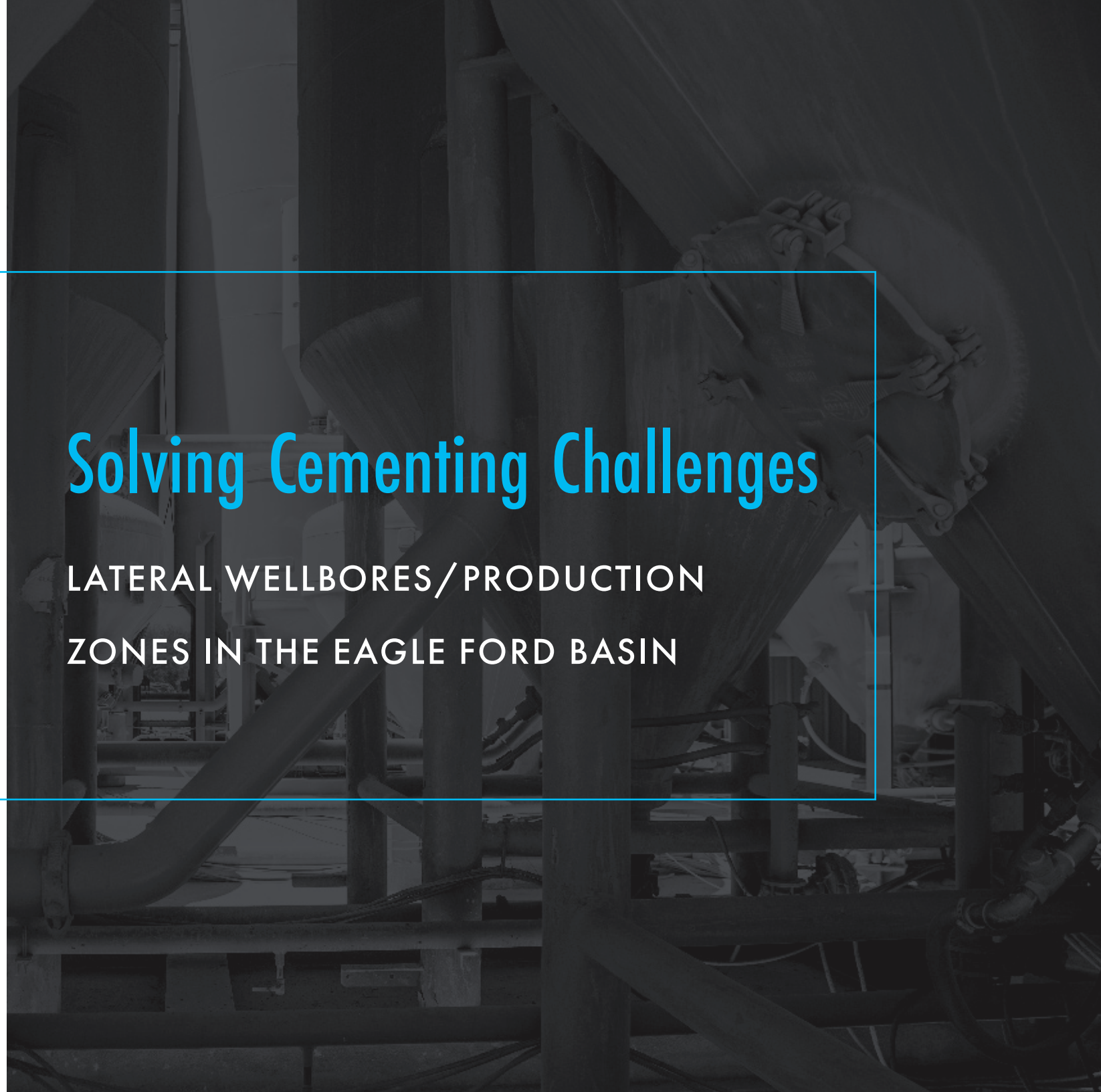
Nine



Solving Cementing Challenges

LATERAL WELLBORES/PRODUCTION ZONES IN THE EAGLE FORD BASIN

CONTENT

SECTION 1

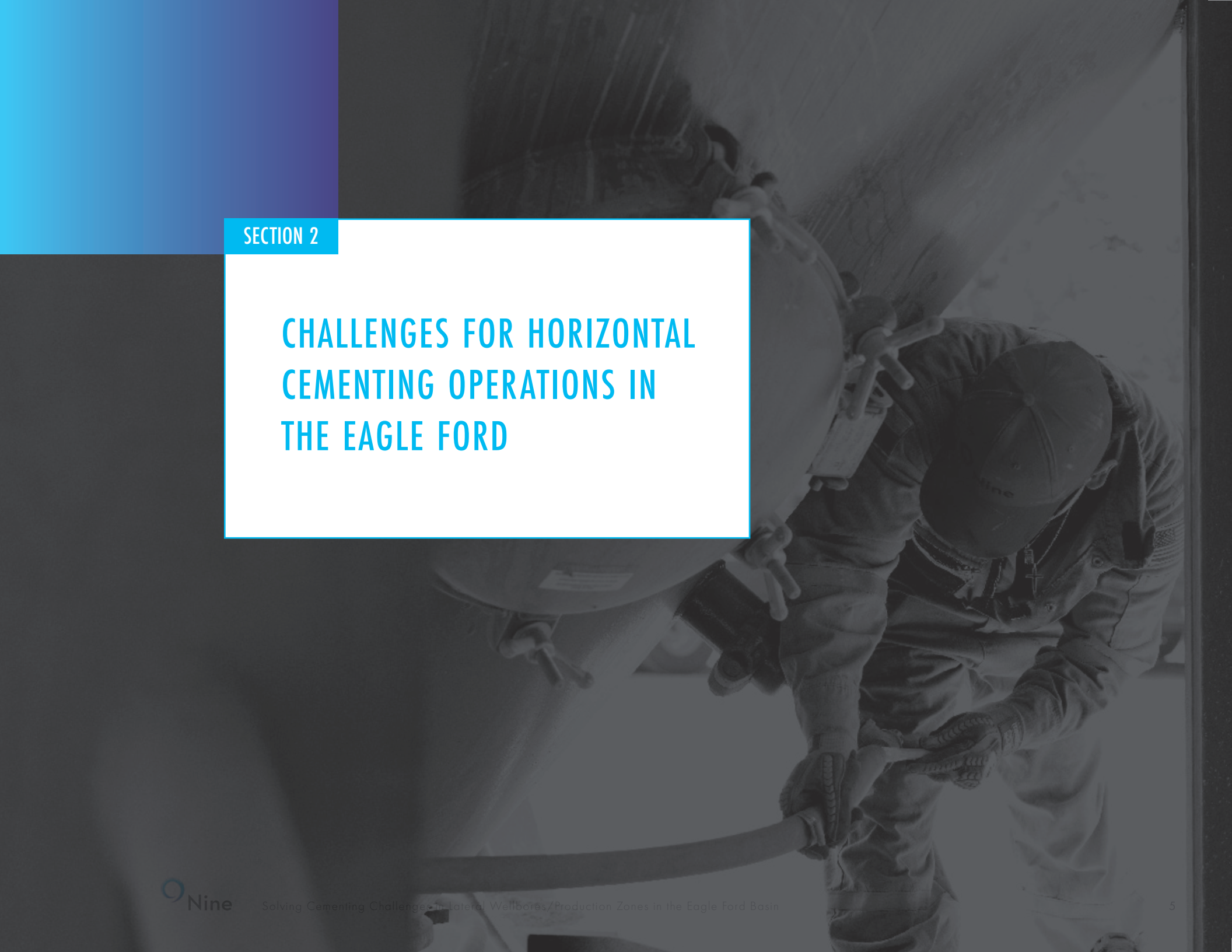
A COMPLEX RESERVE

THE EAGLE FORD SHALE

The Eagle Ford Shale is a complex, stacked play formation that sprawls beneath south and central Texas at widely varying depths (3,000 to 12,000 ft). Pressures in the formation can reach up to 10,000 psi and temperatures up to 330°F. The formation is relatively dense, though not as dense as the neighboring Permian basin. Different sections of the Eagle Ford formation vary in their level of porosity and permeability. Achieving consistent and effective zonal isolation across these heterogeneous formations can be difficult.

