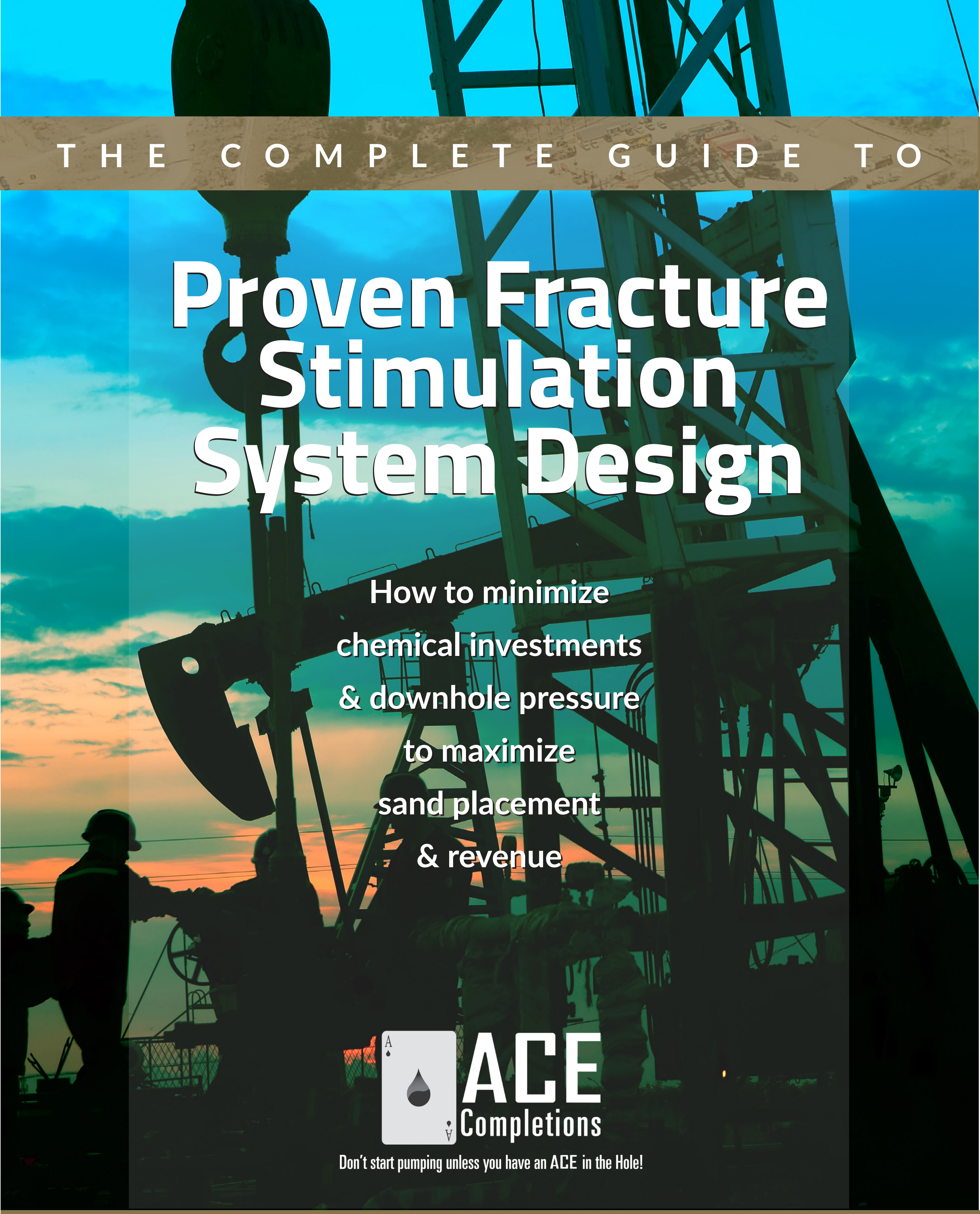


THE COMPLETE GUIDE TO

Proven Fracture Stimulation System Design

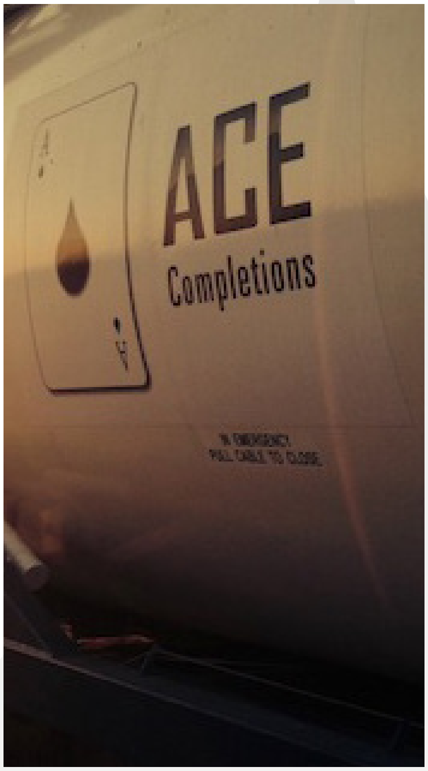
How to minimize chemical investments & downhole pressure to maximize sand placement & revenue

ACE Completions

Don't start pumping unless you have an ACE in the Hole!

ACE Completions • 325 Pronto Rd. Odessa, TX 79762 • (888) 256-5325 • info@acecompletions.com

ACE Completions is not just an ordinary chemical company. It is a fully integrated chemical services platform that maximizes your valuable uptime.



We pioneered bulk to the wellhead chemical delivery and continue to push the boundaries of what's possible. With ACE, you get access to custom stimulation chemicals designed to your specific fluid system requirements with the finest quality completion products.

ACE provides a complete suite of wellhead services designed to keep you pumping 24/7. As pioneers of bulk to the wellhead, we specialize in full-service last mile logistics. Leverage our best-in-class trucking fleet, managed service yard deliveries, and bulk storage on-site at the wellhead with no third-party interruptions to streamline your operations.

LEARN MORE

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INTRODUCTION

The First Four Questions

High-performance fracture stimulation system design is an essential component of every successful unconventional well. But times have changed.

When oil was over $100 per barrel, you could go full bore into a formation with the lowest-quality brine water on the market. Blasting truckloads of high-end cationic friction reducers (FR) and gel proppants downhole in advanced crosslink systems was not an issue.

Time is money, but efficiency is no longer enough. When you have $35 million worth of equipment on-site at a burn rate of $50,000 to $60,000 per day and unpredictable oil prices, time AND money are precious commodities you cannot afford to waste. In order to drive down cost, you want to maximize sand placement into the formation while using the minimum amount of chemicals given the quality of water you're pumping.

If you took the time to download this guide, I don't have to tell you getting oil out of the ground ain't as easy as it sounds. No two wells are the same and you can't use cookie cutters to maximize production.

But, while cookie cutters don't work downhole, there are a handful of foundational principles that go into efficient and cost-effective fracture stimulation systems. To apply those principles, we first need to answer four basic questions.

1. Where Are You Fraccing?

To get chemicals delivered on time, you first need to know where you are fraccing. Chemical companies operate like vendors in any other vertical market. They focus assets where they have the greatest success. As a result, the location of your well determines which companies and chemicals you have to choose from.

2. What Basin Are You Fraccing?

Every basin is its own animal. Basins contain a host of plays, formations, and acreage grades. They also contain operators doing extraordinarily well and operators getting extraordinarily poor results from the exact same rock. Top operators in your particular basin leave powerful clues about what might work in your situation.

