A Safety Net for Controlling Lost Circulation

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Extreme circulation losses during cementing operations jeopardize wellbores. To limit the potential impact of lost circulation, engineers typically reduce slurry density, limit friction pressure while pumping, or perform stage cementing operations, but these approaches do not always work. Cementing operations using advanced, chemically inert fibers mitigate lost-circulation problems without compromising operational efficiency or the quality of the slurry or set cement.

How do you catch a thief? When the "thief" is a fractured formation, a cavern or a highly permeable formation that is stealing the fluid circulating in a wellbore, its capture requires advanced technology. This type of theft, known as lost circulation, is a common problem in oil fields. Lost circulation costs the industry hundreds of millions of dollars each year in lost or delayed production and in spending to deal with drilling problems, repair faulty primary cement jobs and replace wells irreparably damaged by lost circulation.

Lost circulation is the reduced or total absence of fluid flow up the formation-casing or casing-tubing annulus when fluid is pumped down drillpipe or casing. Loss of fluid circulation is a familiar hazard when drilling and cementing in highly permeable reservoirs, in depleted zones, and in weak or naturally fractured, vugular or cavernous formations. Circulation may be impaired even when fluid densities are within the customary safety margin—less dense than the formation fracture density. Stopping circulation losses before they get out of control is crucial for safe and economically rewarding operations.

Although engineers define lost circulation in many ways, it may generally be classified as *seepage* when losses are less than 10 bbl/hr [1.5 m^3/hr] (below). *Partial lost returns* involve losses greater than 10 bbl/hr, but some fluid returns to surface. During *total lost circulation*, no fluid comes out of the annulus. In this most

Degrees of Lost Circulation

Type of loss	Severity of loss
Seepage	Less than 10 bbl/hr [1.5 m^3/hr]
Partial lost returns	Greater than 10 bbl/hr, but some fluid returns
Total lost circulation	No fluid comes out of the annulus.

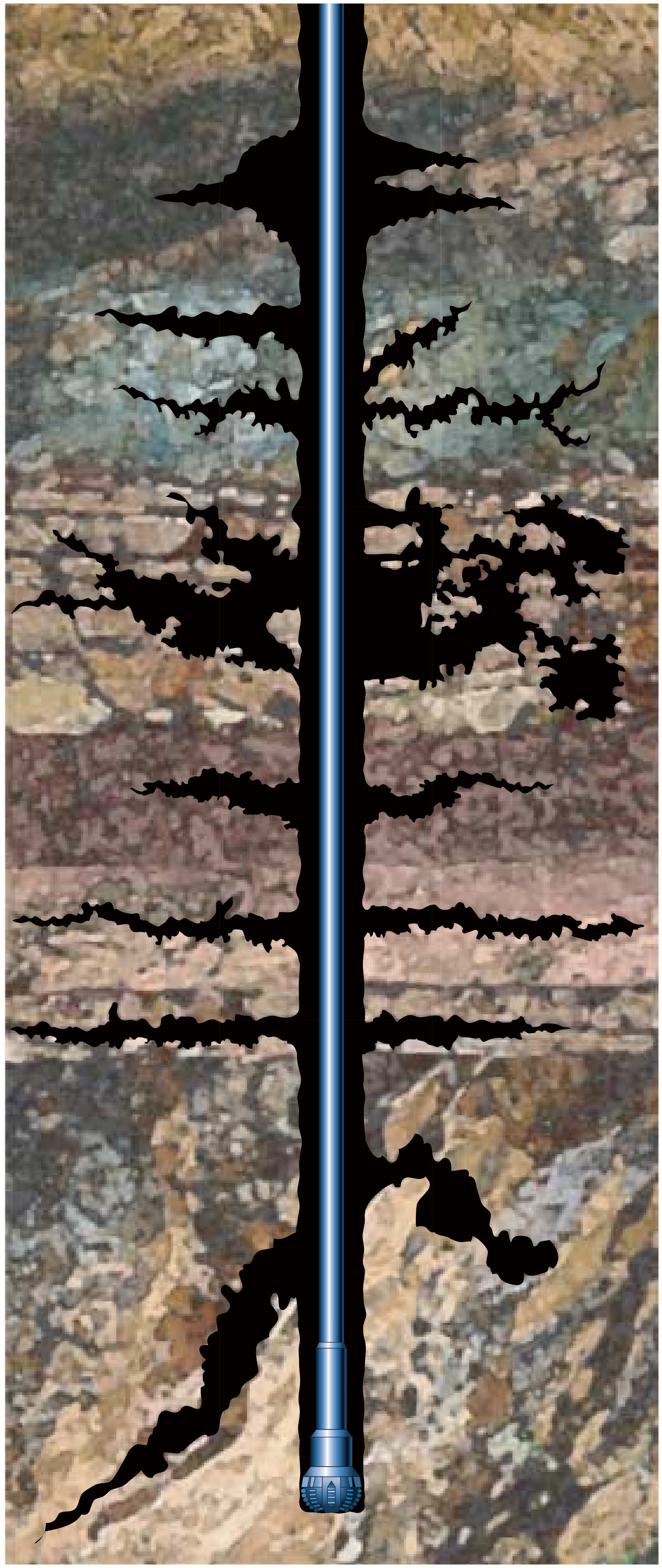
^ Classification of lost-circulation severity by amount of fluid lost.

severe case, the borehole may not retain a fluid column even if the circulating pumps are turned off.