SECTION 2

CHALLENGES FOR HORIZONTAL CEMENTING OPERATIONS IN THE EAGLE FORD

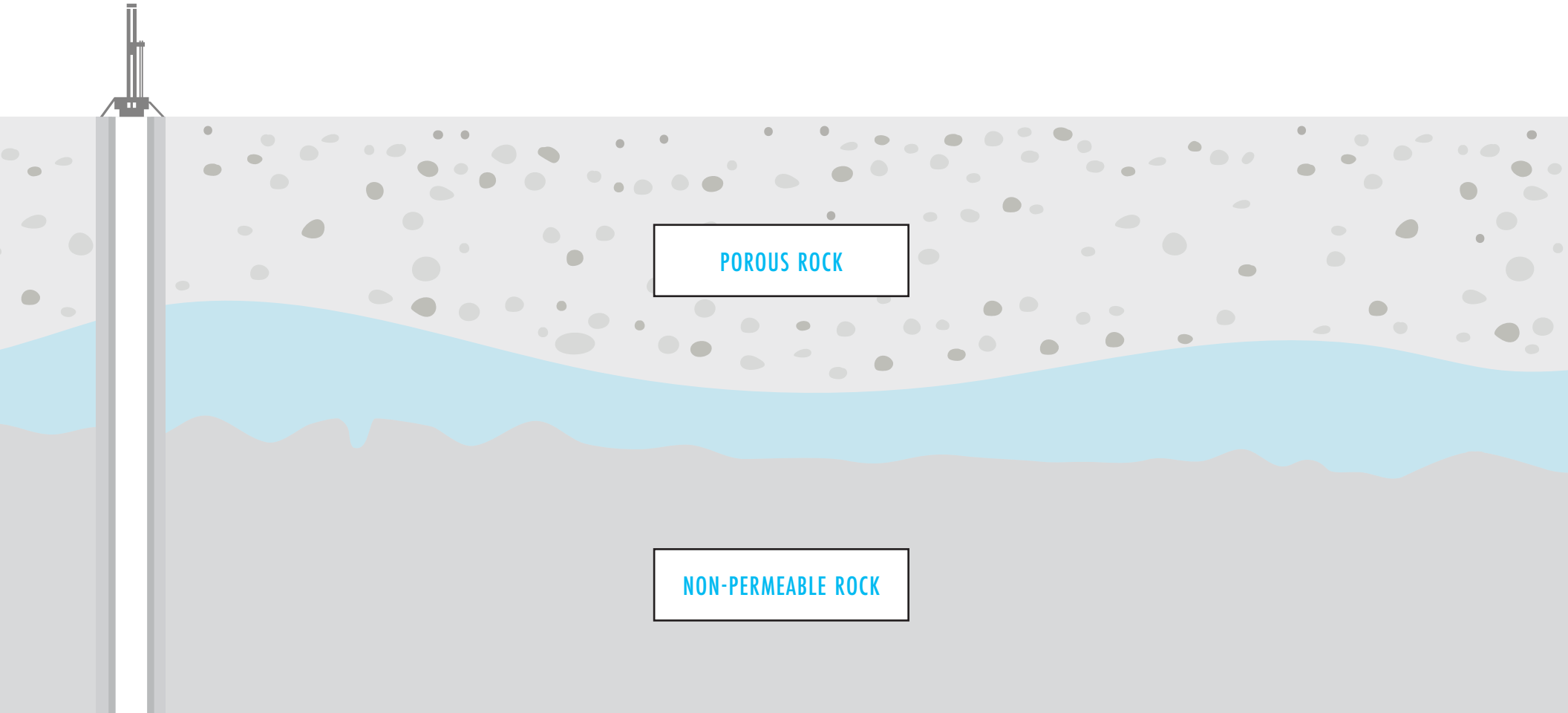


PRESSURE TO MAXIMIZE

For operators in the Eagle Ford, there is strong pressure to maximize economic efficiency in wells with laterals that keep getting longer. Operators routinely drill laterals up to 3 miles long. Economic success depends largely on optimizing zonal isolation by creating a cement sheath that protects the casing and prevents fluid migration. In the Eagle Ford Shale, this objective is often confounded by complex formations, gas presence, and formation fluids.