3. What Formation Are You Pumping Into?

Each rock in a formation has its own fingerprint. That fingerprint can vary vastly across the formation. Fraccing the dry gas window of the Eagle Ford is entirely different than fraccing the oil window. It's impossible to overstate the value of thoroughly understanding the unique characteristics of your formation to maximize production from it.

4. What Is Your Track Record?

What experience have you had fraccing this type of rock in the past? Did you run cationic or anionic friction reducers (FRs)? Were you running freshwater or produced water? What combination of each do you anticipate using downhole in this well?

Each of these questions is loaded with follow-up questions. Once again, we see there is no one right answer for every well. However, we have discovered a handful of general best practices over the years that hold true the majority of the time.

This guide will give you the fracture stimulation system design knowledge you need to start boosting production and revenue today.

LET'S GET STARTED.

CHAPTER 1

How To Reduce Drag With Slippery Water

How Slippery Water Reduces Drag

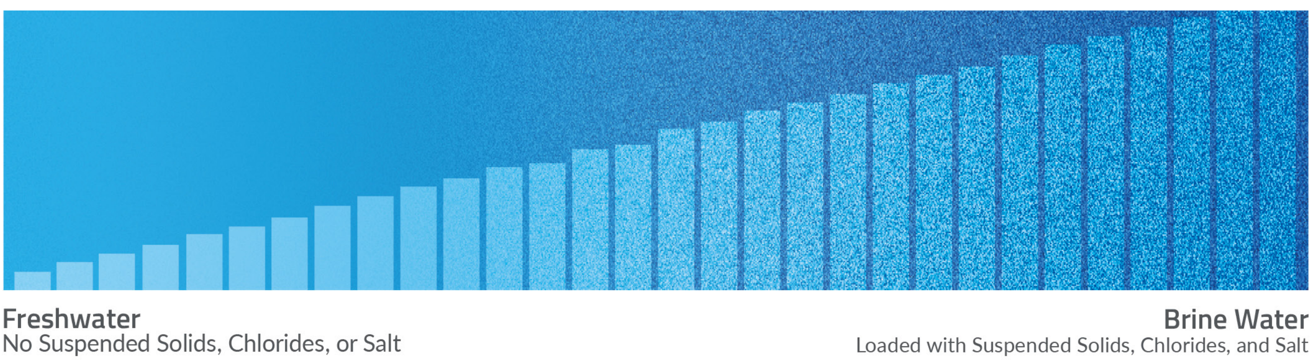
The Role of Polymer Surfactants in Fraccing

At its core, your goal in optimal fracture stimulation system design is twofold.

1. Maximize your sand and/or proppant placement.
2. Minimize the amount of chemicals sent downhole to achieve your objectives.

When you bake a cake, the flour you start with determines the right mix of eggs, milk, butter, sugar, and heat you need to make it rise in the oven. Fracture stimulation system design is no different. The water you start with determines every decision you make moving forward.

The quality of your water exists on a spectrum from freshwater to fully produced brine water. As we move from left-to-right along the spectrum, we go from freshwater with no suspended solids to brine water that is loaded with suspended solids on the right.



The cost of your fluid system directly aligns with this spectrum beginning with freshwater systems that require the lowest capital investment on the left to brine water systems that require the greatest capital investment on the right. More on this in Chapter 2, but before we dive into cost let's look at how the technology to break-up suspended solids and maximize flow rates came about.

Slippery Water

Humans started moving liquids at scale with the appearance of agricultural irrigation around the year 6,000 B.C. in both Egypt and Mesopotamia (modern day Iraq and Iran). Farmers have been using this method to water their ever since.

From the beginning, people moving water from one place to another noticed a curious fact: the quality of your water determined its "drag" across a surface. Water with more suspended solids moved slower than freshwater. This created a problem because timing is everything when you're watering crops. If you don't get it right, we'll all starve come harvest.

The problem only compounded with the advent of modern oil production. If drag can slow down a liquid as pure as water, imagine what it does to oil and gas in pipelines.

The problem persisted until 1946 when British scientist **B. A. Toms** discovered the lubricating effect of polymers on liquids almost by accident. Toms hypothesized that adding a polymer to a liquid flowing at low-pressure would slow it down. He ran a brass tube between two glass jars and discovered he was right. But, surprisingly, when he reversed the experiment under high-pressure with turbulent flow, the polymer had the opposite effect. There was finally a way to increase water flow rates.

Mass adoption of polymer technology didn't begin in earnest until the 1960s. In the subsequent decades, stimulation engineers and oilmen of all stripes tried and failed to perfect enhanced oil recovery (EOR) using polymers and other additives.

It wasn't until oilfield legend **George P. Mitchell** invested 20 years of toil in West Texas to revolutionize hydraulic fracturing (fraccing) that oilmen fully realized the power of polymers and proppant. Today, sending the right mix of water, chemicals, and sand (and/or proppant) downhole has become a science all of its own.

Chemical companies across the world now specialize in manufacturing surfactants that lower surface tension and drag for liquids in every industry under the sun.

Fraccing vs. Fracking

Fraccing has become a hot topic in America over the past decade. Oil and gas opponents seized the phrase, spelling it with a "k" for added emphasis on its supposed danger. They stoked the fears of ordinary Americans with frightening tales of flammable water brought about by greedy oil companies who sent bombs beneath the earth's surface to realize maximum profits.

But, like any conspiracy theory, reality is much more benign.

If you work in the industry, it's not news that bombs are not used in the fraccing process. Instead of explosives, drillers use water to fracture source rock that contains oil and gas. Ceramic and sand proppant are then sent downhole to hold fractures open allowing oil and gas to flow.

The typical frac job uses 3 to 6 million gallons of water. If that sounds like a lot, the average golf course needs roughly 130,000 gallons of water every day. **As of 2015, there were 34,011 golf courses in America using a total of 4,421,430,000 gallons of water every day.** If you believe watering golf courses is more important than American energy independence, you probably would not have downloaded this guide.

History and philosophy lessons out of the way, let's look at the other end of the water spectrum.

The Real Problem with Brine

To recap, our goal in designing a high-performance fluid system is twofold.

1. Maximize your sand and/or proppant placement.
2. Minimize the amount of chemicals sent downhole to achieve your objectives.

Water carries your sand and proppant downhole. Surfactants break-up suspended solids and increase the rate you can pump liquids into the well.

As we move from left-to-right across the spectrum, the water used to pump chemicals and proppant downhole gets progressively dirtier. Likewise, the friction reducers required get progressively more expensive. This is the real problem with brine water. Surfactants that break-up high suspended solid, chloride, and salt concentrations cost more than basic polyacrylamide friction reducers.