If the borehole does not remain full of fluid, then the vertical height of the fluid column drops and the pressure exerted on exposed formations decreases. As a result, another zone can flow into the wellbore while the primary loss zone is taking fluid. In the extreme, a catastrophic loss of well control can occur. Even in the less severe situations of seepage and partial losses, fluid loss to a formation represents a financial cost that the operator must address. The impact of lost circulation is directly related to the cost of the drilling rig, the drilling fluid and the loss rate over time. In addition, high daily rig costs in deepwater and other frontier operating arenas mean that any time spent mitigating lost circulation is extremely expensive.[1]

During cementing operations, lost circulation commonly leads to insufficient cement fill in the annulus, either because of leakoff during the pumping stage or cement fallback after the pumps are shut down. When this happens, the final cement level is below the planned placement level. Lost circulation during cementing may lead to drilling difficulties in subsequent sections of the borehole or to inadequate zonal isolation. Other deleterious effects, such as fluid leakage or corrosion caused by poor cement placement around the casing, might not be evident for years, by which time these problems might be impossible to repair. In some situations, remedial cementing operations, known as cement squeezes, may be sufficient to repair the damage, but these procedures can be expensive and time-consuming, and the success rate is generally low. In extreme situations, total lost circulation can result in a blowout—complete loss of well control—or a borehole collapse.

In this article, we discuss lost circulation in the context of well cementing. Examples from



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1. For more on lost circulation in deep water: Power D, Ivan CD and Brooks SW: "The Top 10 Lost Circulation Concerns in Deepwater Drilling," paper SPE 81133, presented at the SPE Latin America and Caribbean Petroleum Engineering Conference, Port-of-Spain, Trinidad, West Indies, April 27–30, 2003.

the Middle East, Southeast Asia, North Sea and North America demonstrate the effectiveness of advanced technology in addressing lost-circulation problems during well cementing.

Common Approaches to Lost Circulation During Cementing

Engineers choose from several techniques and materials to alleviate lost circulation during cementing operations (below left). If circulation losses occur, a key task is to locate the loss zone. Downhole flowmeter, or spinner, surveys, temperature logs, or radioactive tracer injection and monitoring commonly reveal loss zones. The location of a loss zone also may be apparent if losses occur immediately after penetration by the drill bit. Once the loss zone is identified, treatment or actions to avoid additional losses can begin.

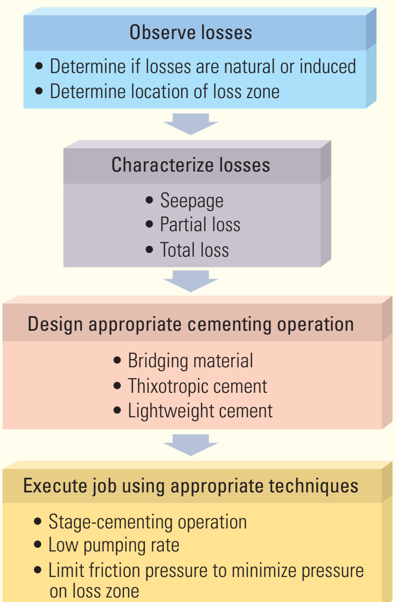
In some situations, merely reducing slurry density is enough to avoid significant losses. The slurry density may be reduced by foaming the slurry or adding extenders—low-density particles or materials that allow the addition of extra water.[2] Pumping different cement systems as the lead slurry and the tail slurry can prevent some lost-circulation problems.[3]

Limiting friction pressures during slurry placement mitigates some lost-circulation problems because reducing friction pressure also reduces the pressure exerted by the slurry on the formation. Adjusting rheological properties of the slurry by using dispersants, changing concentrations of fluid-loss additives and antisettling agents, using an optimized particle-size-distribution slurry, or reducing the pumping rate may lessen circulation losses during cementing operations.[4]

Some operators elect to perform stage cementing operations, in which individual portions of a zone are cemented separately using special tools that isolate each stage. Stage operations reduce cement-column heights, lowering the dynamic and hydrostatic pressures. However, multistage operations require more rig time than a single-stage operation. Multistage operations also pose the risk of fluid contamination from one stage to the next, and the stage tool is a weak point in the casing string.[5]

Another option for minimizing losses during cementing is to use a shear-sensitive, thixotropic cement slurry, which gels as soon as shearing ceases; these cements develop high gel strength as soon as they are lost to a formation, plugging the zone.[6]

