# Cement Pulsation Reduces Remedial Cementing Costs

by David Stein,
*RITS*
Tom J. Griffin, Jr.,
*Griffin Cement Consulting, LLC*
Dale Dusterhoft,
*Trican Oilwell Service Company Ltd.*

*A simple new technique to improve primary cement jobs has resulted in a 36 percent decrease in average remedial cementing costs for a group of Canadian gas wells.*

A chronic problem for the oil and gas industry is failure to achieve reservoir isolation as a result of poor primary cement jobs, particularly in gas wells. A new technology designed to address this problem, cement pulsation (CP), has proven technically and economically successful in Canada. CP technology has demonstrated excellent results in preventing early gas leaks in over 150 cemented wells. The basic approach of this technology is to improve reservoir isolation by mitigating fluid migration during the cement setting process.

## Primary Cementing Failures Costly

Approximately 15% of all primary cement jobs fail, costing the oil and gas industry an estimated $470 million annually *(Newman, et al., 2001)*. One-third of these failures are attributed to fluid influx into the cement-filled annulus that results in channeling and subsequent communication. Fixing this problem is challenging for several reasons: channels are difficult to locate and often too small to easily fill, and remedial squeeze treatment are expensive and treating pressures may breakdown the formation. The best solution to the problem is the prevention of fluid migration in the initial (primary) cement job.

Studies have shown that in the Gulf of Mexico there are more than 11,000 strings of casing in over 8,000 wells that exhibit sustained casing pressure (SCP) *(Bourgoyne, et al., 1998)*. SCP is defined as a build up of pressure on any string of casing that can not be attributed to an applied pressure or temperature fluctuation. SCP is an indication of communication between a reservoir and the surface. SCP can be the result of tubing or casing leaks, cement damage after setting or what is more likely, a poor primary cement job. The problem can lead to tubular failures, and at the extreme, an underground or surface blowout.


*Figure 1: Compressible Volume Response*

## Defining the Problem

With fluid migration, the fluids invading the cement matrix can be either gas or liquid. Fluid migration in primary cement jobs can be attributed to four general factors. First, with a pressure differential across the curing cement, fluid can leak from the cement into the formation causing a volume reduction. Second, during the hydration process, the volume of the slurry contracts up to 6%, allowing micro-annuli to form along the casing and formation surfaces. Third, the unset cement is very permeable until it develops sufficient strength to prevent fluid influx. And fourth, the development of gel strength in cement slurries causes a lowering of the hydrostatic pressure in the annulus that can lead to influx.

The combination of volume losses due to fluid loss and hydration, loss of hydrostatic pressure because of gel strength and a weak, permeable cement matrix provides a perfect environment for fluid influx to take place. If this occurs, bonds between the formation and casing can be destroyed. If there is sufficient pressure and if the invading fluid volume is great, channels can become quite large and ultimately lead to fluid communication.

## Attempted Solutions

To increase the chances of a successful cement job and provide good bonding between the formation and casing, the annular space must be completely filled with cement and drilling fluids must be completely displaced by the cement slurry. Cement properties must be controlled to minimize fluid-loss, free fluid and gel strengths, in order to help to lower the risk of a poor cement job. Additional techniques are used to attempt to prevent fluid migration, but no universal solution exists. Techniques include carefully controlling cement properties and the use of casing hardware to isolate the producing zone. Many of these solutions are costly and complicated to implement.

## Cement Pulsation

Cement pulsation is the application of low-intensity pressure pulses to the annulus after a primary cement job to delay gel strength development in the cement slurry. Gel strength of the cement causes a lowering of the hydrostatic pressure transmitted through the annulus *(Newman, et al., 2001)*. By delaying gel strength development, the hydrostatic pressure on the formation is maintained until the cement has built sufficient strength to prevent the influx and migration of reservoir fluids through the cement matrix.

The pulsation process starts immediately after pumping stops and the annular BOP is closed. Low-pressure pulses, typically in the range of 80 to 200 psi, are applied to the casing annulus at a time interval of 30 to 60 seconds. Pulsing continues until the compressible volume levels-off or the thickening time test indicates the cement has reached 70 Bc, usually 4 to 6 hours (Figure 1). The compressible volume is the volume of fluid required to pressurize the annulus when the pulse is applied.

The cement pulsation system employs an air compressor to continuously pressurize an air tank on the unit. To pressurize the annulus, a controller opens a value between the air and water tanks (Figure 2). Air pressure forces water into the casing annulus and pressurizes it for a specific time. After pressurization, the control system releases the pressure by closing the pressurizing valve and opening an exhaust valve. Water returns from the casing annulus back into the water tank, de-pressuring the casing annulus. As the cement sets, the compressible volume decreases, giving a real-time indication of the setting process.