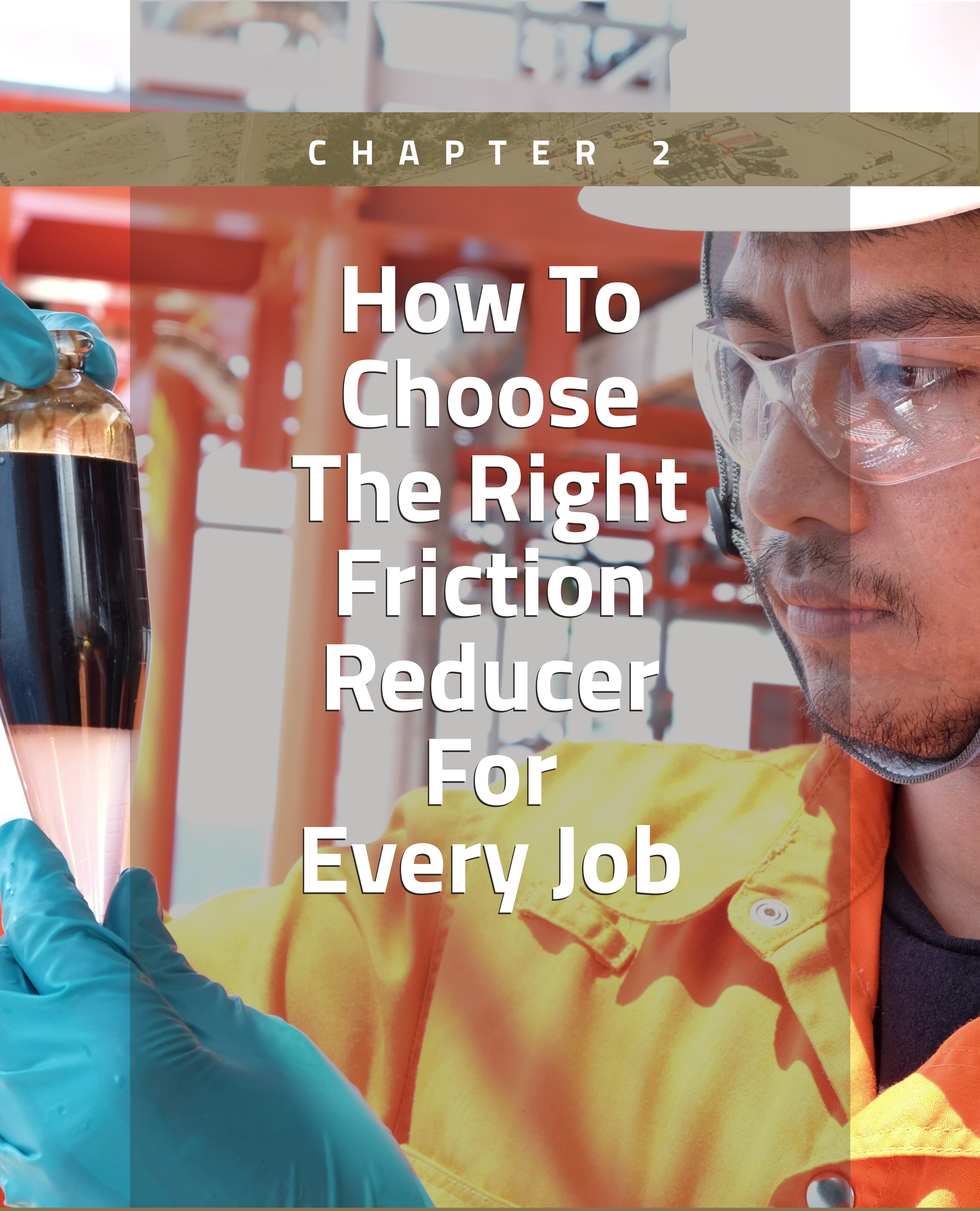
There are several friction reducers across the spectrum, but they generally fall into four categories. Let's look at each one and see how they're used to enhance oil recovery.

“Where oil is first found is in the minds of men.”

Wallace Everette Pratt

(1885–1981)

Pioneering American Petroleum Geologist



CHAPTER 2

How To Choose The Right Friction Reducer For Every Job

Anionic, Nonionic, & Cationic Friction Reducers

Ionic stimulation chemicals are the foundation of optimal fracture stimulation system design. These chemicals fall into one of three categories: anionic, nonionic, and cationic. Each chemical contains a unique molecular structure known as a "hydrophilic end" that holds an electric charge. A friction reducer's electric charge determines its ability to break-up total dissolved solids (TDS).

An anionic friction reducer contains a negative charge in its hydrophilic end. Nonionic friction reducers contain no charge. Cationics contain positively charged ends. In addition to friction reducers, stimulation engineer have several stimulation additives and acidizing chemicals to choose from.

Before we can go any further, we need a 50,000-foot view of the three types of fluid systems used in the field.

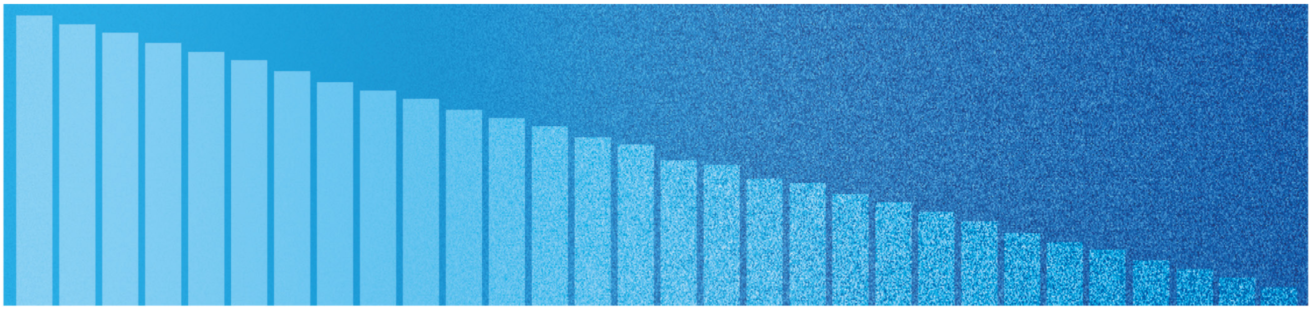
Slickwater Fracs

Dollar-per-dollar, barrel-per-barrel, slickwater fracs are the most cost-efficient method of cracking rock. These fracs allow you to use cost-effective anionic FRs to enhance well stimulation.

Without slickwater fracture systems, your pumps top out at roughly 60 barrels of water per minute. With a slickwater fluid system that number jumps to 100 barrels per minute. This is possible because anionic FRs lay a film on the inside of drillpipe making it slipperier than pumping water by itself. As a result, you can pump more liquids downhole at higher pressures.

The drawback to slickwater fracs comes as you move from left-to-right across the water quality spectrum. Slickwater systems are perfect for freshwater with very little suspended solids. However, the effectiveness of slickwater systems decrease as chloride and salt concentrations increase.

This means stimulation system design changes with water quality.



Freshwater
Very Little Suspended Solids, Chlorides, or Salt

Brine Water
Loaded with Suspended Solids, Chlorides, and Salt

Hybrid Systems

While you can invest in higher-quality FRs to keep pumping at high-velocity, these chemicals can only do so much on their own. This is where hybrid systems come into play.

Hybrid systems are exactly what they sound like: a combination of friction reducers, surfactants, and other chemicals used to stimulate well production. These combinations allow you to keep pumping at maximum velocity despite increasingly diminished water quality. Prices vary for hybrid systems; however, your investment is driven by three things.

1. The quality of water you're pumping.
2. The quality of friction reducers and other additives required to accomplish your goals.
3. The volume of sand-to-water in pounds-to-gallons you need to pump downhole.

ACE BREAK AP is an example of a "gel breaker" used in hybrid systems.

Advanced Crosslink Systems

Advanced crosslink systems are the most capital-intensive option and have become rare across the oilfield. The exact chemical components can vary widely; however, crosslinkers and cationic FRs are the primary ingredients.

These chemicals come together to break through the dirtiest brine allowing you to open fractures and transport proppant along the length of the fracture in almost any environment.

ACE FRC is an example of a cationic FR used in these systems. ACE BXL-4 is an example of a crosslinker used in conjunction with cationic FRs in advanced crosslink systems.

Freshwater vs. Flowback

As the saying goes, "You get what you pay for." When you go with low-cost anionic friction reducers, you are paying for FR that can maximize flow rates in freshwater with minimal TDS. Unfortunately, trucking in 6 million gallons of freshwater for every well you frac is cost prohibitive. Especially when you're running dozens of frac stages across hundreds of wells.