Fluid Loss During Cementing Operations

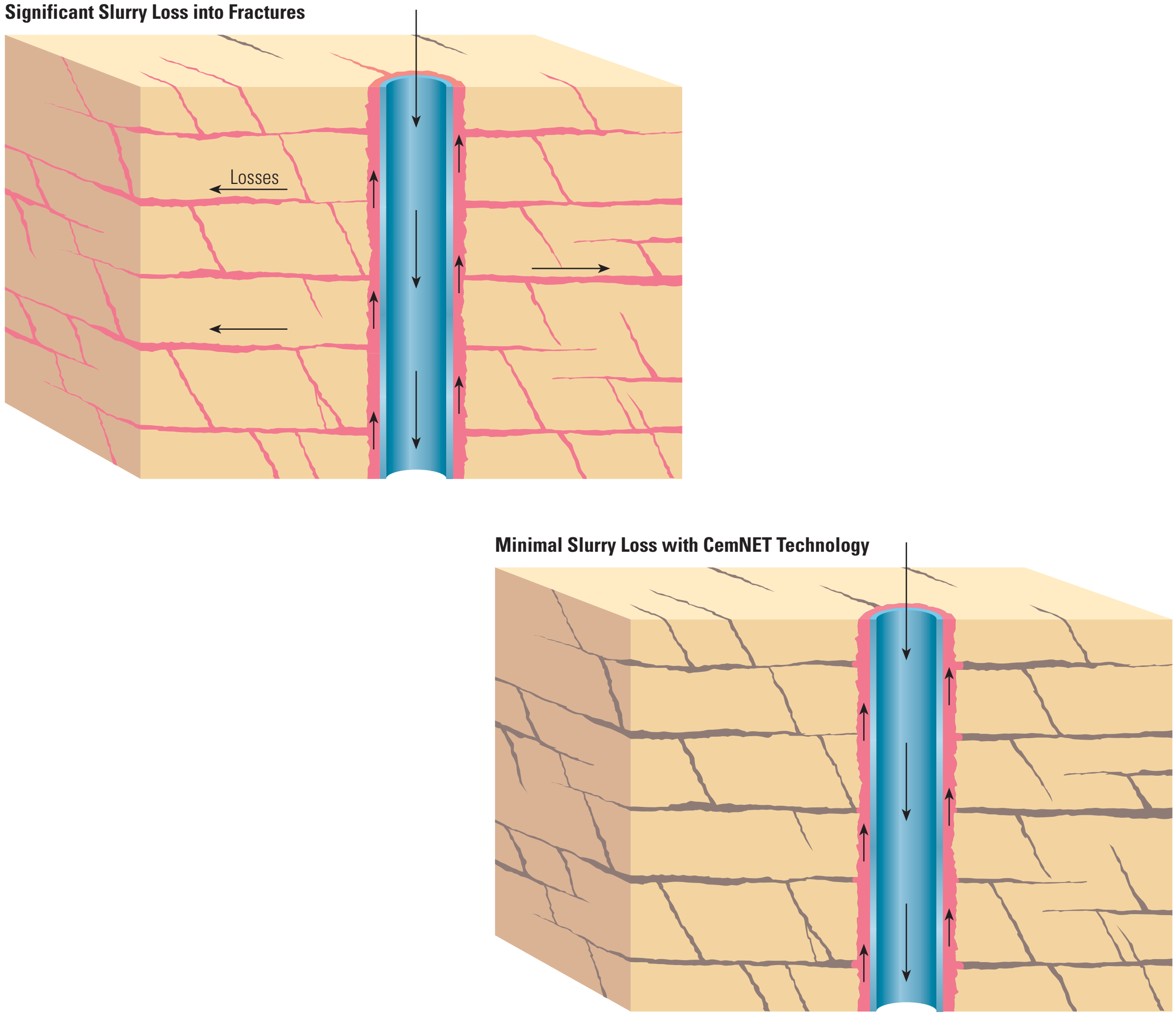


^ Workflow for countering lost circulation during cementing operations.

^ CemNET technology. Dry CemNET fibers are easy to handle (*left*). Once mixed with water, the fibers form a mat-like network across zones of lost circulation (*right*).

2. For more on foamed and ultralightweight cements: Al Suwaidi A, Hun C, Bustillos JL, Guillot D, Rondeau J, Vigneaux P, Helou H, Martínez Ramírez JA and Reséndiz Robles JL: "Light as a Feather, Hard as a Rock," *Oilfield Review* 13, no. 2 (Summer 2001): 2–15.
3. Primary cementing operations may involve as many as four slurries, but jobs with two slurries, known as the lead slurry and the tail slurry, are more common. "Lead" refers to the first slurry pumped during primary cementing operations. "Tail" refers to the last slurry pumped during primary cementing operations. Typically, the tail slurry covers the pay zone and is denser than the lead slurry.
4. For more on slurries that use optimized particle-size distributions: Boisnault JM, Guillot D, Bourahla A, Tirlia T, Dahl T, Holmes C, Raiturkar AM, Maroy P, Moffett C, Pérez Mejía G, Ramírez Martínez I, Revil P and Roemer R: "Concrete Developments in Cementing Technology," *Oilfield Review* 11, no. 1 (Spring 1999): 16–29.
5. For more on stage cementing operations: Boisnault et al, reference 4.
6. Nelson EB, Baret J-F and Michaux M: "Cement Additives and Mechanisms of Action," in Nelson EB: *Well Cementing*. Sugar Land, Texas, USA: Schlumberger Dowell (1990): 3-30–3-31.
7. For more on lost circulation in well cementing: Nelson et al, reference 6.

   Baret J-F, Daccord G and Yearwood J: "Cement/Formation Interactions," in Nelson EB: *Well Cementing*. Sugar Land, Texas, USA: Schlumberger Dowell (1990): 6-7–6-16.
8. Low N, Daccord G and Bedel J-P: "Designing Fibered Cement Slurries for Lost Circulation Applications: Case Histories," paper SPE 84617, presented at the SPE Annual Technical Conference and Exhibition, Denver, Colorado, USA, October 5–8, 2003.



^ Net-like fibers to bridge loss zones. Fluid loss in fractured formations, shown schematically in red, is an undesirable occurrence during cementing operations (*top*). By adding fibers to cement slurry, a fibrous net forms, the cement slurry builds a filter cake and slurry circulates up the annulus to provide zonal isolation and prevent additional fluid losses (*bottom*).

Engineers may also adjust tubular designs or casing-setting depths on the basis of computer modeling. Modeling helps operators apply a combination of approaches to limit losses during cementing. However, recent innovations in cementing materials are helping operators combat lost circulation.