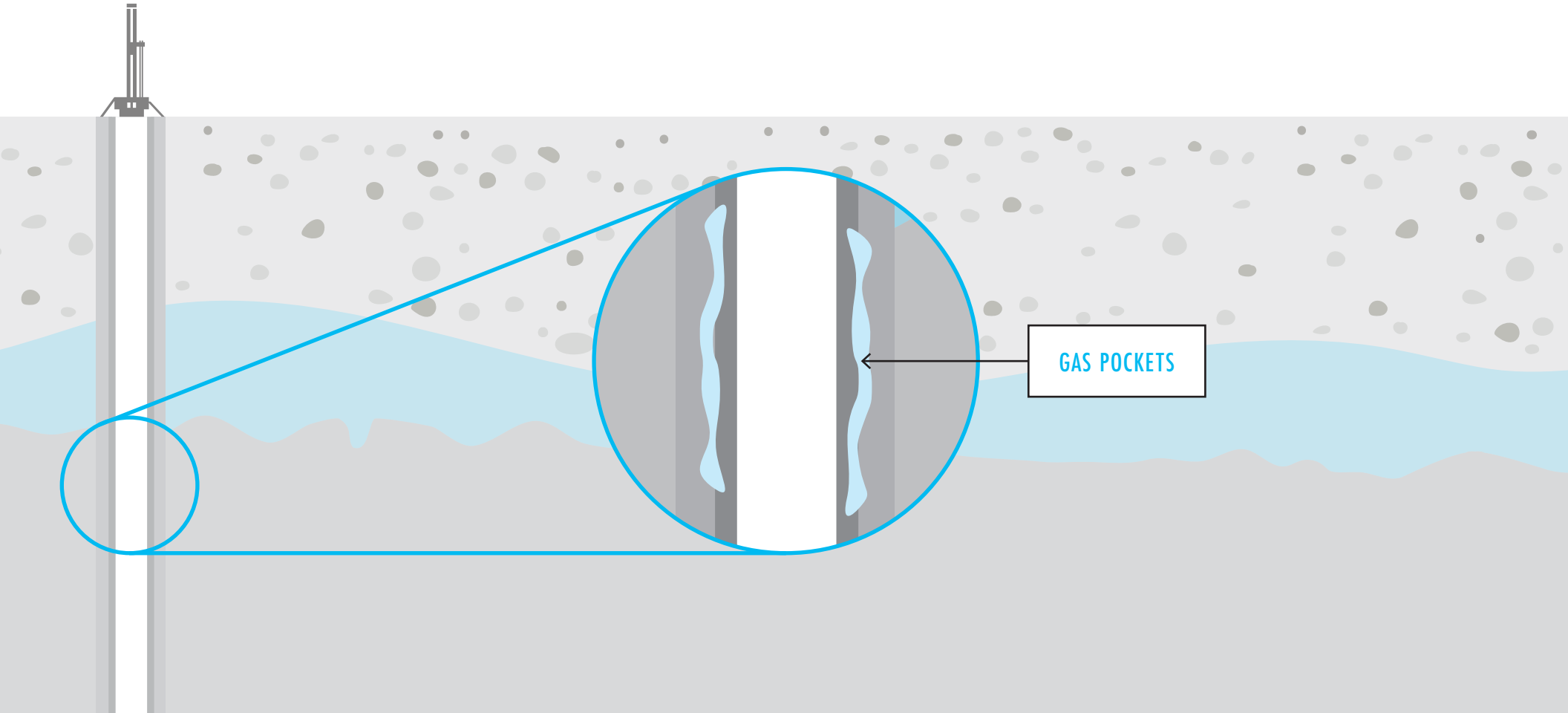
FORMATION COMPLEXITY

Eagle Ford rock contains a wide range of porosities and permeabilities. This complexity can make it challenging to displace drilling fluids from the formation, impacting the quality of the cement bond and making it impossible to achieve effective zonal isolation.



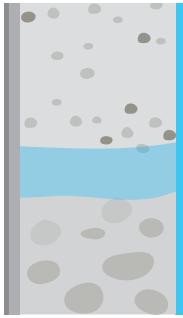
GAS PRESENCE

The Eagle Ford also contains pockets of gas throughout the formation. Gas migration is a concern during and after cementing operations. The presence of gas in the formation can create channels or voids in the cement sheath, compromising zonal isolation.



FORMATION FLUIDS

The Eagle Ford is rich in hydrocarbon resources, and the presence of oil and natural gas in the formation fluids can affect cementing jobs. Operators sometimes encounter hydrocarbon intervals in laterals where oil-based mud (OBM) or synthetic-based mud (SBM) channels form. If hydrocarbons fill these voids, this can interfere with cement bonding, cause poor zonal isolation, and detract from overall stimulation.

