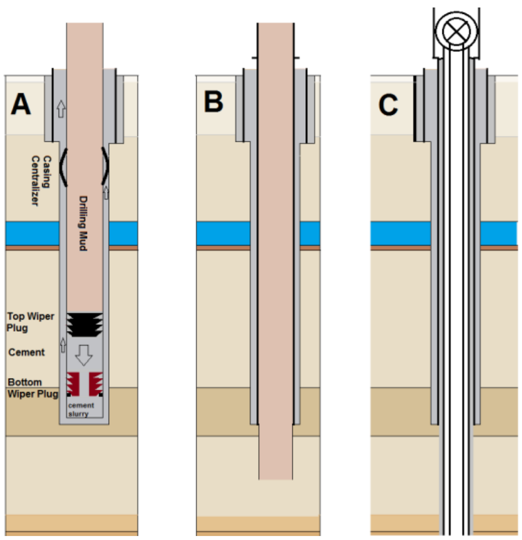
The Basics of Wells - How is an Oil or Gas Well Built?

Throughout the 150+ year history of oil and gas production, technologies used for well construction have changed enormously. In 1821, William Hart's first shale gas well near Fredonia New York, struck flowing gas at 28 ft. In 1859, Edwin Drake's first purpose-drilled oil well in near Titusville, Pennsylvania, reached an oil bearing sandstone layer at a depth of 69-1/2 feet. These wells, drilled and constructed with primitive tools, roughly a century before fracturing was invented, illustrate the near surface location of some gas and oil, which sometimes are found in the same zones as fresh water.

Oil and gas producing wells are built with steel pipe, cement, and other mechanical seals in a pipe-in-pipe design that puts several barriers between the producing fluids and earth or water sources outside the well. If a well's inside pipe barrier fails from a corrosion leak in the innermost tubing, the next steel and cement barrier will prevent leakage outside of the well. Modern well design uses more barriers at the surface and across protected water zones and fewer barriers toward the bottom of the well where oil and gas flow into the well. For a well to pollute, a leak must form and extend from inside the well to the outside environment, past all the steel and cement barriers, and the pressure inside the well must be higher than the pressure outside the well at the depth of the leak.



A - "Surface" casing section of the well being cemented by displacing drilling mud with a cleaning flush, followed by enough cement to reach the surface.

B - After passing a manditory pressure test, the well can be drilled deeper. Each section of drilling targets a certain section of the well design controlling wellbore stability and isolating different fluids such as fresh water, salt water, oil or gas.

C - The completed well. There may be 2 to 4 barriers across the fresh water zones. Multiple long cemented sections minimize potential for leaks.

Construction of a well's barrier system begins during drilling as each section is drilled and each casing string of the well is put in place and cemented. The completed well is a system of interactive barriers formed by steel pipe and cement. The number of barrier sets is matched to the needs of isolation for a specific section of the well.

Cementing for Isolation

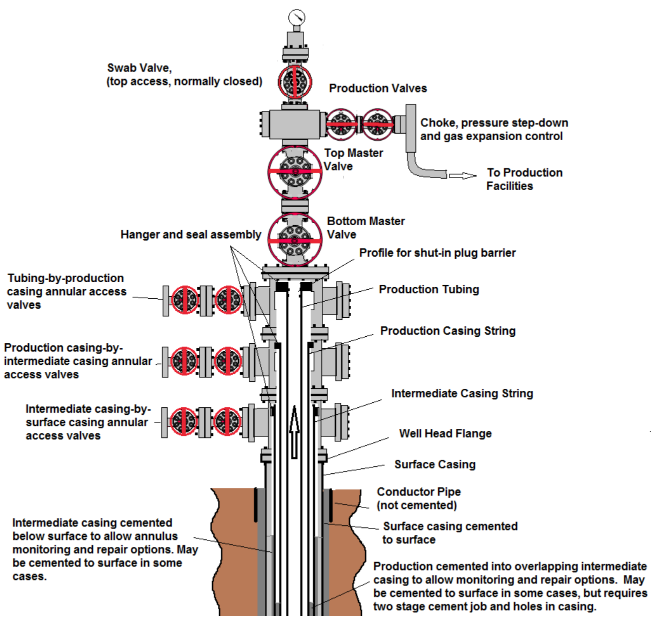
Once a section of a well has been drilled, a steel pipe (casing) is run to bottom and cement (powdered cement, mixed with water – no sand or gravel) is pumped down the casing to the bottom and then up around the area between the casing and the drilled hole, forming a strong bond with very high resistance to pressures and flow. Once the cement hardens (a few hours) it has similar strength and leak resistance to the rocks through which the hole was drilled. A required pressure test and other monitoring tests insure that the seal is in place and preventing leaks. The effectiveness of a cement seal depends on well design, which considers local engineering and chemical factors. Cement is as strong as the rock that has kept gas, oil and saltwater isolated underground for millennia. There are many records of cemented wells that are still effectively sealed after 100 years.

Control at the Surface - The Well Head

The wellhead is the only part of a well that is visible in most cases and is the access point for further well operations such as production, treating and workovers to modify the well as pressures in the reservoir decline. After the deepest casing is set and cemented, the blowout preventer used during drilling is replaced by a set of valves that can be used for surface control and routing of pressure and produced fluids. The wellhead is an intricate control center using multiple valves and seals barriers to enable maximum control of fluids flowing from the formation. Wellheads and their control systems may be simple on low pressure wells or very complex on high pressure wells.

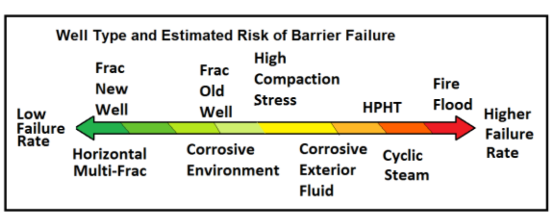
Well Integrity and Leak Potential

Data from studies of over 650,000 wells worldwide have been examined to give a clearer picture of the leak potential for wells and the difference between a single barrier failure that is contained by the next barrier without leaking and an isolation failure that results from failure of multiple barriers. Older era vertical well leak rates are about 0.02%, but the newer generation of horizontal wells have leak rates of less than 0.004% (4 detected leaks in a hundred thousand wells) and this leak rate continues to be reduced through improvements in design and cementing and an on-going goal is to locate and correct a single barrier failure before it becomes a leak.



The technology in practice at the time of well construction is a reflection of how well operators and regulators are doing their jobs in applying and checking for use of the best technologies. Early drilling methods, such as cable tools, allowed blowouts and old-time "gushers", a practice that is extinct in modern completions. Texas established cementing and abandonment rules in 1919, and over 15,000 "orphaned" wells have been identified and been plugged in 25 years by a state-run program funded by operator permitting fees.

Well Type may be one of the largest factors in well-to-well variances in well failures and risk. Wells that operate at the extremes of temperature, pressure, corrosion tolerance, high erosion potential or are in areas of tectonic induced movement or active subsidence will usually have shorter well life or more integrity problems than wells in less extreme or lower stress environments. All wells require periodic maintenance to control production deposits such as scales, paraffins and asphaltenes or require corrosion protection or other issues.



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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