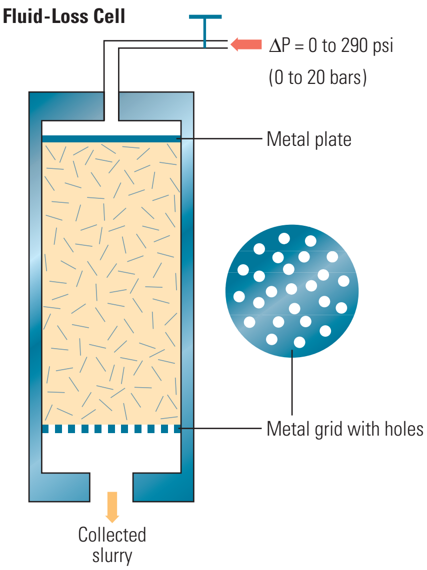
Uncommon Cementing Technology for Lost Circulation

For decades, cementing specialists have incorporated grains, fibers, flakes or other lost-circulation materials (LCMs) in cement slurries.[7] Although LCMs may alleviate lost-circulation problems, many LCMs are difficult to disperse in slurries and to mix and pump using ordinary cementing equipment. The low specific gravity of some LCMs causes them to float on the slurry surface. The inability of some of these materials to disperse in the slurry or to become properly water-wet has caused plugging problems in both mixing and downhole equipment.

A new, advanced fiber can be mixed with cement slurries to form a high-performance bridging network across zones of lost circulation. The fibers of CemNET advanced fiber cement, engineered to optimal sizes generally less than 12 mm [0.5 in.] long and 20 microns in diameter, are chemically inert and compatible with most cementing systems and additives at temperatures up to 450°F [232°C].[8] These fibers can be added at the wellsite, and may be combined with the portions of the slurry that will be placed across potential loss zones.

The main advantage of the CemNET fibers is their ability to easily disperse in the cement slurry. Unlike conventional fibers, CemNET fibers are coated with a special surfactant that keeps individual fibers together when dry, but also helps the fibers disperse and mix without difficulty when added to the slurry (previous page, right). When added at an optimal concentration, CemNET fibers form a bridging network, but do not alter crucial slurry or cement properties, such as thickening time, rheological properties, fluid loss, free-water content, tensile strength, shear strength and compressive strength (above).

By incorporating advanced fibers, operators may avoid problems such as low cement tops, the need for squeeze-cementing operations, and more serious cement losses and borehole failures. When the bridging action of fibers in the cement slurry seals loss zones, less slurry is lost during pumping operations. Laboratory experiments have verified the effectiveness of fiber-laden slurries in plugging loss zones,



^ Laboratory testing of fibrous slurries. An API fluid-loss cell was modified to test CemNET slurries (*top*). The top of the test cell acts like a piston; the plate at the bottom simulates a loss zone. Round holes in the plates, measuring 1, 2, 4 and 6 mm [0.04, 0.08, 0.16 and 0.24 in.] in diameter, simulate high-permeability zones; the slotted plates represent fractures 1 and 2 mm wide (*middle*). After testing, the plates with slots or holes are plugged with fibrous slurry (*bottom*).

including simulated fractures and highly permeable formations (left).[9] The experiments also confirmed that fiber length is a crucial parameter for sealing fractures, but that the fibers must be short enough to avoid plugging pumping equipment. Higher concentrations of fibers proved more effective, but increased the risk of affecting slurry rheology. For high concentrations of fibers, increasing the amount of dispersant helped maintain slurry pumpability.

To assist engineers designing slurries to combat lost-circulation challenges in the field, Schlumberger and M-I L.L.C. jointly developed the Lost Circulation Advisor, which can be used in conjunction with CemNET treatments. This software uses decision trees to analyze lost-circulation situations and then recommends the best treatment to control losses.[10] Regardless of whether the losses are partial or complete, or whether the application is for drilling or cementing, the Lost Circulation Advisor examines well data, previous lost-circulation treatments, estimated loss rate and the stratigraphy in the exposed borehole section. From these inputs, the software identifies the type of loss and estimates its depth. Next, the software recommends the optimal lost-circulation treatment from a database of generic and specialized systems available from M-I and Schlumberger. Once the treatment is selected, the software provides complete technical data to design the treatment.

Optimizing the selection and design of lost-circulation treatments usually helps operators reduce the amount of cement slurry they pump. Accurate estimates of the slurry volume required for an operation mean lower volumes of excess cement, which in turn decreases cement-disposal costs. As the examples that follow demonstrate, proper slurry selection, job design and execution contribute to successful treatment with CemNET technology.

Alleviating Lost Circulation in the Middle East

Carbonate rocks of the Middle East are known not only for prolific oil and gas reserves, but also for lost-circulation problems. Abu Dhabi Company for Onshore Oil Operations (ADCO) confronts these problems regularly when drilling the Umm El Radhuma and Simsima formations. In the past, the company attempted to control lost circulation by performing stage cementing operations and top jobs, by using lightweight cements and by setting plugs during primary cementing operations.[11] None of these approaches is satisfactory because any casing not surrounded by cement is exposed to corrosive brines. However, the operator continues to perform top jobs when the most severe losses occur to protect the casing as much as possible from corrosion.

Recently, ADCO cemented two wells using slurries containing CemNET fibers.[12] During the drilling of one well, the rate of lost circulation reached 150 bbl/hr [23.8 m^3/hr], even though a relatively light, 9.1-lbm/gal [1091-kg/m^3] drilling fluid was being pumped. A heavier cement slurry—10.7 lbm/gal [1283 kg/m^3]—was planned, so the operator was concerned about additional losses. A combination of fiber-laden slurry and high-performance lightweight slurry was pumped, followed by a 16.7-lbm/gal [2002-kg/m^3] tail slurry. After recovering full returns of 134 bbl [21.3 m^3] of drilling fluid at surface, and experiencing no difficulties in mixing or pumping the slurries, ADCO deemed this operation successful.