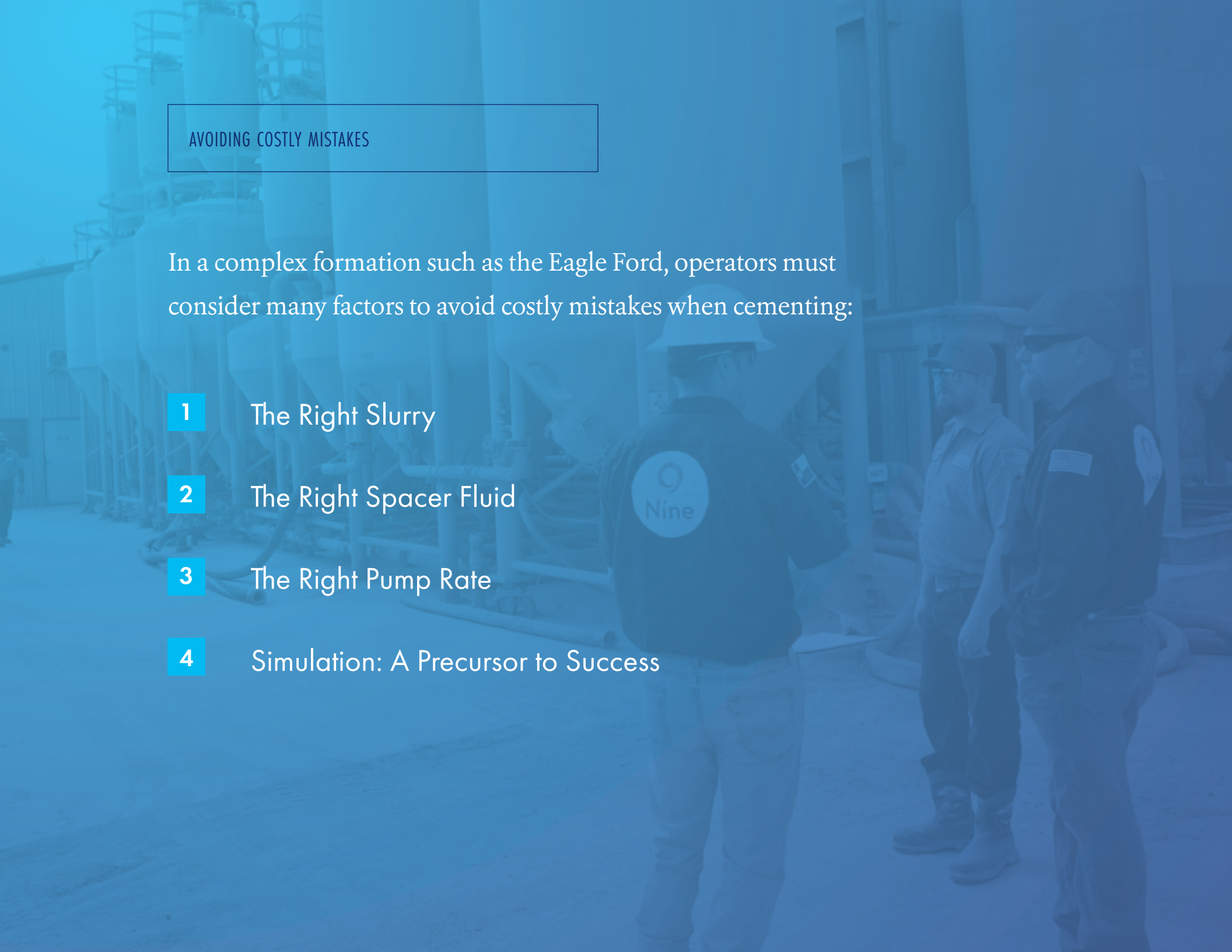


DID YOU KNOW:

Formation water, formation gases, salt water, and drilling fluid residues can also create problems for cementing jobs.

SECTION 3

IMPORTANT SUCCESS FACTORS



AVOIDING COSTLY MISTAKES

In a complex formation such as the Eagle Ford, operators must consider many factors to avoid costly mistakes when cementing:

1. The Right Slurry
2. The Right Spacer Fluid
3. The Right Pump Rate
4. Simulation: A Precursor to Success

THE RIGHT SLURRY

The success of a cementing operation hinges upon slurry selection. When selecting a slurry for a cementing operation, Eagle Ford operators need to identify slurries that are both relevant for the conditions and protective against harmful formation fluids and gas migration.

SLURRY & ADDITIVE SAMPLES

FLOWLOK

A specialized combination of additives

CRACK ATTACK

Multi-particle size lost circulation material

FLEX 50H

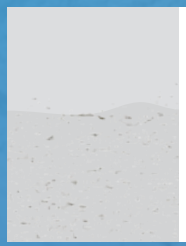
A versatile, advanced polymer additive

RELEVANT

Slurries must align with the specific conditions of the well, including temperatures, pressures, and formation complexities. Because long term zonal isolation is a concern in the Eagle Ford's complex, high-pressure formations, most cement slurries are mechanically enhanced, with densities ranging anywhere from 13.5 ppg to 16.4 ppg.

