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# “Shielding” technology prevents wellbore instability issues

Alternative approach cuts NPT and reduces casing string requirements in weak, depleted horizons.

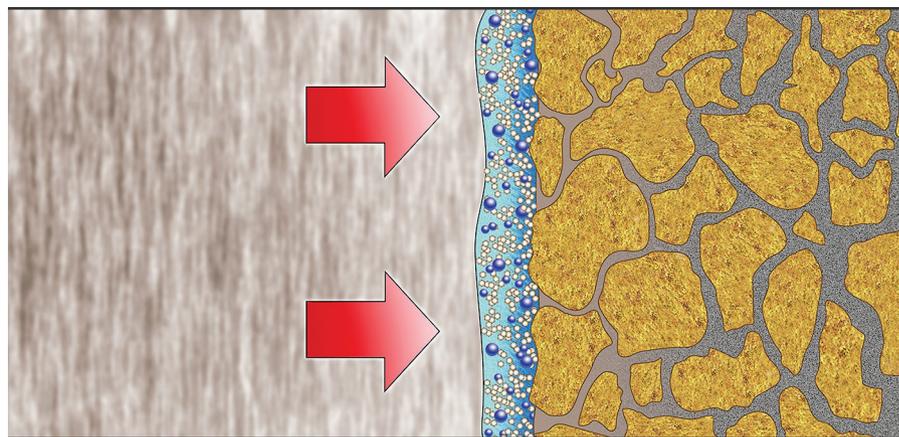
■ ANDY BRADBURY, JACK DEGRAND, MARCUS BRASSETTE, and CODY WELLMAN, Impact Fluid Solutions

The methodologies employed to tackle the profit-draining ramifications of wellbore instability run the gamut, from pumping wellbore strengthening materials (WSM) with drilling fluid, to so-called “stress caging,” whereby fractures are actually created and subsequently sealed with exceptionally precise concentrations of bridging or sealing agents. For the most part, these widely different approaches to maintaining wellbore stability are reactive processes, each of which require additional rig time and costs.

A new-generation alternative to conventional wellbore strengthening techniques has been developed that essentially deposits an impermeable “shield” across mechanically weak, highly depleted, and equally fragile formations while drilling. As such, the wellbore shielding technology prevents—rather than remediates—the whole mud losses, stuck pipe and other wellbore instability issues that exponentially increase non-productive time (NPT), costs and HSE risks.

The core of the proactive, technology-based shielding process is a proprietary, ultra-low invasion additive, which quickly deposits the impenetrable barrier (Fig. 1) across highly permeable formations and microfractures (natural or induced) up to 3,000 microns ( $\mu\text{m}$ ). Unlike traditional wellbore strengthening techniques, the shielding technology essentially stabilizes troublesome zones by minimizing fluid and pressure invasion into matrix pores and microfractures, thus blocking the propagation of loss-inducing fractures. Furthermore, complementing the well-specific design of a wellbore shielding application is a

**Fig. 1.** When mixed in oil, water or synthetic-based drilling fluid, the ultra-low invasion additive forms an impenetrable “shield” over unstable formations.



proprietary sand bed test apparatus, which ensures that optimal product concentration is established and maintained in the active drilling fluid system.

The uniquely engineered stabilization approach has been field-proven in a myriad of applications, from unconventional shale plays to highly depleted in-fill drilling programs in mature offshore fields. The shielding technology enabled one operator to eliminate an intermediate casing string in its Eagle Ford shale wells.

## REACTIVE APPROACHES

As Manshad, et al, and others<sup>1,2,3,4</sup> have pointed out, the whole mud losses, differential sticking and equally costly consequences of wellbore instability, cost the global industry hundreds of millions of dollars each year. They account for most of the while-drilling NPT, unrelated to weather. Moreover, loss circulation-induced well control issues and dropped objects while jarring stuck pipe pose severe HSE risks.

Unmitigated fluid invasion can destabilize the geology further, either chemically or mechanically, also while laying down a thick and difficult-to-remove filter cake. The increasing depth of filtrate invasion—coupled with the thicker filter cake—can severely, and oftentimes permanently, restrict reservoir drainage. Obviously, the

risks of severe-to-whole loss returns and stuck pipe are increased appreciably which, at worse, can lead to total loss of returns.

Once losses occur, one common remedial approach is pumping loss circulation pills or treating the whole mud with high concentrations of bridging or sealing agents, such as graphite, calcium carbonate and an array of conventional lost circulation materials. Along with increased NPT and costs, these and other traditional loss prevention additives typically propagate the build-up of problematic low gravity solids (LGS), which eventually deteriorates the rheological properties, preventing the re-use of premium oil-based drilling fluid. Furthermore, though calcium carbonate, owing to its acid solubility, is used commonly as a reservoir bridging agent, it has been shown to generate formation damage,<sup>5</sup> oftentimes permanently restricting optimal production.