To break even on a well you simply cannot afford a steady stream of trucks pumping freshwater, especially in drought-prone areas like North Texas.

Since moving hundreds of millions of gallons of water is cost-prohibitive, you start pumping with freshwater and then flowback produced water into a pond for reuse in subsequent fracs. Unsurprisingly, water gets dirtier with each use requiring higher-qualify FRs to keep pumping.

Now that we understand the various fluid systems, let's look at the three categories of ionic friction reducers and their appropriate application in each system.

Anionic Friction Reducers

Since anionic FRs contain a negative charge, they are best suited for applications that require little resistance. For example, you can find anionic surfactants in household cleaning items like carpet shampoo.

Retailers often group products into three categories: good, better, and best. Good products cost less than better and best. Likewise, anionic surfactants are priced in three categories: Level 1, Level 2, and Level 3.

ACE-FRW is an example of Level 1 anionic friction reducers. It is engineered for applications with freshwater or light-brine fracturing fluid and reduces pressure losses attributed to friction by up to 70%.

ACE-FRW has the following characteristics.

Appearance	Specific Gravity	Storage Temp	Shelf Life	Pour Point
Opaque Liquid	8.8 lbs/gal	31-95°F	6 Months	-22°F

Nonionic Friction Reducers

Emulsions occur when you attempt to combine multiple immiscible liquids (liquids that do not blend together) into a single fluid. If you have ever watched Top Chef, you might have heard contestants refer to "emulsified vinaigrette."

Chefs on the show use blenders to mix liquids, such as olive oil and red wine vinegar. When you do this, you break the olive oil into microscopic droplets that are suspended throughout the red wine vinegar. Throw in a few sun-dried tomatoes along with a handful of fresh herbs and you've got a tasty vinaigrette.

Unlike chefs that want to create emulsions, oilmen want to avoid them. Upstream exploration companies are not in the business of refining and blending hydrocarbons. While refineries and chefs seek out emulsions to create new products and recipes, oilmen want to bring pure products to market. Therefore, they don't want oil and wet gas emulsifying downhole.

Since the hydrophilic end of nonionic surfactants contain no electric charge, they are ideal for preventing emulsions. In everyday life you can find nonionic surfactants in household items like dish detergent. This is what prevents your dishwater from becoming a gooey soup.

In the oilfield, you use nonionic surfactants like ACE SF-8915 to prevent crude oil emulsions. While anionic surfactants have less viscosity, nonionic surfactants are thick liquids. In addition to preventing emulsions, they can carry more sand downhole allowing you to prop open more fractures and increase production.

To make this more practical, let's look at how ACE FRW (anionic) stacks up against ACE SF-8915 (nonionic).

ACE FRW

Appearance	Specific Gravity	Storage Temp	Shelf Life	Pour Point
Opaque Liquid	8.8 lbs/gal	31-95°F	6 Months	-22°F

ACE SF-8915

Appearance at 25°C	Odor	Density (lb/gal)	Specific Gravity	Solubility
Light Amber	Alcohol	7.7	0.92	Water Soluble

Right away, we can see a large difference in Appearance and Specific Gravity, along with the addition of odor and solubility. These numbers come together to create a propriety surfactant blend that drastically reduces surface tension. Since the molecules that make up **ACE SF-8915** contain no electric charge, it's also compatible with cationic, anionic, and other nonionic additives.

Your investment in nonionic friction reducers depends largely on the nature of the problem you need to solve downhole. For example, **ACE SF-8915** is designed to reduce surface tension while **ACE NE-227** is a nonionic non-emulsifier designed to prevent crude oil emulsions.

Cationic Friction Reducers

If you're following along at home, we've made our way from freshwater on the far-left end of the spectrum to brine water at the far-right end of the spectrum. This is where it gets ugly. Here we are dealing with fully produced brine water that's loaded with suspended solids.

Breaking Out the Big Guns

Cationics contain positively charged hydrophilic ends making them ideal for applications that require a little elbow grease. You can find cationics around the house in products like hand sanitizer and kitchen cleaners. For instance, Formula 409.

We already discussed the capital-intensive investment required for cationic friction reducers in advanced crosslink systems. Unfortunately, the price of cationics does not vary. If you want them to do the dirty work, expect to invest anywhere between 1½ to 2 times more than you would using anionic FRs.

The Bottom Line

In this chapter, we looked at the three fluid systems used in the fracture stimulation process: slickwater, hybrid, and advanced crosslink. We then looked at anionic, nonionic, and cationic friction reducers.

We saw how to reduce capital expenditures by using Level 1 anionic FRs in slickwater fracs. We also saw how to minimize your investment across the water quality spectrum by combining Level 2 or Level 3 anionics with other additives used to stimulate production. We then learned the cost of nonionic FRs depends on the problem you need to solve and the specific friction reducer required to solve that problem. Lastly, we saw that while cationics are costly, you get what you pay for. As a result, we discovered cationics make sense when the cost of pumping anionics exceeds the investment required to deploy cationics downhole.

In short, we found the cost of fluid systems is driven by the quality of your water, your goals, and the amount of proppant you want to carry downhole. Therefore, while you can reduce the investment required to achieve your objectives, you must run a thorough cost/benefit analysis to ensure you are not wasting capital or time pumping the wrong combination of friction reducers and other chemicals.

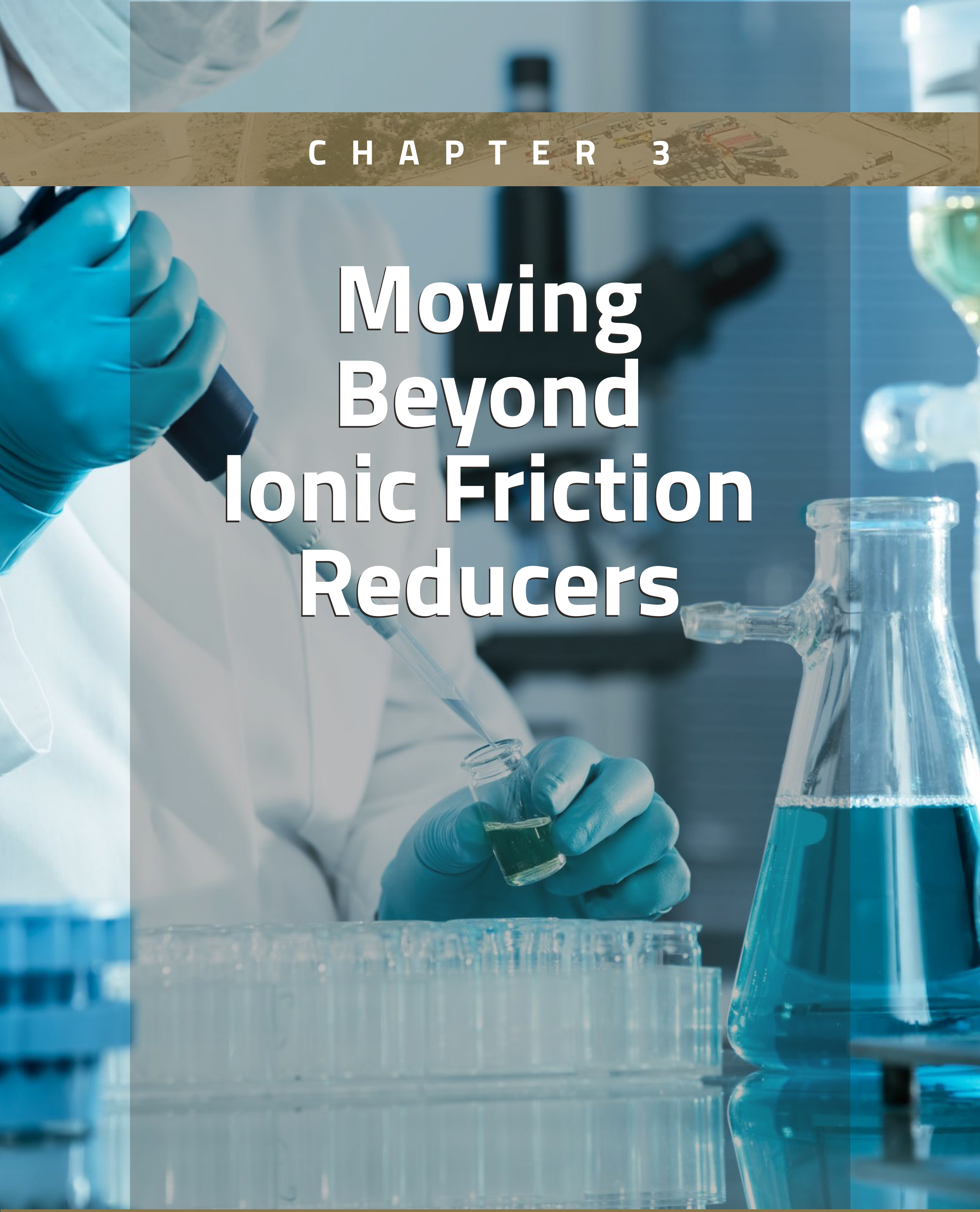
This brings us to the next component of cost-effective fracture stimulation system design: other additives. At long last, it's time to move beyond ionic friction reducers.