OTHER SLURRY FEATURES THAT MIGHT PROVE USEFUL IN UNIQUE EAGLE FORD SCENARIOS INCLUDE:

+ Delayed gel strength development
+ Zero free fluid
+ Zero slurry segregation
+ Post set expansion
+ Rapid strength development

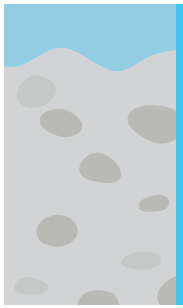


Eagle Ford slurries are also usually designed to **prevent fluid migration** at temperatures of up to 330°F.

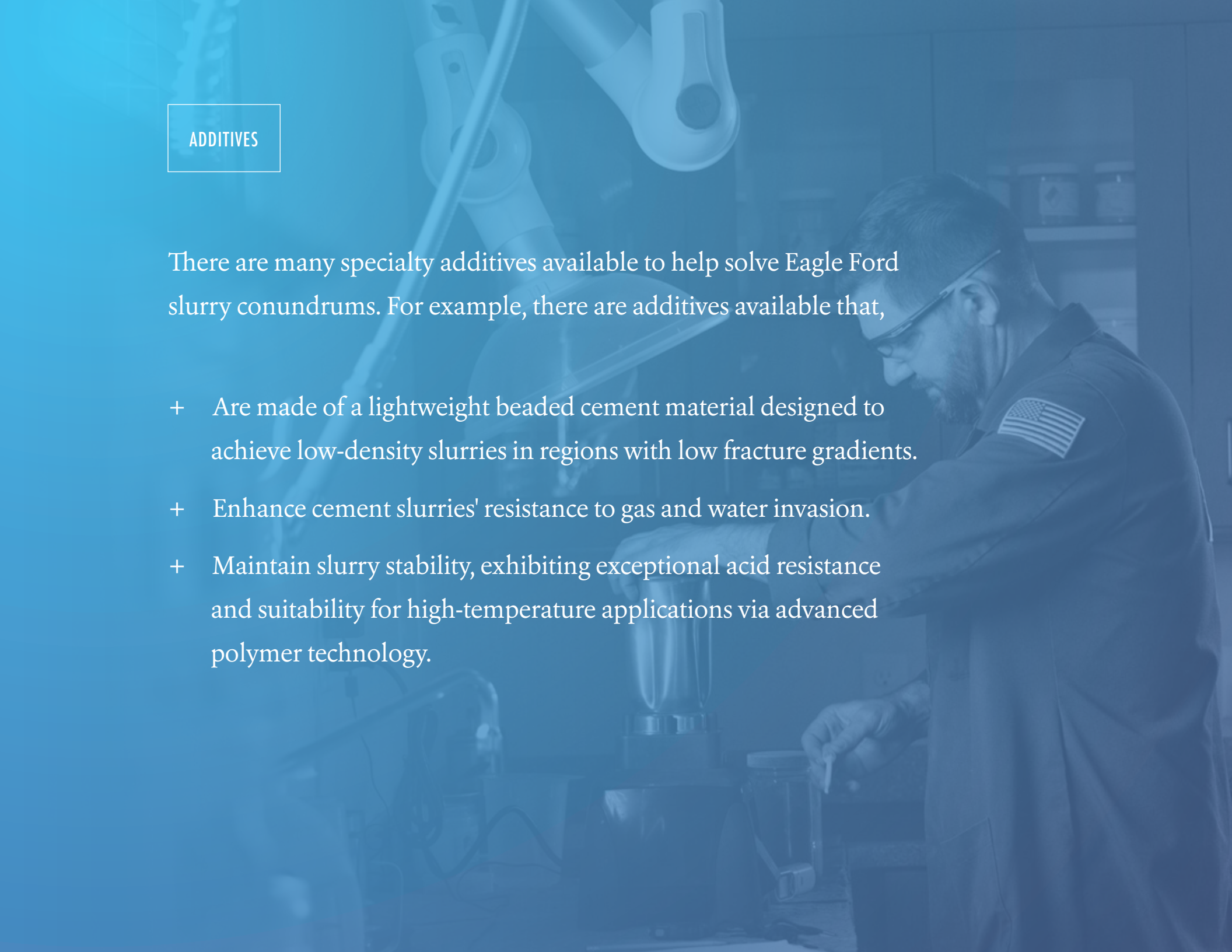
PROTECTIVE

Hydrocarbons and other formation fluids can be damaging to a cement sheath, deteriorating it over time and compromising its sealing properties. As a protective measure, Eagle Ford operators need to ensure that their slurries are compatible with the formation fluids at play.