Over the past several years, one pseudo-proactive tactic for stabilizing fragile formations embraces the well-documented stress cage theory,<sup>6,7,8</sup> the fundamental principal of which is to boost the hoop stress to strengthen the targeted zone. Referred to as hoop stress enhancement, the technique requires pre-fracturing of the wellbore, with the now-created fractures fortified with what is varyingly referred to as wellbore strengthening (WSM) or loss prevention

**Fig. 2.** The acrylic window of the proprietary sand bed test apparatus enables measurement of invasion depth during drilling to be calculated quickly, with “shielding” concentrations adjusted accordingly.



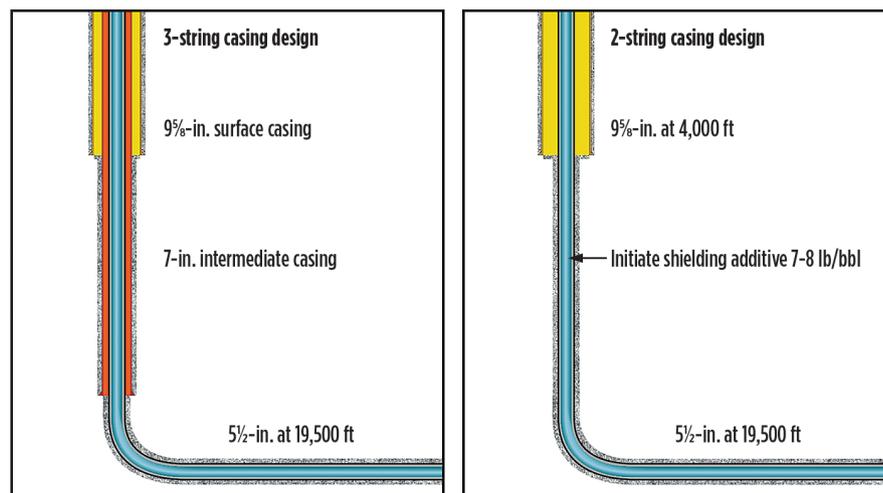
material (LPM). Stress caging comes with significant limitations and downside consequences, in that the already unstable formation is first destabilized and then stabilized with a concentration of crush-resistant materials that must be designed meticulously to meet the required fracture width and particle size distribution (PSD).

The glaring limitations of these more customary, and curative, approaches spurred the development of alternative technology, essentially sealing weak zones while drilling, thus preventing wellbore instability issues without altering the in-situ geology.

### THE SHIELDING PROCESS

Though relatively new terminology in the oil and gas industry lexicon, the wellbore shielding technology is gaining a wider following, as operators seek a proactive approach to stabilizing troublesome formations. Specifically, wellbore shielding technology comprises proprietary cellulosic material, engineered to form small and deformable aggregates in the drilling fluid system. Once developed, these aggregates produce an extremely low permeability barrier at the fluid-rock interface, thereby delivering an equally low invasion

**Fig. 3.** By shielding the loss-prone Wilcox sandstone prior to kick-off, an Eagle Ford operator was able to eliminate an intermediate casing string.



area across a broad range of permeability and microfractures, up to 3,000  $\mu\text{m}$ .

The ultra-low-invasion product, which is compatible with all oil, water and synthetic-based muds, has demonstrated effectiveness at controlling fluid invasion at concentrations as low as 4–12 lb/bbl. In addition, the resulting non-damaging shield or seal is nonetheless sufficiently robust and flexible to withstand high-pressure differentials.

By laying down the impenetrable shield over pores and microfractures, the technology effectively restricts the transmission of destabilizing wellbore pressure to the pore fluid and, in turn, reduces filtrate invasion into the matrix permeability and microfractures. This mechanism, in essence, raises the fracture initiation pressure by shielding or isolating the mud pressure in the wellbore from the geology, effectively inhibiting the fracture propagation process.

Specifically, when a fracture begins to develop, a low-permeability seal instantly forms over the core of the fracture itself, preventing the continued invasion of fluid into the fracture and shutting down continued fracture generation. Since the unique sealing mechanism limits the transmission of wellbore pressure into the geology, the dramatic reduction of fluid influx in the microfractures minimizes the risks of formation breakdown and effectively stabilizes weak shales, sandstones and carbonates.

Since the product particles deposit themselves along the wellbore, much like plates or “shields,” once production is initiated, the inflow of the well lifts off the plates, requiring minimal differential pressure. Along with delivering a well with exceptional return permeability, the “shield-

ing” approach differs markedly from conventional plugging with formation-damaging calcium carbonate and other wellbore sealing materials.