"Prospecting for oil is a dynamic art... The greatest single element in all prospecting, past, present and future, is the man willing to take a chance."

Everette Lee DeGolyer
(1886–1956)
Prominent Dallas Oilman,
Geophysicist, and Philanthropist.

CHAPTER 3

Moving Beyond Ionic Friction Reducers



Additives, Purpose, Downhole Results, & Other Common Uses

As we have seen throughout this discussion, there are a host of other additives you can use to stimulate production over and above anionic, nonionic, and cationic friction reducers. At ACE Completions, we group these stimulation fluids fall into two categories: **Stimulation Chemicals** and **Acidizing Chemicals**.

Ionic friction reducers fall into the Stimulation Chemicals category. They are joined by various surfactants, non-emulsifiers, clay stabilizers, scale controllers, breakers, buffers, guar gels, and crosslinkers. In like manner, there are myriad chemical choices for acid stimulation treatments. However, while there is an endless supply of acid choices for stimulation systems, engineers acidize wells for one of two purposes: to stimulate reservoir flow or remove damage.

Let's first look at some of the other chemicals used in fracture stimulation systems outside of ionic friction reducers.

Facts on Hydraulic Fracturing

We started the conversation around fracture stimulation system design with a baking analogy. We saw how the flour used in baking is analogous to the water used in fraccing. Just as flour determines every subsequent decision in baking, water quality determines every subsequent decision in fraccing.

We can think of stimulation chemical options in similar fashion. While you add other ingredients to enhance the flavor of your cake, you add other chemicals to enhance oil recovery.

The following page contains a table taken from **Anadarko's "Facts on Hydraulic Fracturing"** document. The company published the fact sheet to educate Colorado residents on the hydraulic fracturing process in 2015. While it's well worth your time to read the entire fact sheet, the table serves as an excellent departure point for our conversation in this chapter.

Additive	Purpose	Downhole Results	Other Common Uses
Acid	Helps dissolve minerals and initiate cracks in the rock	Reacts with minerals present in the formation to create salts, water and carbon dioxide	Swimming pools, chemical cleaners
Corrosion Inhibitor	Protects casing from corrosion	Bonds to metal surfaces (pipe), any remaining product not bonded is broken down by micro-organisms and consumed or returned in produced water	Pharmaceuticals, acrylic fibers and plastics
Breaker	Allows a delayed breakdown of gels	Reacts with the crosslinker and gel once in the formation, reaction produces ammonia and sulfate salts	Hair coloring, disinfectant, manufacture of common household plastics
Clay Stabilizer	Temporary or permanent clay stabilizer to lock down clays in the shale structure	Reacts with clays in the formation through a sodium-potassium exchange, reaction results in sodium chloride (salt)	Low sodium table salt substitute, medicines, intravenous fluids
Crosslinker	Maintains viscosity as temperature increases	Combines with breaker in the formation to create salts	Laundry detergents, hand soaps, cosmetics
Gel	Thickens water in order to suspend the proppant and sand	Combines with breaker in the formation to enhance fluid return to the bore hole	Cosmetics, baked goods, ice cream, toothpaste, sauces, salad dressings
Iron Control	Helps to prevent precipitation of metal oxides	Reacts with minerals in the formation to create simple salts, carbon dioxide and water which are returned in produced water	Food additives, beverages, lemon juice
Non-Emulsifier	Used to break or separate oil and water mixtures	Generally returns in produced water, in some shale formations, can return via produced natural gas	Laundry detergents, dishwasher detergents, carpet cleaners
pH Adjusting Agent	Maintains effectiveness of other additives such as crosslinkers	Reacts with acidic agents in the treatment fluid to maintain a neutral (non-acidic, non-alkaline) pH, produces salts, water and carbon dioxide, returns in produced water	Detergent, washing soda, water softener, soap
Scale Inhibitor	Prevents build-up of scale in pipe and formation	Product attached to the formation, majority of the product returns with produced water, remainder consumed by micro-organisms	Household cleaners, deicers, paints
Surfactant	Reduces surface tension of the treatment fluid in the formation and helps improve fluid recovery from the well post-stimulation	Some made to react with the formation, some to be returned with produced water, or some enter the produced natural gas	Glass cleaner, multi-surface cleaner, antiperspirant, deodorants, hair coloring

Grateful Adulation

We would be remiss if we did not take a moment to thank the good folks at Anadarko for this fantastic resource. They managed to summarize dozens of pages of valuable information in a single table. Many thanks to the team over there for putting this together. Whether you're looking to study up or share the truth about the safety of fraccing, **"Facts on Hydraulic Fracturing"** has a little something for everyone.

Standing on the Shoulders of Giants

Trying to transmute lead into gold sounds silly to modern ears. Yet, oddly enough, oilmen who acidize wells have alchemists to thank for the birth of chemistry. Muslim alchemist Jabir ibn Hayyan discovered hydrochloric acid (HCl) around the year 800 A.D. when he mixed common salt with sulfuric acid in his alchemy lab. In the 15th Century, pseudonymous German authors using the pen name "Basilius Valentinus" expanded on Hayyan's work. English theologian, clergyman, and chemist Joseph Priestley was the first to produce pure hydrogen chloride in the lab in 1772. Priestly was followed by Cornish chemist and inventor Humphry Davy, who proved the chemical composition of HCl included hydrogen and chlorine in 1818.

Just under 100 years later in 1859, Edwin Drake became the first American to successfully drill for oil in Western Pennsylvania. By that time, the corrosive power of HCl was known across the globe. Within a generation of the Drake Well, oilmen were using acid treatments (acidizing) to stimulate well production. It was tough going in the early days. You could send HCl downhole to dissolve source rock, but that didn't stop it from eating through drillpipe and collapsing your well. It wasn't until the introduction of corrosion inhibitors in the 1930s that oilmen finally started to master acidization. The subsequent decades saw a steady stream of hydrochloric acid patents filed in the United States as industrialists harnessed the corrosive power of HCl for a host of applications.