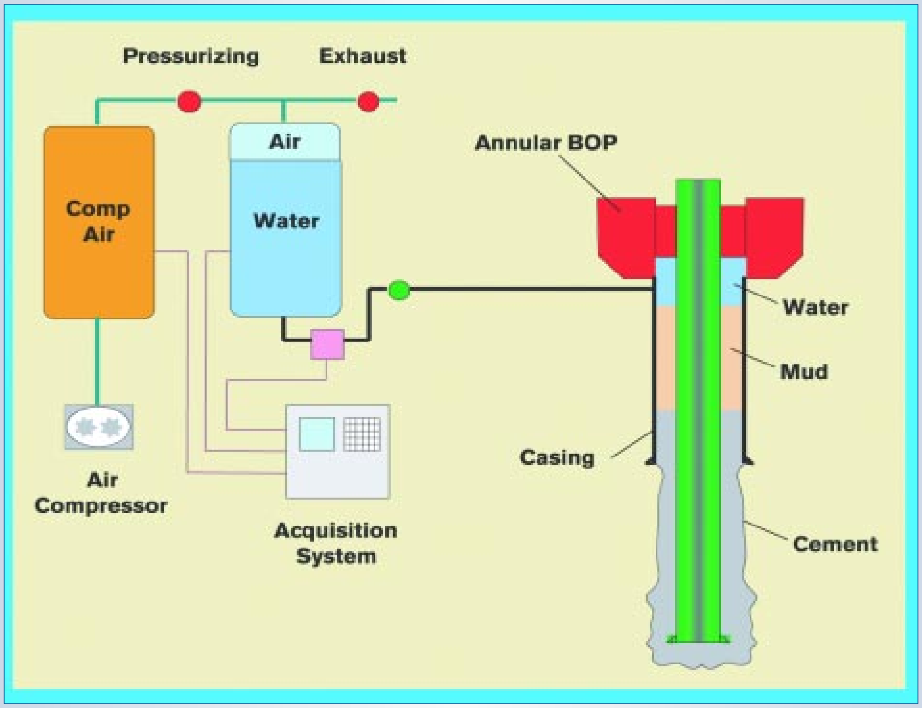


*Figure 2: Cement Pulsation Layout*

## History of CP

In the early 1990's, John Haberman at *Texaco E&P* proposed the application of pressure pulses to the casing annulus after a primary cement job to control fluid influx and migration. GTI and *Texaco E&P Technology Company* collaborated in the development of a simple procedure to achieve these goals. In a recent effort to extend this technology, CTES L.C. developed the system and collected downhole annulus pressure data during the pulsation procedure. Concurrently, efforts to model a well's response to cement pulsation were undertaken by researchers at Louisiana State University *(Chimmalgi, 2001)*.

The goal has been to gain a better quantitative understanding of how successful the procedure is in maintaining the pressure throughout the column and also to develop tools for modifying the procedure to suit specific conditions. After verifying that the pressure pulse did transmit completely through the cement column, a field trial was conducted on a group of Canadian wells *(Dusterhoft, et al., 2002)*.

## Canadian Results Impressive

Cement pulsation was applied during 2000-2002 in areas of Alberta and Saskatchewan that historically have had problems with gas migration. Typically, these wells are vertical with a depth ranging between 1900 to 5900 feet. On average, 57% of these wells develop leaks after the primary cement job. Canadian regulations mandate that any