### BEST PRACTICES

During both the pre-job planning and execution of a wellbore shielding application, the proprietary sand bed test apparatus is employed, to ensure an effective concentration of material is incorporated and maintained in the active mud system, Fig. 2. Basically, the sand cell is used as a tool to prevent over-treatment and minimize solids-loading in the mud system.

The test protocol, which is designed to meet application-specific requirements, begins with filling the cell to a pre-determined level with 20–40 frac sand. Drilling fluid is added to the top of the sand, after which the apparatus is sealed and pressured. As the mud flows freely through the sand, a baseline concentration of the shielding additive is added, and the reaction is monitored via an acrylic window, with the concentration fine-tuned accordingly.

Once the invasion ceases, the depth is measured physically in centimeters (cm), with product added until the depth of invasion is maintained at the desired 3-to-5-cm level. Throughout the well construction process, the level of invasion recorded by the device is tracked against the daily volume control (losses) and wellbore stability indicators. Based on geology, the mud and the drilling process, a depth of invasion as low as 1–2 cm may be required, while in other instances, a depth of invasion of 5–7 cm may be sufficient. In other words, the targeted invasion depth

is optimized by listening to the well and responding accordingly.

Effective solids control is paramount, particularly in applications, unconventional and otherwise, where the build-up of low-gravity solids poses a significant risk. On the basis of field experience and independent geometric solids and PSD analysis, a range of API-mesh primary shaker screens can be used to effectively prevent the wellbore shielding product from screening out.

Furthermore, to minimize LGS entrainment caused by screen wear, gasket failure or bypassing, the shale shaker deck, gaskets and screens must be inspected frequently during the well construction process. Defective shaker deck or screen gaskets can result in significant volumes of cuttings falling through the sides, or bypassing the shakers entirely. Field experience with the wellbore shielding additive has shown that replacing screen gaskets will have a positive impact on LGS concentrations.

## FIELD RECAPS

The capacity of the wellbore shielding technology to stabilize weak zones and prevent whole mud losses in mature, highly depleted wells is reflected in different applications in the Eagle Ford and Woodford shales of Texas and Oklahoma, respectively, as well as the North Sea and deepwater Gulf of Mexico.

A number of wells drilled in the South Texas Eagle Ford play, particularly in its deeper northeastern quadrant (Karnes, Fayette, Gonzales and DeWitt counties), often are designed with three casing strings to isolate the overlying and fragile Wilcox sands.<sup>9</sup>

In one northeastern Eagle Ford well, designed with three casing strings, the operator had encountered significant gas influx while drilling the lateral, requiring a higher-than-programmed 13.5 lb/gal mud density. Afterwards, total loss circulation with significant NPT was encountered in the Wilcox while placing a “mud cap.”

Incorporating the shielding material in subsequent wells allowed the operator to maintain stability in the Wilcox with a mud weight that exceeded the leak-off test (LOT) results, eliminating an intermediate casing string. Successive wells are being drilled consistently to total depth (TD) and completed with two casing strings, **Fig. 3**. This prevents the wellbore instability issues related to insufficient mud weight, while avoiding loss returns in the Wilcox while drilling, running casing and cementing. Using the shielding technology, the operator

reduced NPT, and eliminated the intermediate casing string and associated costs.

Elsewhere, a similar situation exists in horizontal wells targeting the Woodford shale in the SCOOP (South Central Oklahoma Oil Province) of Oklahoma's Anadarko basin. There, operators must first contend with the instability issues and severe mud losses when drilling the depleted Red Fork formation. The higher mud weights required to prevent sloughing shale in the Springer/Woodford lateral section can prove problematic by inducing lost circulation in the Red Fork sands. By incorporating the wellbore shielding process, one operator effectively drilled 20,619 ft of open hole to TD, also with two casing strings and zero NPT related to wellbore instability.

Offshore, in an ongoing in-fill drilling program, in a mature field in the UK North Sea, induced losses had been a given in the highly depleted, 8.5-in. hole section in a sandstone reservoir. The reservoir section routinely is fraught with mechanical instability and equivalent circulating densities (ECD) typically near the LOT values, thereby leading to breakout, as well as differential sticking and severe losses.

The wellbore shielding technology was later selected to drill the reservoir section, which was drilled to programmed TD. The liner was run with no losses. One of two sidetracks was drilled with zero losses, while the second lost only 8 bbl while running the liner in hole. The preventative technology, which conforms to stringent UK environmental regulations, has since been approved for use in the reservoir sections of the upcoming infill wells.

Similarly, the depleted production zone of wells drilled in the deepwater Gulf of Mexico (Keathley Canyon) has encountered whole mud losses while drilling and running casing. By maintaining 8 lb/bbl of the shielding additive in the circulating system, an operator was able to successfully drill to TD, run production casing and cement with full returns. **WO**

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