Modern reservoir engineers stand on the shoulders of giants. Yet, while we have come a long way since Hayyan's day, the application of acidizing chemicals remains fairly straightforward.

Today, acid treatments fall into three categories: acid washing, matrix acidizing, and fracture acidizing. Acid wash treatments are designed to strip away scale (calcium carbonate, calcium sulfate, barium sulfate, etc.) and similar deposits from completion equipment and well perforations.

Unlike matrix acidizing and fracture acidizing, you typically do not inject treatment fluid into the reservoir formation during an acid wash.

Sadly, matrix acidizing has nothing to do with Keanu Reeves. In the **words of Wikipedia,** "matrix" here refers to "the finer-grained mass of material wherein larger grains, crystals or clasts are embedded." It stands to follow that matrix acidizing is the process of treating reservoir formations with fracture stimulation fluids; specifically, reactive acid. The type of acid(s) you use is dictated by your formation. Permeability determines the pressure required to pump acid into a formation. **ACE HCL** is an example of hydrochloric acid used in matrix acidizing treatments.

Last, we have fracture acidizing. Fracture acidizing occurs when you increase pumping pressure over and above the pressure required to fracture your formation. In other words, this is an acid frac or acid fracturing. Though cracking the Monterey Shale code proved to be a bigger problem than the industry anticipated, many experts touted acidizing as the **ideal solution** in the early days of the play.

Things didn't pan out in California, but that doesn't mean fracture acidizing never works. Under the right circumstances with the right reservoir (carbonate formations for example), acid fracs offer the opportunity to reduce capital expenditures. Instead of using proppant to hold open reservoir fractures, you use an acid — typically HCl — to do the job. When all goes well, you increase the area of oil and gas flow to the surface and boost production. At the same time, fracture acidizing is not a silver bullet. If you apply too much pressure to push acid into the formation, the acid can quickly "spend" and limit the length of your fractures defeating the purpose of the treatment.

Getting Dialed In

We could spend another dozen (or hundred) pages breaking down every other fracture fluid component in the **Acidizing Chemicals** category. However, given the breadth of information we have covered to this point and Anadarko's yeoman's work above, you are now armed with the basics to execute optimal fracture stimulation system design.

Suffice it to say, well stimulation is equal parts art and science. It's an intricate interplay between water, rock, chemicals, proppant, and pressure. Now that you know enough to be dangerous, let's discuss how to manage downhole pressure so you don't actually become dangerous in the field.

“My formula for success? Rise early. Work late. Strike oil.”

Jean Paul Getty

(1892–1976)

American Industrialist and
Founder of the Getty Oil Company.

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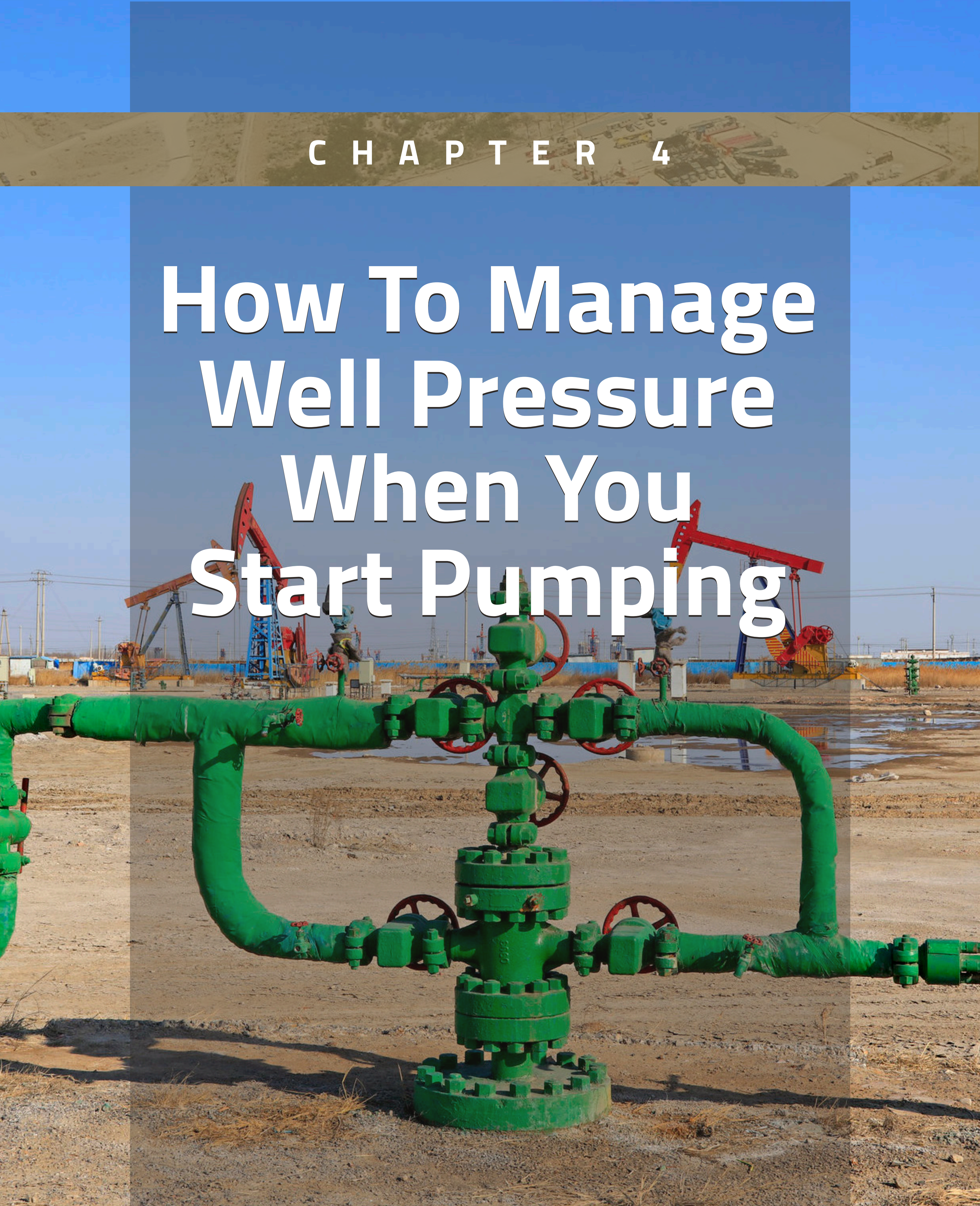
CHAPTER 4

How To Manage Well Pressure When You Start Pumping



How Pressure Drives Decisions

It goes without saying fracture stimulation system design is complicated. Between rocks and chemicals and pressure, you walk a constant tightrope. The slightest miscalculation could lead to reservoir fluid flooding the wellbore and collapsing the hole you spent millions to drill.

As a result, planning a successful well is not about getting one thing right; it's about getting dozens of things right and making them work in concert simultaneously. Humans have a tendency to focus on one thing at the expense of another. This can be a fatal mistake when designing well fluid systems.

If you can bear one more food analogy, it's much like cooking gumbo. If you've ever cooked it, you know a great bowl of gumbo doesn't come together in minutes in your microwave. Even novices know you have to clear your calendar to get it right.

First, you have to mix up the roux until it's a rich brown color that smells like deeply roasted nuts. Once the roux comes together, you add andouille sausage and vegetables like celery, onion, okra, etc. Next come liquids like stock, clam juice, Worcestershire, etc. After bringing to a boil, you back the heat down to a simmer and add filé powder over the course of an hour.