The second well suffered losses at an even greater rate—500 bbl/hr [79.5 m^3/hr]—while drilling with 8.65-lbm/gal [1036-kg/m^3] mud. The company decided to set casing 500 ft [152 m] higher than originally planned to address the losses. An ultralightweight slurry weighing 8.0 lbm/gal [959 kg/m^3] at surface was blended with CemNET fibers. This slurry was followed by a 15.7-lbm/gal [1882-kg/m^3] tail slurry. Although returns were not expected, partial returns were observed at surface. To protect the casing from corrosive brine, a top job was pumped. However, the volume of slurry pumped for the top job was reduced by approximately 40%, or 100 bbl [15.9 m^3], because more CemNET slurry had been placed in the annulus during the primary cementing operation. In light of these results, ADCO plans to use CemNET slurries routinely.

Applying Advanced Cementing Technology in Asia

The giant Duri field in Sumatra, Indonesia, has been steamflooded for enhanced recovery of heavy-oil reserves since 1985.[13] The operator, P.T. Caltex Pacific Indonesia (CPI), produces more than 205,000 B/D [32,575 m^3/d] of oil from 6800 wells. The 200- to 900-ft [61- to 274-m] deep sandstone reservoirs have gravel-pack completions. Lost circulation in these unconsolidated and faulted reservoirs often necessitates remedial cementing operations. The recent introduction of CemNET technology is reducing cementing costs by limiting the need for remedial cementing.[14] Previously, many different cementing techniques were attempted in the

Duri field, such as cement plugs incorporating various LCMs and foamed, thixotropic or other types of primary cement. Even though these techniques increased the primary cementing success rate to 60%, the failure rate remained unacceptably high.

To improve the cementing success rate, CPI pumped CemNET plugs—15.0-lbm/gal [1797-kg/m^3] cement slurry with 2.5 lbm/bbl [7.1 kg/m^3] of fibers—in cases of total lost circulation. In certain circumstances, a 5-bbl [0.8-m^3] cement plug cured losses, although seepage continued in the most severe instances. CPI next decided to use CemNET technology in the primary cement slurry to cure lost circulation, adding 2.5 lbm/bbl of fibers while pumping a 15.8-lbm/gal [1893-kg/m^3] cement slurry. In one situation, a Duri well suffered total lost circulation while drilling, which was reduced to seepage losses after placement of a CemNET plug. Nevertheless, this well was cemented successfully using CemNET slurry.

Of the 98 most recent CemNET plugs in Duri field, 63 completely cured lost circulation, and in 18 others, losses were reduced. In 30 primary cementing operations using CemNET fibers, 28 had complete cement coverage. Overall, the cementing success rate improved from 60% to 85%. Using CemNET technology, CPI saves 32 hours of rig time per well because the initial cementing operation is usually successful and remedial operations are required much less frequently.

CPI is finding additional uses for CemNET technology in other fields it operates. For example, CemNET slurries are pumped through coiled tubing to shut off perforations that produce water.[15]

Curing Losses in the UK North Sea

Shell Expro experienced severe circulation losses in the Brent field, UK North Sea, in reservoirs penetrated by extended-reach and nearly horizontal wells. This field, which began producing oil in 1976, contains substantial solution-gas reserves in bypassed and residual oil zones. The company began depressurization operations to recover gas as it evolved from the oil by discontinuing water injection in 1998.

Depressurization has led to a narrower window between pore pressure and fracture pressure because the formation stress gradient decreased as reservoir pressure declined. Successfully drilling shale sections required a minimum drilling-fluid density to prevent stuck pipe and to counteract instability in interbedded sands and shales. The combination of the narrow pressure window and the decreasing fracture gradient also posed serious problems during well-cementing operations.

To ensure that the Brent wells could be cemented successfully, engineers simulated cementing operations to optimize pumping rates, mud removal and equivalent circulating densities. In the Brent Delta Well BD-42s4, drilled in 2002, engineers confronted potential lost circulation. This sidetrack was drilled with a PowerDrive rotary steerable system to recover gas from the Statfjord reservoir. The 8½-in. borehole section, with an inclination of 57°, and the 6-in. section, with an inclination up to 72°, experienced no losses while drilling. However, all the Brent wells drilled in 2002 experienced losses while drilling or cementing, so the cementing plans for Brent Delta Well BD-42s4 were adapted accordingly.

The operator set 1000 ft [305 m] of 7-in. liner after drilling the 8½-in. section. The lowest 250 ft [76 m] covered the Statfjord formation. Poor primary cement in the 9⅝-in. casing string meant that the 7-in. string would need 1000 ft of good cement to isolate zones effectively. After pumping unweighted chemical wash and weighted spacer for mud removal, engineers pumped the cement slurry. This slurry, weighted to 14.5 lbm/gal [1737 kg/m^3], included CemNET fibers to mitigate potential losses. The operation proceeded as planned, with full returns to surface indicating no losses during cementing.

The next section, which penetrated the Statfjord reservoir, experienced partial lost returns of 66 bbl/hr [10 m^3/hr] when drillpipe was pulled out of the hole. Before the 4½-in. liner was run, LCM was pumped, but losses continued, increasing to 122 bbl/hr [19 m^3/hr] prior to cementing. High pressures at the bottom of the well made a successful cementing operation critical to future production. During pumping of the 14.5-lbm/gal slurry with CemNET fibers, losses dropped to 43 bbl/hr [6.8 m^3/hr] and there were returns to surface. A successful pressure test of the top liner after the cement set indicated that zones were isolated adequately.

