When chemist Paul Jones was using a detailed spreadsheet to highlight the benefits of a bold new technology for a room full of executives and regional operations managers at Halliburton, it appeared the concepts he was trying to explain weren’t going over very well.

“I could see everybody’s eyes glazing over,” recalls Jones, who was then a senior scientist at the Houston-based oilfield services company.

On an impulse, he stopped his presentation, pulled out a five-centimetre sample of the epoxy resin technology that he had been carrying in his pocket and handed the sample to the company’s vice-president. The epoxy resin was passed around the room, and Jones could see people starting to get excited. Jones recalls a cement operations manager saying, “I can use this. We need something like this to combat gas migration.” Jones adds that’s “because it was clear that it was an impermeable material.”

“And from then on it was full development—make it happen. Being able to collaborate effectively with technology, operations and marketing really drove the success of this material in 2012.”

The development of the new synthetic resin, called WellLock resin, which Halliburton now uses in cased-hole cementing operations, was one of the first projects Jones spearheaded when he joined Halliburton in 2010 as a newly minted PhD.

“It improves our ability to maintain wellbore integrity,” says Jones, 34, who took Halliburton’s existing chemical portfolio of resins and designed the system now in use.

A synthetic resin product is entirely different from cements currently in use, and conventional wisdom when Jones joined Halliburton dictated it could not substitute for conventional cement due to the intricate chemical processes involved.

In order for the resin to work as a secondary protective barrier, it had to meet several stringent requirements, including mixability and pumpability at the surface; the ability to harden once it reaches the downhole location and to withstand high pressures and temperatures; and to not react or break down with cement, water, acids, salts and other elements present in a well.

Jones started looking at Halliburton’s existing chemical portfolio and developed a new set of polymer molecules that met the required criteria, illustrating how a background outside oil and gas enabled him to view a problem differently and develop a unique solution.

Unlike with a cement system, the Poisson’s ratio of WellLock resin is closer to that of rubber, whereas cement is closer to that of glass. In other words, cement is inherently stiff and this resin is inherently flexible. Some formulations of WellLock resin have achieved
compressive strength of up to 48,500 pounds per square inch, according to Halliburton.

“The conventional solution, cement, has difficulty in entering those very fine channels due to the particulates in the slurry,” adds Jones. “With WellLock resin, it’s a completely liquid system. We get a very high penetration of fluid into those channels, which increases our success at remediating gas flows or sustained casing pressure in the wellbore. Instead of doing multiple squeezes, we can do one and fix the problem. It’s a much more efficient solution.”

Jones was born and raised in Ocean Springs, Miss., a small town on the Gulf Coast, 145 kilometres east of New Orleans. He holds a Bachelor of Science in chemical engineering from the University of Mississippi and a PhD in polymers and high-performance materials from the University of Southern Mississippi.

“Understanding the process that goes into developing long-range technology and fundamental scientific investigation was a big skill I learned in graduate school,” Jones says. “Not everything works; you might have 10 failures before one success, or even 100 failures before one success.”

What he learned at graduate school has served him well in the oil and gas industry. “There were a lot of people that didn’t believe in resin technology. They thought it was too expensive and would never catch on,” says Jones, who is now principal scientist at Halliburton.

How his team approached the challenge was to focus on the total cost of solving the problem, rather than on the material cost of one component of the solution, “because the solution to restoring wellbore integrity involves much more than just materials,” Jones explains. “It’s also the engineering design, job procedure and job placement. Our philosophy in designing jobs is to use the minimal amount of material, placed in an effective manner to achieve maximum results, and look at the total cost of the operation.”

Jones and his team worked on WellLock resin day and night to make sure they got it right. After they finished the development phase, Jones went out on the first jobs, in Pennsylvania’s Marcellus Formation, to show people that the technology actually worked. “First, it can penetrate the wellbore much more effectively and more deeply than conventional solutions, such as cement,” notes Jones.

“Second, WellLock resin transforms from a liquid into a high-compressive-strength elastic material that is very resilient to strain and stress. Third, operationally it can be injected into cracks and leaks at very low rates without having to overcome a yield point or yield stress.

“The resin can be injected into micro-channels very effectively to seal off unwanted flows, where it reacts to form a high-compressive-strength elastic seal to restore wellbore integrity. It’s very effective at shutting off gas flows or unwanted hydrocarbon flows.”

He adds that the ability to remediate any leaks with this solids-free resin, and maintain the interior diameter of a well, means that companies can complete their hydraulic fracturing programs as planned and “maintain production as you would have before.”

Another application for WellLock resin is in difficult abandonments, where gas bubbles might be forming in the wellbore. “This gives us another tool to do those types of abandonments,” Jones says. “We can use this material to arrest that bubbling and form a plug in the wellbore, achieving a competent barrier for abandonment.”

Additionally, “our operations have pumped this as a lead slurry to provide extra assurance in maintaining zonal isolation. They want to improve the chances of achieving zonal isolation the very first time, in areas where there is significant potential for gas flow.”

WellLock resin can also be used in situations where there is gas migration. “If a well is experiencing pressure at the wellhead due to gas, it could be channelling through a breach in the material used for zonal isolation, and that pathway can be thousands of feet long. Once we find where the breach in well integrity is, we can squeeze WellLock resin into the leak and have it flow long-range through that crack and seal it.”

Its mechanical properties, such as density, elasticity and strength, can be tailored to meet a variety of wellbore challenges. When pumped ahead of cement, a film of WellLock resin is left behind on the formation and outer diameter of the casing, and it can increase the shear bond strength of cement up to six-fold.

Halliburton has completed more than 200 operations with WellLock resin worldwide. “We have taken on significant challenges in Canada related to gas migration and loss of wellbore integrity,” Jones notes.

“WellLock resin has been applied successfully to remediate annular gas in Canadian oilfields. Its ability to be formulated solids-free for effective placement and its high-strength elastic nature when set have enabled engineers to design and execute remediation operations with much higher success rates than previously achievable.”