When cooking the roux, liquids, vegetables, etc., you cannot become so focused on the right balance of ingredients that you forget to control the heat of your burners. Too little heat and you end up with crunchy vegetables, watery gumbo, and frustrated dinner guests. Too much heat and you burn dinner and ruin the whole night.

In similar fashion, you cannot become so focused on the right balance of surfactants and other chemicals that you neglect to precisely map the pressure at each stage. Frac stages that run into the dozens are commonplace in the oilfield today. Each stage requires exact planning around surfactants, sand, water, and pressure.

Now that you are too hungry to finish this chapter, let's tie it all together.

Fluid Planning in Broad Strokes

To this point, we have discussed the surfactants, friction reducers, and other chemicals you can use to increase the velocity and volume of the liquid you pump downhole. The reason to increase velocity and volume is obvious; you need a lot of pressure to crack open the rocks in a shale reservoir and produce hydrocarbons.

Anyone outside of the industry might hear that and naturally think, "Then blast that sucker with everything you've got!" As fun as that would be, you can't just go pushing the pressure equivalent of an atom bomb downhole.

Granted, the Atomic Energy Commission got together with the U.S. Bureau of Mines and El Paso Natural Gas Company to give atom bomb fraccing a shot back in December, 1967, but that's besides the point … and pumping radioactive waste proved to be unsustainable. As did smoking two packs of Marlboros a day and not wearing seat belts. Ahhh, the 1960s … but, we digress.

The pressure required to crack rock and produce oil from shale reservoirs varies depending on the formation and play. As a result, providing specific pressure prescriptions for every well you frac is beyond the scope of this guide. However, if you're reading this guide we assume you know all of this. Calculating bottomhole pressure and mapping the appropriate psi for each frac stage is table stakes for engineers in oil and gas.

The problem we are solving for here is not understanding how to calculate pressure in well planning, it's how to sustain that pressure once you start pumping. It's high time we set aside the basics and talk inside baseball.

Performing Under Pressure

Murphy's Law states, "Anything that can go wrong will go wrong." Sadly, when you're completing a well there are 1,001 things that can go wrong. You can't calculate pump pressure and fluid supply on the back of a napkin. You don't fuel the energy needs of the world on a whim.

However, while the problems that could arise when cracking rock with 600,000 gallons of water are in endless supply, there are three ways to guard against massive spikes and drops in pressure.

1. **Friction Reducer:** Given the amount of time we have spent discussing quality friction reducers, this is no surprise. Without quality FRs, you can't pump water fast enough to properly crack rock.

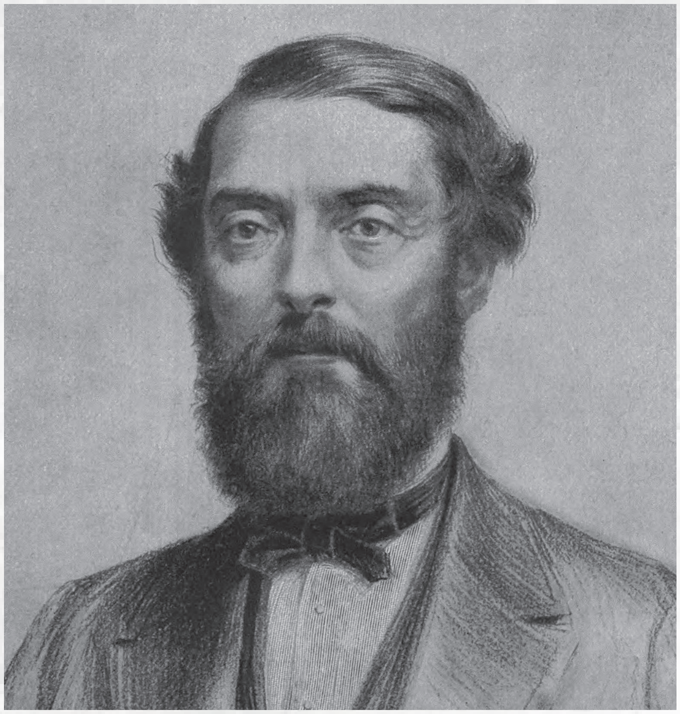
2. **Water Quality:** Earlier we discussed how water quality is everything. Designing your well without accounting for water quality puts you on the fast track to pressure problems.
3. **Chemical Compatibility:** You can't properly manage pumping pressure with incompatible chemicals.

Overlook these details and you will quickly find yourself facing a host of other issues, two of which we alluded to at the beginning of this chapter. Let's look at some of the consequences that can come from cutting corners on pressure.

1. **Well Collapse:** When the hole collapses due to low pressure. Can create total loss if you have to abandon the well.
2. **Broken Pipe or Casing:** When the pipe or casing breaks due to high pressure. Can lead to downtime losses tripping new pipe or recasing the well.
3. **Insufficient Fractures:** When cracks in the rock are not deep and/or wide enough due to low pressure. Can lead to production losses.
4. **Insufficient Sand Placement:** When proppant cannot properly set within fractures due to low pressure. Can lead to losses in oil production and steep declines when fractures close due to surface pressure.
5. **Insufficient Chemical Supply:** When a frac runs long due to reservoir pressure changes. Can lead to downtime losses waiting for additional chemical delivery.

Even with sufficient well design and planning, there are no guarantees downhole. You could run into any of these issues anytime in the patch. As a result, your chemical vendor is more than just another commodity supplier. With everything that can go wrong on-site, your chemical vendor should be a trusted partner that is as invested in your success as you are.

This brings us to our final and perhaps most important chapter; how to choose a chemical vendor. Let's look at the five key factors to consider when evaluating chemical companies for your next project.



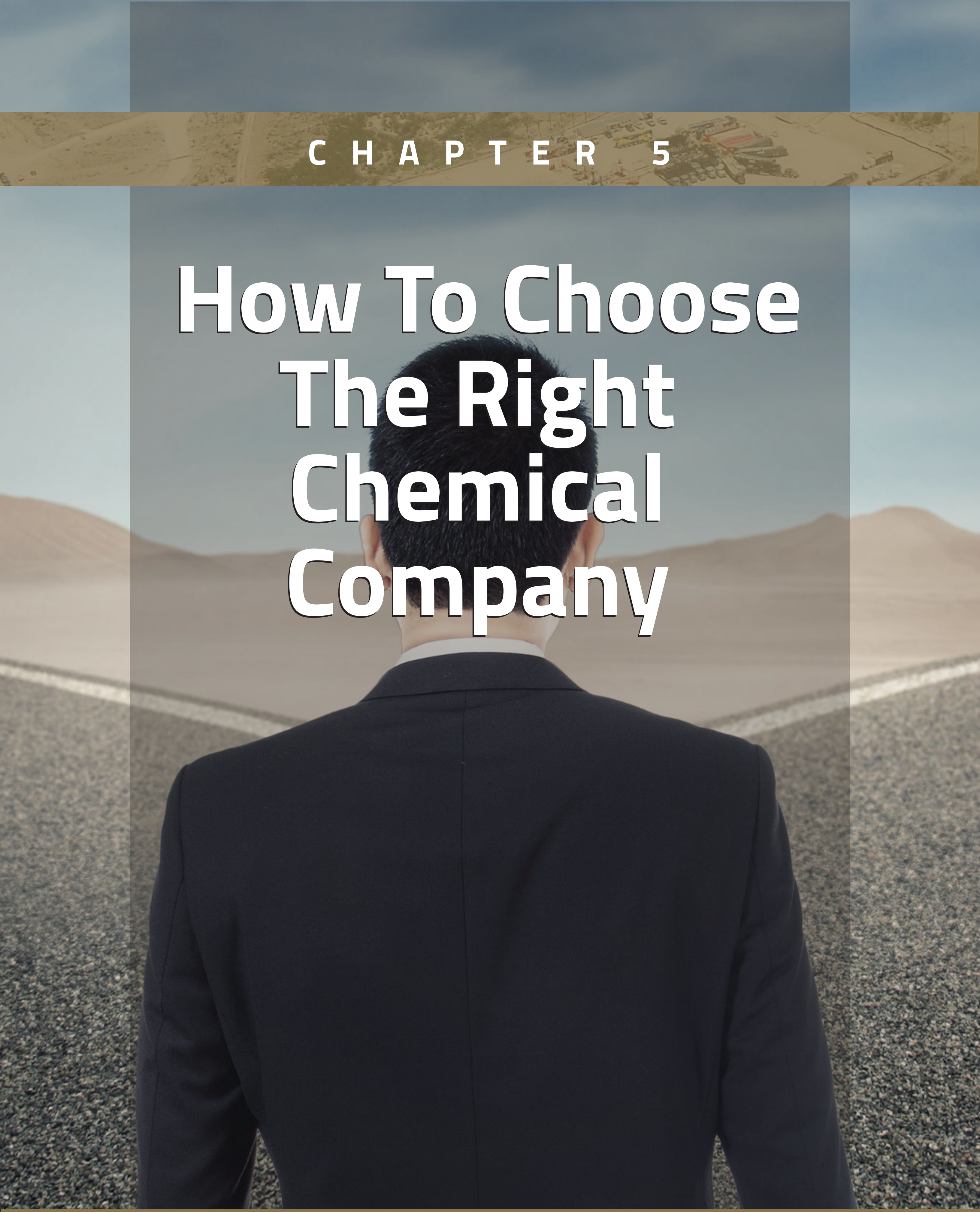
“Drill for oil? You mean drill into the ground to try and find oil? You’re crazy.”