As demonstrated in this Brent well, new cementing technology can prevent or minimize losses without constraining other aspects of operations. In fact, these operations required no extra equipment to avoid expensive fluid losses.

Avoiding Wet Shoes in the Norwegian North Sea

In one of the fields in the Tampen area of the Norwegian North Sea, Statoil sets 18⅝-in. casing in unconsolidated sand formations.[16] Historically, Tampen-area wells have been prone to poor leakoff test (LOT) results at this casing shoe because of a phenomenon known as a "wet shoe."[17] A wet shoe occurs when the cement does not set around the shoe or when the cement is lost to thief zones. More generally, any time a driller does not tag, or contact, hard cement around a shoe, it is known as a wet shoe.

When a wet shoe occurred, Statoil usually performed squeeze-cementing operations to obtain adequate LOT results, but this remedial cementing work was costly. Taken to an extreme condition, an inadequate LOT might require a contingency casing string, meaning that the diameter of the production string might be narrower than planned and production economics not as favorable, or it might not be possible to drill to the target formation.

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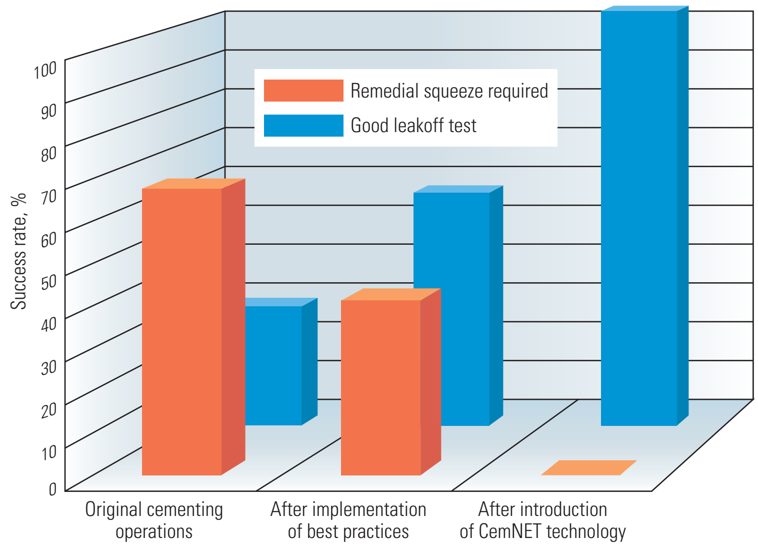
9. For details of the experiments: Low et al, reference 8.
10. For more on decision trees: Coopersmith E, Dean G, McVean J and Storaune E: "Making Decisions in the Oil and Gas Industry," *Oilfield Review* 12, no. 4 (Winter 2000/2001): 2–9.
11. Top-job operations involve pumping cement down the annulus from surface, rather than down the drillpipe and up the annulus, to fill the space between the formation and the casing.
12. For more on the use of CemNET technology in the Middle East and Asia: El-Hassan HI, Abbas R, Jarouj H and Munk T: "Using a Novel Fiber Cement System to Control Lost Circulation: Case Histories from the Middle East and the Far East," paper SPE 85324, presented at the SPE/IADC Middle East Drilling Technology Conference and Exhibition, Abu Dhabi, UAE, October 20–22, 2003.
13. For more on heavy oil and the Duri field: Curtis C, Kopper R, Decoster E, Guzmán-Garcia A, Huggins C, Knauer L, Minner M, Kupsch N, Linares LM, Rough H and Waite M: "Heavy-Oil Reservoirs," *Oilfield Review* 14, no. 3 (Autumn 2002): 16–29.
14. Effendhy, Junaidi H, Abbas R and Malik BZ: "Fibers in Cement Form Network to Cure Lost Circulation," *World Oil* 224, no. 6 (June 2003): 48–50.
15. Effendhy et al, reference 14.

    For more on the use of CemNET technology in Indonesia: El-Hassan et al, reference 12.
16. For more on zonal isolation in the Tampen area: Abbas R, Cunningham E, Munk T, Bjelland B, Chukwueke V, Ferri A, Garrison G, Hollies D, Labat C and Moussa O: "Solutions for Long-Term Zonal Isolation," *Oilfield Review* 14, no. 3 (Autumn 2002): 30–51.
17. A leakoff test is performed to determine the strength or fracture pressure of the open formation, and is usually conducted immediately after drilling below a new casing shoe. During the test, the well is shut in and fluid is pumped into the wellbore to gradually increase the pressure on the formation. At some pressure, fluid will enter the formation, or leak off, either moving through permeable paths in the rock or by creating a space by fracturing the rock. The results of the leakoff test dictate the maximum pressure or mud weight that may be applied to the well during drilling operations. To maintain a small safety factor to permit safe well-control operations, the maximum operating pressure is usually slightly below the leakoff test result.

Working with Schlumberger, Statoil developed new cementing practices to solve the wet-shoe problem. These included reducing the lead-slurry density and the length of the shoe track cemented using a tail slurry.[18] Although these techniques reduced the number of wet shoes, the problem was not eliminated. Therefore, Statoil began pumping tail slurries containing CemNET fibers. To date, two wells have been cemented using CemNET tail slurries; both operations were successful and required no remedial work (right). Consistent with other CemNET cementing operations, the fibers were mixed and pumped with ease.



