing treatment, the fluids are flowed back to surface into a vinyl lined pit (Figure 9) for disposal or reuse by the operator.

**Fracturing Fluids**

Today’s fracturing fluids are primarily water (Figure 10) with a gelling agent and number of additives available to provide the necessary characteristics. Fracturing fluids must be able to perform at bottomhole temperatures ranging from 100 to over 400° F. The high temperatures can make achieving the required fluid performance exceedingly difficult. Due to the earth’s thermal gradient, higher temperatures occur at the greater depths from which much of today’s hydrocarbons are produced.
The material used to make the fluid thick (viscous) is usually a natural polymer derived from guar beans. It is the same agent used in cosmetics and soft ice cream. Fracturing fluid additives include clay control agents, gel stabilizers, surfactants, foamers, gel breakers, fluid loss additives, friction reducers, scale inhibitors, bactericides, and pH control agents.

Each of these additives has special properties that can be used to maximize certain characteristics. For example, foaming additives have been designed for different temperature conditions. Clay control additives have been developed for initial contact as well as for longer lasting protection. Gel breakers have been developed for various temperature applications and for release-rate control.

**The Fracturing Water Challenge**

In many parts of the world, fresh water for fracturing is becoming an increasingly precious resource, sometimes difficult and expensive for the operator to obtain. For this reason and overall operational efficiency, Halliburton is striving to develop fluid systems that can be mixed using produced water from the field.

In 2008, Halliburton introduced a new fluid system that can function with a wide variety of produced water. Work continues at the Duncan Technology Center (Figure 11) on extending the capabilities of this system.

In one field, 70% of all treatments are being performed with produced water.

**The Fracturing Fluid Environmental Challenge**

In addition to using produced water, Halliburton is working diligently to remove environmentally undesirable agents from the entire suite of fracturing fluids.

Water-based fluids have been developed that virtually eliminate the need for hydrocarbon-based fluids, even in the most sensitive formations that contain hydrocarbon that may react strongly to fresh water.

Diesel-based carrier fluids have been removed from all fluid concentrates and replaced by food-grade mineral oil.

Bactericides have been developed to replace more hazardous versions used by others.

Halliburton has patented a high-intensity ultraviolet light process to control bacteria growth in fracturing fluids. This process will greatly reduce the need for conventional bactericides.