Drillers responding to Edwin Drake 1859

Edwin Laurentine Drake

(1819–1880)

The First American to Successfully Drill for Oil.



CHAPTER 5

How To Choose The Right Chemical Company

How To Evaluate Chemical Vendors

This has been quite a journey. We looked at the history of slippery water, all of the different types of friction reducers and when to apply them, then moved beyond friction reducers, and finally discussed managing well pressure once you start pumping.

Since we are a chemical company and in the title of this chapter is "How To Choose The Right Chemical Company," you're probably assuming were just going to tell you to work with us. Naturally, that would be a fantastic choice. However, more than trying to sell you, we want to help you.

We started by discussing the first four questions to select the right chemicals. Let's conclude with the four questions you need to select the best vendor for the job.

Do they have a thorough presale process?

The most important element in fracture stimulation system design is chemical compatibility downhole. At the least, incompatible chemicals lead to unsuccessful wells. At the worst, incompatible chemicals become deadly.

As a result, when selecting a chemical vendor you need a company who invests the time, money, and effort up-front to ensure your success once you start pumping. Don't work with just anyone because they can fulfill an order quickly. While speed is essential, you should never sacrifice speed for safety and chemical continuity.

A quality chemical vendor will take the time to get to know exactly what you're trying to accomplish and the problems you are facing downhole. Once they fully understand the scope and magnitude of the problem, they can help you develop the right solution for your specific situation. Lastly, they will put the solution to the test in a lab staffed by experts with real-world experience who can verify compatibility to ensure you get the best results.

What does delivery look like?

We don't mean to brag, but we invented bulk chemical delivery straight to the wellhead. Before ACE Completions, you had to pay third-party trucking companies to pick up your chemicals from loading docks in 50-gallon drums. Trucking companies delivered chemicals to your warehouse and you had to personally store, inventory, and ship them. Needless to say, this was extremely costly and inefficient.

Bulk-to-the-wellhead has become the industry standard since ACE pioneered the process in 2012. However, not all deliveries are created equal. Choose the right company and all will go smoothly. The drivers will be fully trained in their own process AND your processes, adhere to strict safety standards on-site, and follow a methodical step-by-step process rigging up hoses and checking container levels to offload appropriate amounts in the right containers. Choose the wrong company and union drivers will show up, turn off their engines, and tell your crew to do their job.

Every second counts on-site. Every minute your crew wastes doing a driver's job is one minute they could be making you money. When engaging chemical vendors, be sure you understand their entire delivery process before signing on the dotted line.

Do they rigorously track inventory to ensure accurate invoicing?

Inaccurate scales and measurements are as old as human civilization. There are at least a dozen passages in Scripture stressing the importance of just measures. Proverbs 11:1 states, "A deceitful balance is an abomination before the Lord: and a just weight is His will." As you can see, accurate weights and measures are critical to more than just business.

It's especially important to keep this in mind when purchasing chemicals that are sold on consignment and delivered in bulk-to-the-wellhead. When you engage a new chemical vendor, ask how they track inventory on consignment. Do they weigh trucks in and out of their yard? If so, how can you verify the accuracy of previous orders before you commit to the company? Will they introduce you to other customers? How much transparency do they have in the process? You don't want to end up paying tens of thousands of dollars for hundreds of thousands of gallons you did not use.

Additionally, how do they invoice transactions? A trusted partner will work to streamline your processes on-site and in the office. They will provide innovative solutions, such as Inventory Management Systems (ACE's is called "AIM") and consolidated invoicing.

Are you a transaction or a partner?

Since the average chemical company typically specializes in one chemical, they can commoditize their thinking. Instead of developing deep and valued relationships. There are plenty of reputable vendors in the field. You just don't want to end up with one that makes you call an 800 number, fight with a phone tree, and hope for the best when you need support.

Organizations focused on lasting partnerships know making a sale is just the beginning. They hire the best and send their best. They also ensure a driver is not your only contact in the field.

The ideal vendor provides additional on-site support personnel. For example, every ACE the customer is assigned a dedicated Field Service Coordinator (FSC). He works with your company man and/or fluid tech to set up ISO tanks on-site, manage and organize tank positions, troubleshoot issues, and help solve downhole problems. He also makes regular on-site visits to verify drivers are following protocol.

Everyone in the oil business is here to make money, but look for companies that care about more than just money. Anyone can find success cutting corners and going with the cheapest solution. Unfortunately, that approach leads to countless headaches, including short-lived profits and costly problems.

Seek out chemical companies that want to maximize your rate-of-return at the wellhead long before maximizing their profits in the board room. When you work with vendors that invest in people and relationships, you set yourself up for lasting success.

If you made it this far, congratulations!

Most people call themselves lifelong learners focused on continual improvement, but only a small percentage follow through and do the work to grow personally and professionally. We hope this guide has given you practical knowledge you can immediately apply to the projects and problems you're tackling in the field today.

We emphasize immediate application because knowledge is only worthwhile when we act on it. Therefore, in addition to congratulating you, we would also like to challenge you to put the knowledge gleaned from these pages to work right away. And, like any great company focused on building strong partnerships, we are going to hold you accountable by asking one question:

What is one thing you will do differently now that you have read this guide?

Send us an email with your answer to **info@acecompletions.com**. Of course, we'd also like to have a conversation to see if it makes sense for us to work together, but that isn't required to email us your one thing.

We look forward to hearing from you!

GodSpeed!
The ACE Team

CONTACT US

“Saudi Arabia appears devoid of all prospects for oil.”

Director of Angelo Oil Company, 1926

King Abdulaziz bin Abdul Rahman

Founder of Saudi Arabia with
Egyptian Economist, Talaat Harb.

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Don't start pumping unless you have an ACE in the Hole!