Cement options include reactive additives that swell to seal off cracks when they contact hydrocarbons.



To provide adequate contact area, operators should use a minimum additive concentration of 10-to-15 lb/bbl. **Maximize the concentration of additives, keeping slurry mixability and stability in mind.**



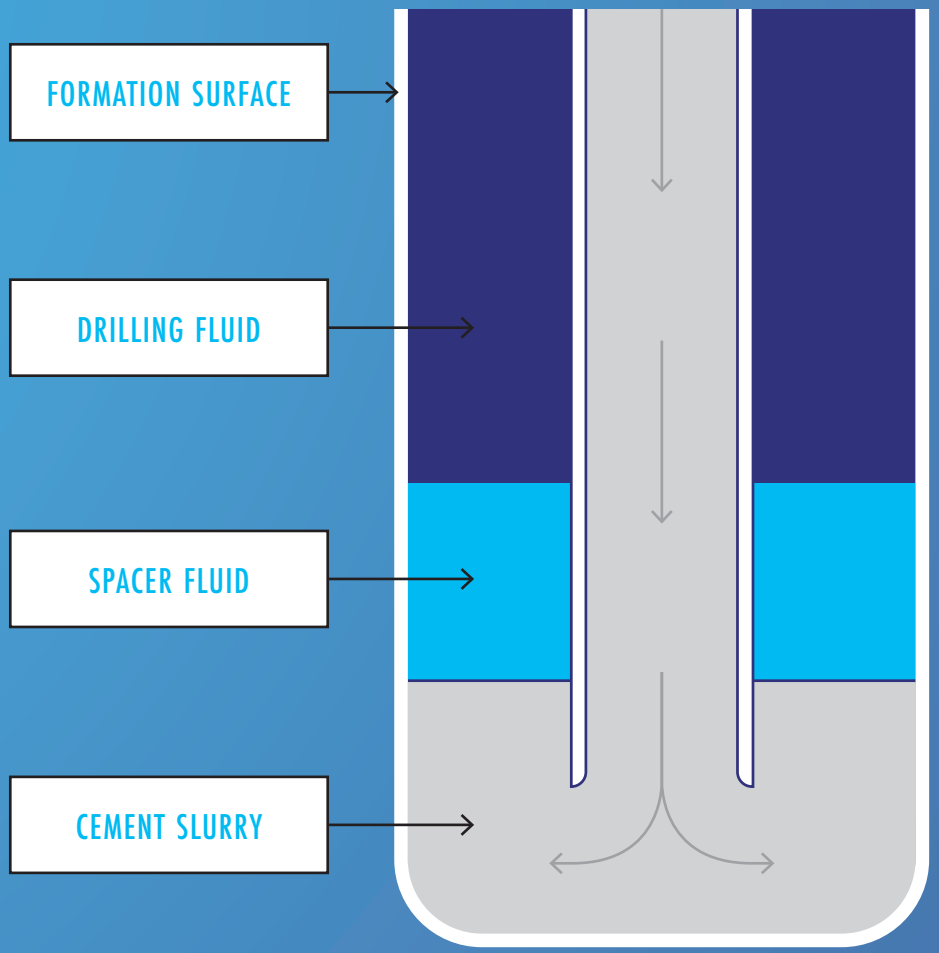
ADDITIVES

There are many specialty additives available to help solve Eagle Ford slurry conundrums. For example, there are additives available that,

+ Are made of a lightweight beaded cement material designed to achieve low-density slurries in regions with low fracture gradients.
+ Enhance cement slurries' resistance to gas and water invasion.
+ Maintain slurry stability, exhibiting exceptional acid resistance and suitability for high-temperature applications via advanced polymer technology.

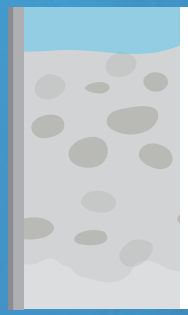
THE RIGHT SPACER FLUID

Spacer fluids help the mud displacement process and optimize zone isolation in horizontal wells. Spacer fluids must be compatible with the drilling fluid and the cement slurry and, in the Eagle Ford, must remain stable at temperatures of up to 330°F.