^ Cementing success rates using typical cementing techniques, best practices and CemNET technology in the Tampen area. Red bars indicate subsequent need for remedial cementing; blue bars indicate good leakoff test (LOT) results.

Avoiding Lost-Circulation Problems in North America

Onshore operations in North America encompass an enormous variety of challenges in reservoirs of many geological ages and lithologies. Nevertheless, many drilling operations throughout the continent have something in common—lost circulation. Recently, several operators have successfully counteracted lost circulation using CemNET technology.

In West Virginia, USA, Cabot Oil & Gas Corporation required excellent zonal isolation in a low-pressure producing reservoir that would be fracture stimulated. Like most wells in the area, this well was drilled using air as the drilling fluid, which often leads to lost circulation during cementing. Because of the low fracture gradient of some of the formations, the cement had to be lightweight, but the planned stimulation treatment meant that the cement also would have to be durable.

In previous cementing operations, 12 of 41 production-casing strings required remedial cementing. After studying these results, Cabot employed a variety of advanced cementing systems, each with progressively better results. Initially, Cabot used RFC regulated fill-up cement, which is a thixotropic and expansive mixture of Portland cement and plaster—a seemingly ideal formulation to avoid losses and provide good cement bonding in lost-circulation zones. Even though the RFC slurry is designed to quickly become immobile after placement, cement losses continued. Next, CemNET fibers were added to RFC cement slurry. This system yielded better results in obtaining the desired cement heights.

Later, Cabot decided to reduce the slurry density using KOLITE cementive additive for low-density slurries. The lightweight KOLITE granular solids have a specific particle-size distribution designed to combat lost circulation. Although this additive led to some improvement, cement heights remained suboptimal, so CemNET fibers were added to the KOLITE slurries. This system has produced the best and most reproducible results to date in terms of achieving the cement height necessary to cover multiple zones of interest.

To better satisfy the requirements for lightweight yet durable slurries, Cabot next used a LiteCRETE slurry system with CemNET fibers to achieve zonal isolation. In a well that is 3500 ft [1067 m] deep, 2095 ft [639 m] of cement was placed in the annulus instead of being lost to the formation. Although this result continues the trend towards steady cementing improvement, Cabot continues to evaluate the use of the LiteCRETE and CemNET blend for future wells. To date, Cabot has used CemNET slurries in 51 cementing jobs.

Cementing improvements were not limited to slurry selection; Cabot and Schlumberger engineers also developed guidelines for using lighter slurries, reducing water content and minimizing slurry viscosity and fluid loss.

Hundreds of miles from West Virginia, the Permian-age Brown Dolomite formation of the Texas panhandle, USA, presents significant lost-circulation problems. Total lost circulation while drilling is not uncommon. This naturally fractured reservoir is prone to damage from excessive drilling-mud and cement losses. Thousands of barrels of cement have been pumped into this formation in attempts to offset circulation losses.

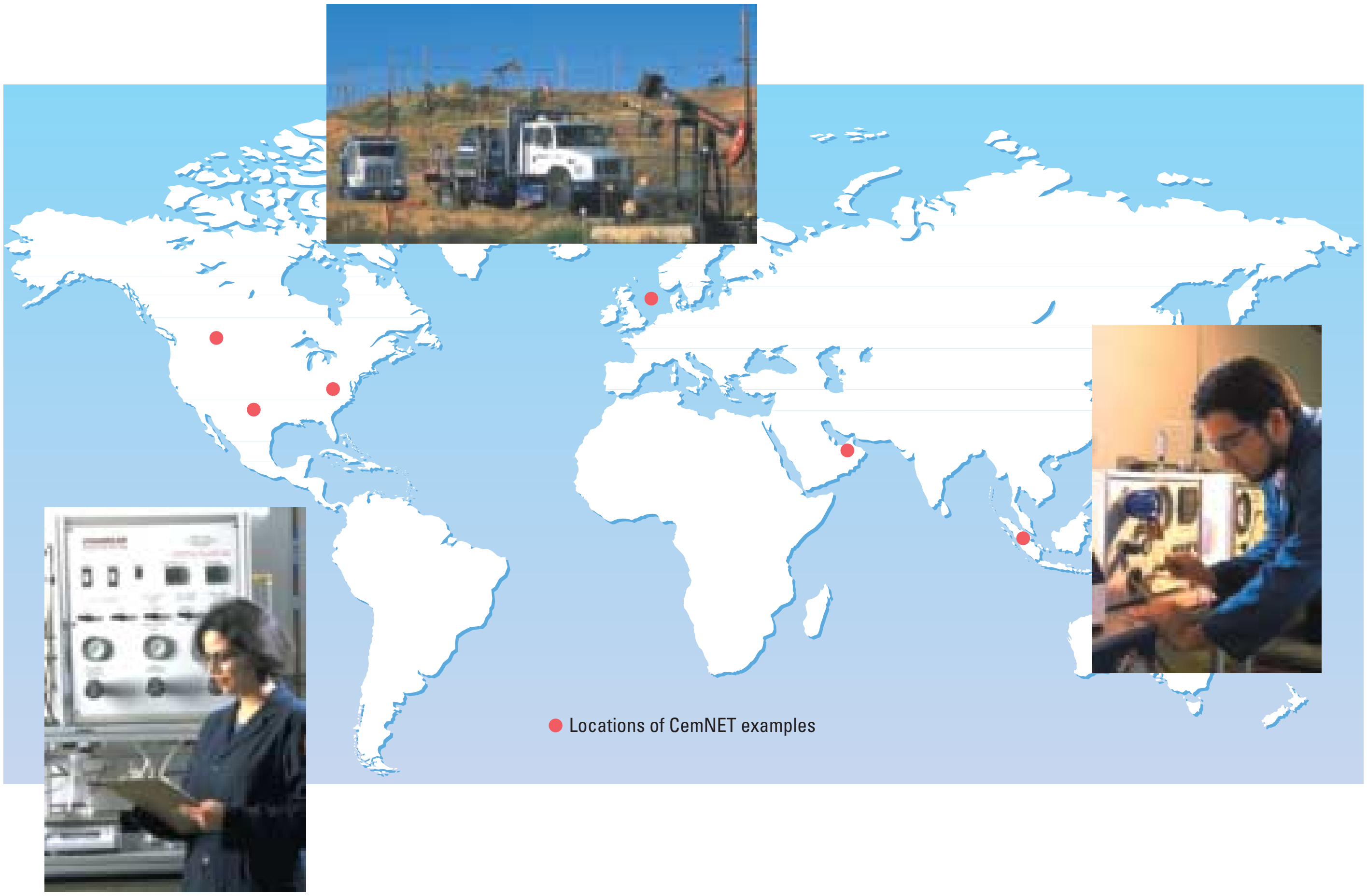
In a well in Roberts County, Texas, Brighton Energy LLC encountered total lost circulation in the Brown Dolomite formation. Two attempts to stop losses using ordinary cement plugs failed. After one week of lost rig time, Brighton decided to discontinue pumping massive volumes of cement as lost-circulation treatments, and instead contacted Schlumberger for assistance. A CemNET plug was placed in the Brown Dolomite loss zone. The severity of the losses caused the plug to break down when drilling resumed. A second CemNET plug was pumped, which successfully sealed the loss zone. Brighton was able to continue drilling operations with full circulation. Brighton saved approximately US $26,000 per day on rig time, mud losses and other materials, and plans to use CemNET technology when cementing troublesome Brown Dolomite wells.