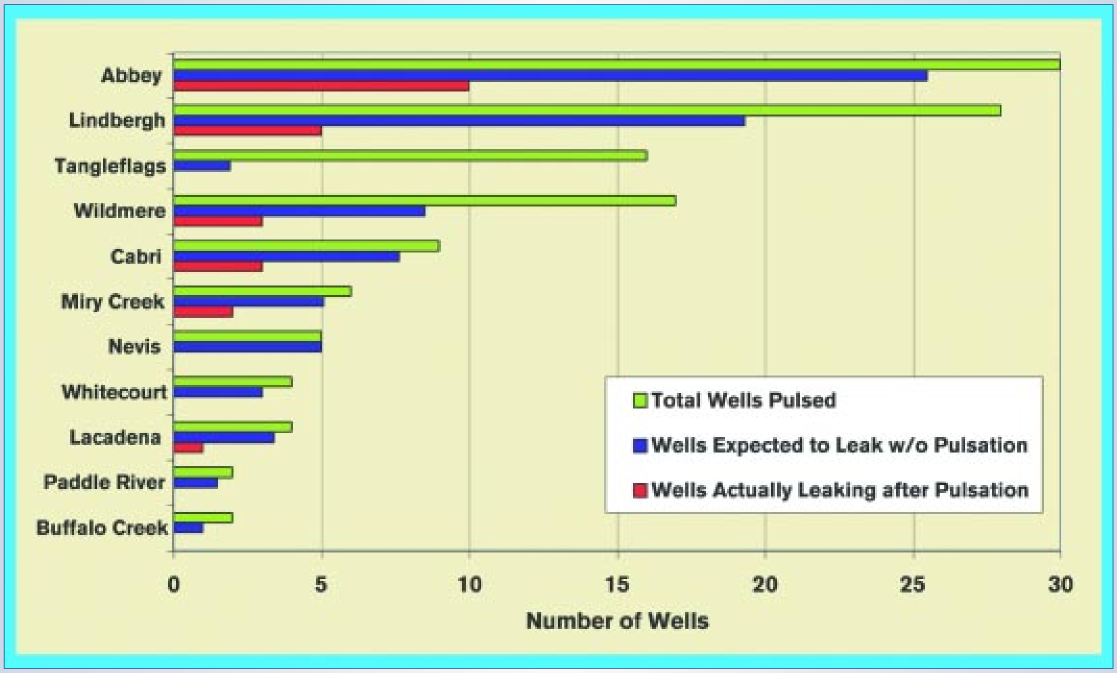


*Figure 3: Summary of the Top 11 Fields Pulsed in Canada*

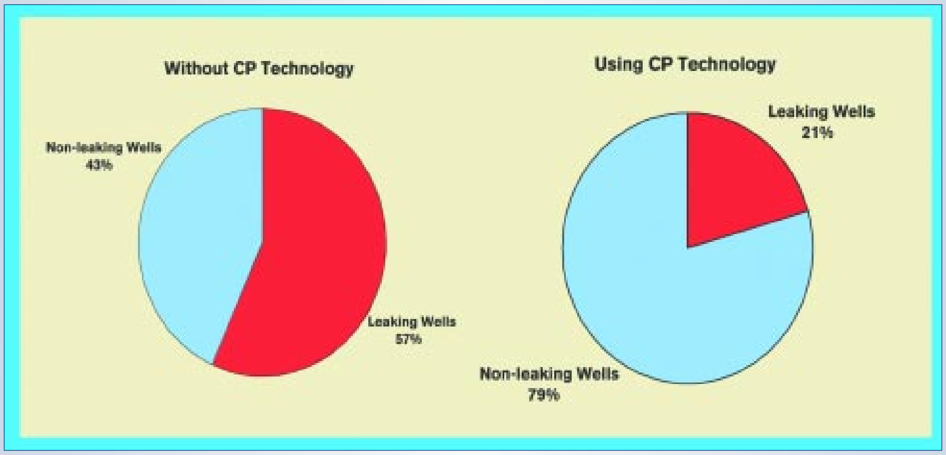


*Figure 4: Improvement in Number of Leaking Wells*

well with casing pressure problems must be fixed before abandoning. Repairing the leaks can cost anywhere from $30,000 to $50,000. If the problem is related to poor zone isolation, remediation costs can become significant.

Cement pulsation was applied on over 150 shallow gas wells in Alberta and Saskatchewan. A comparison of the total number of wells pulsed, the expected number of leaking wells without pulsing (based on historical data) and the actual number of leaking wells after pulsing is shown for the top 11 fields, which account for 88% of the total (Figure 3). Overall, with the use of CP the percentage of leaking wells declined from 57% to only 21% and the cost of performing remedial cement squeezes related to leaks was reduced from 59% to 43% of average total cementing cost (Figure 4). This results in an overall average cementing cost (primary plus remedial) reduction of 35%.

Based on these results, cement pulsation appears to provide a simple and cost effective solution for controlling fluid migration in gas wells. However, it is still mandatory to maintain good cementing practices to ensure the overall success of the primary cement job. The work in Canada is still continuing and now the service is available in US. ✧

*For more information on cement pulsation contact David Stein, RITS Manager, at 936-521-2212; E-mail:* david.stein@rits.cc *(or see www.rits.cc).*

## References

*Newman, K., Wojtanowicz, A., Gahan, B., 2001. "Cement Pulsation Improves Gas Well Cementing," World Oil, July 2001, pages 89-94.*

*Bourgoyne, A. Jr, Scott, S. L., 1998. "A Review of Sustained Casing Pressure Occurring on the OCS."*

*Chimmalgi, V.S., "Design of Top Cement Pulsation to Prevent Gas Migration During Cementing," MS Thesis, Louisiana State University, Baton Rouge, Louisiana, May 2001*

*Dusterhoft, D., Wilson, G., Newman, K., 2002. "Field Study on the Use of Cement Pulsation to Control Gas Migration," SPE paper 75689*