SPACER FLUID SHOULD ALSO INCLUDE THE FOLLOWING FEATURES:

+ Flexible design rheology with density
+ Sealing properties
+ Wettability of pipe for bonding
+ Reduced fluid loss in cement
+ Loss circulation control
+ Excellent mud removal



Reactive spacers may also be helpful in preventing lost circulation in the Permian. Reactive spacers with the addition of lost circulation materials (LCMs) can help to heal seepage.

THE RIGHT PUMP RATE

A consistent but maximized pump rate is vital to creating a strong cement sheath. Because the Eagle Ford formation is such a high-pressure environment, pumping mechanisms used on cementing jobs need to be consistent and powerful. In some areas of the Eagle Ford, it is common for pumping to occur at 10+ bbls per minute without compromising the formation; however, other areas of the Eagle Ford may require slower pump rates (closer to 6+ bbls per minute).

OPTIONS TO INCREASE A PUMP RATE INCLUDE:

1

PUMP TRUCKS

2

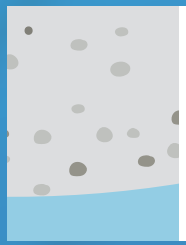
BLENDERS

3

BLENDERS + FRAC PUMP

SIMULATION: A PRECURSOR TO SUCCESS

Simulations can be an immense boost to the success of a cementing operation. Job simulations take into account the geology of the location, well geometry, the physical properties of fluids and friction pressure from the pumping operations to determine the rates, volumes, and tops that can be achieved to balance pore pressure and fracture gradients. They can also calculate how much time the cement requires to be workable and involve safety factors.



Cement simulation allows operators to **fine tune pump schedules and overall cement job design.**

SECTION 4

CASE STUDIES

EAGLE FORD FLOWLOK SURFACE CASING

In a recent study with a client, Nine Energy used specialty additives to successfully cement in an area of the Eagle Ford known for shallow fluid flows. This study focused on two pads housing a total of 10 wells, where previous issues with fluid flows were documented. The initial four-well pad served as the testing ground to devise an effective solution for the prevalent issue. The study demonstrated immediate success in curtailing fluid flows following surface casing operations. Upon completion of the job, the client observed no annular flow, no cement fallback, and no need for a top out. Notably, competing solutions failed to address the challenge, leading the client to allocate an additional six wells on a nearby pad to Nine Energy based on the positive outcomes observed in the study. Consequently, the client has embraced the application of the effective slurry in various regions where the risk of encountering shallow flows exists.

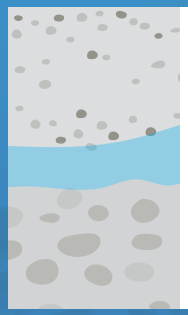

Eagle Ford FlowLOK Surface Casing
Pressure (psi)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Density (ppg)/Rate (bpm)
18
16
14
12
10
8
6
4
2
0
23:16
23:45
0:14
0:43
1:12
1:40
2:09
2:38
3:07
3:36
4:04
Time
Pressure
Rate
DH Density

SECTION 5

REFRACTURING IN THE EAGLE FORD

THE NEED FOR HIGH QUALITY

As refracturing becomes an increasingly popular practice in the Eagle Ford, so does the need for high quality refracturing cement slurries. It is important to use a lightweight slurry in Eagle Ford refracturing jobs in order to reduce treating pressures.



Operators should **compare vendors' slurry weights carefully** when selecting a slurry for a refracturing operation.

IN SUMMARY

The complexity of the Eagle Ford Basin presents unique cementing challenges, especially for lateral wells. Successful cementing in the Eagle Ford requires a careful selection of slurries, spacer fluids, pump rates, as well as simulations. By considering the temperatures, pressures, and complexities of the formation (such as varying formation porosities, gas presence, and fluid flow) operators can avoid problems such as long-term zonal isolation and weakened cement. Specialized design criteria, technology and expertise are essential to operate in the area.

ABOUT NINE ENERGY SERVICE

Nine Energy Service is an oilfield services company that offers completion and production solutions throughout North America. The Company brings years of experience with a deep commitment to serving clients with smarter, customized solutions and world-class resources that drive efficiencies. Strategically located throughout the U.S. and Canada, Nine continues to differentiate itself through superior service quality, wellsite execution and cutting-edge technology. Nine is headquartered in Houston, Texas with operating facilities in the Permian, Eagle Ford, SCOOP/STACK, Niobrara, Barnett, Bakken, Marcellus, Utica and throughout Canada. For more information, visit nineenergyservice.com.