Nearly 2000 miles [3200 km] north of the Texas panhandle, coals and other shallow formations in southern Alberta, Canada, are prone to lost circulation. However, predicting which wells

18. The shoe track is the space between the float or guide shoe and the landing or float collar. The principal function of this space is to ensure that the shoe is surrounded by high-quality cement and that any contamination that may bypass the top cement plug is safely contained within the shoe track.

19. Anderson J, Simpson M, Basinski P, Beaton A, Boyer C, Bulat D, Ray S, Reinheimer D, Schlachter G, Colson L, Olsen T, John Z, Khan R, Low N, Ryan B and Schoderbek D: "Producing Natural Gas from Coal," *Oilfield Review* 15, no. 3 (Autumn 2003): 8–31.

20. Messier E, Stiles D and Morgan R: "Controlling Cement Tops Through Use of Fiber-Based Slurries Reduces Drilling Costs," paper 2002-085, presented at the Petroleum Society's Canadian International Petroleum Conference, Calgary, Alberta, Canada, June 11–13, 2002.



^ A world of success. The CemNET applications described in this article span three continents.

will have lost-circulation problems is difficult; these problems strike no particular formations or areas consistently. In some formations, particularly the coals, this inconsistency stems from the erratic distribution of the rock.[19]

To protect groundwater resources, the shallow gas wells in this region must have cement returns to surface. Like other operators in the area, PanCanadian Energy, now EnCana Corporation, typically pumped significant volumes of excess slurry to place sufficient cement to protect groundwater resources, but the cost to dispose of excess cement was high because the wells were drilled with minimal surface disturbance and there was no disposal facility on location. Given the marginal economics of these shallow gas wells, the operator investigated other approaches, such as changing drilling fluids, but met with limited success. Most other approaches tended to increase drilling time without solving the lost-circulation problem. In fact, the lost circulation typically occurred after drilling—during cementing operations.

PanCanadian also sought to minimize remedial cementing operations in shallow gas wells. Previously, the operator tried granular and lamellar LCMs to combat lost circulation, but these proved ineffective. Over the course of a 77-well project, PanCanadian and Schlumberger optimized pumping procedures and CemNET concentrations.[20] Cement returns improved, which allowed the company to reduce slurry volumes after cementing the first 10 wells. As the project continued, less of the slurry included CemNET fibers, yet the operator continued to pump less excess cement, reduced disposal costs and eliminated remedial cementing operations. After analyzing results from the 77-well project, PanCanadian was able to reduce fiber-laden slurry volumes an additional 25%, which decreased cement returns to approximately 2 m^3 [12.6 bbl].

The numerous changes in cementing procedures and materials eventually led to cost reductions of Canadian $250 per well, which becomes significant for projects involving hundreds of wells.

Winning by Not Losing

In the oil field as elsewhere in the world, thieves will always exist. While lost circulation during well cementing might never be prevented, dealing with this type of thief is certainly not a lost cause. Ideally, lost-circulation problems should be addressed before primary cementing operations occur. When lost-circulation problems are anticipated during primary cementing operations, careful cement-slurry and job design are essential: there is only one opportunity to execute the job successfully.

New technology, including CemNET technology, will combat the most serious side effects in a broad range of temperature conditions and slurry densities. Already a proven remedy for lost circulation, more than 1300 CemNET jobs have been pumped in coal beds, depleted reservoirs, faulted and fractured reservoirs, carbonate rocks, sandstones and shales throughout the world (above). New applications for these exceptional fibrous cement slurries will surely continue to proliferate. —GMG