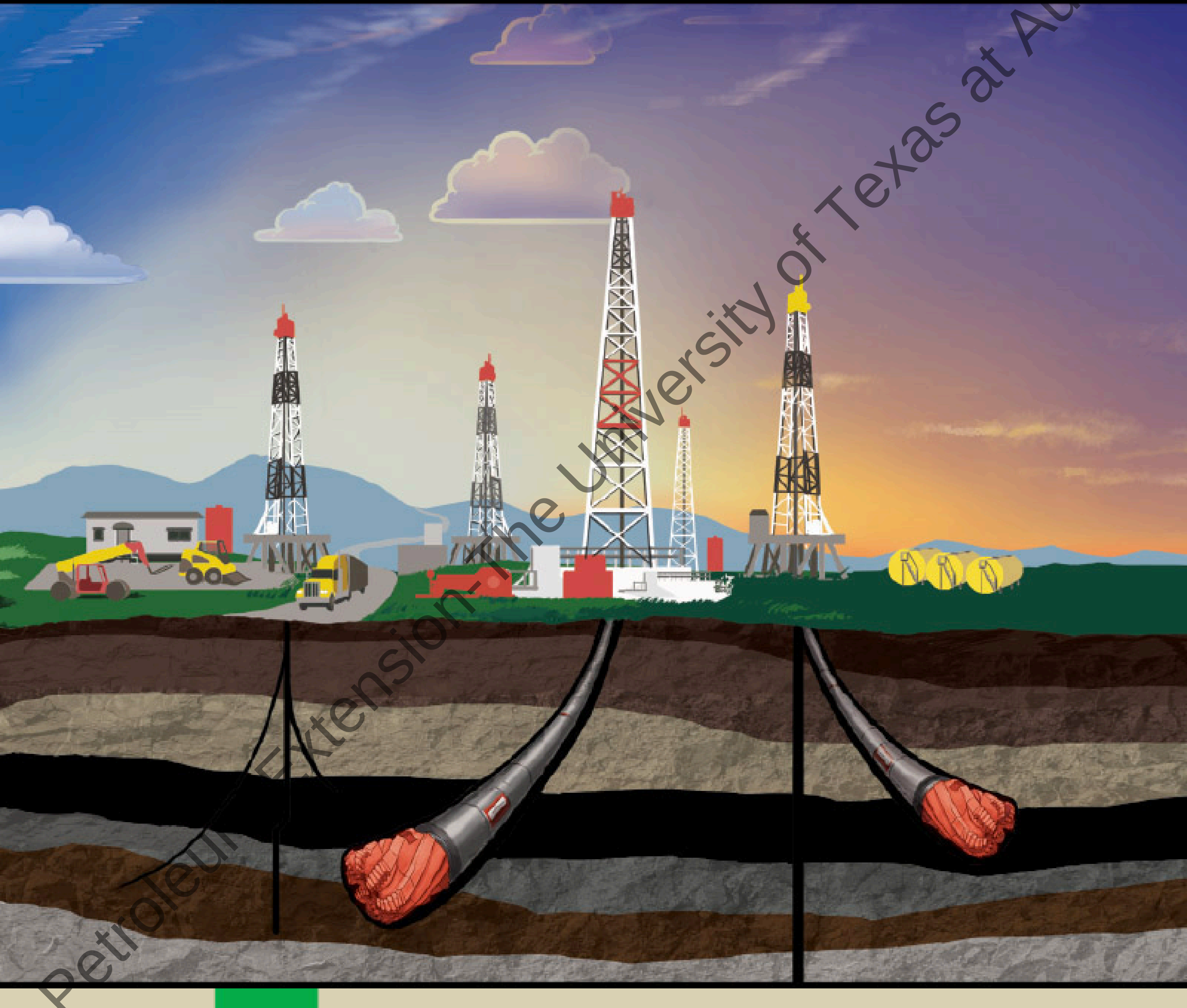
DRILLING TECHNOLOGY SEGMENT

3 Special Drilling Operations



PETEX

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Units of Measurement

Throughout the world, two systems of measurement dominate: the English system and the metric system. Today, the United States is one of only a few countries that employ the English system.

The English system uses the pound as the unit of weight, the foot as the unit of length, and the gallon as the unit of capacity. In the English system, for example, 1 foot equals 12 inches, 1 yard equals 36 inches, and 1 mile equals 5,280 feet or 1,760 yards.

The metric system uses the gram as the unit of weight, the metre as the unit of length, and the litre as the unit of capacity. In the metric system, 1 metre equals 10 decimetres, 100 centimetres, or 1,000 millimetres. A kilometre equals 1,000 metres. The metric system, unlike the English system, uses a base of 10; thus, it is easy to convert from one unit to another. To convert from one unit to another in the English system, you must memorize or look up the values.

In the late 1970s, the Eleventh General Conference on Weights and Measures described and adopted the Systéme International (SI) d'Unités. Conference participants based the SI system on the metric system and designed it as an international standard of measurement.

The Drilling Technology Series gives both English and SI units. And because the SI system employs the British spelling of many of the terms, the book follows those spelling rules as well. The unit of length, for example, is metre, not meter. (Note, however, that the unit of weight is gram, not gramme.)

To aid U.S. readers in making and understanding the conversion system, we include the table on the next page.

English-Units-to-SI-Units Conversion Factors

Quantity or Property	English Units	Multiply English Units By	To Obtain These SI Units
Length, depth, or height	inches (in.)	25.4	millimetres (mm)
		2.54	centimetres (cm)
	feet (ft)	0.3048	metres (m)
	yards (yd)	0.9144	metres (m)
	miles (mi)	1609.344	metres (m)
		1.61	kilometres (km)
Hole and pipe diameters, bit size	inches (in.)	25.4	millimetres (mm)
Drilling rate	feet per hour (ft/h)	0.3048	metres per hour (m/h)
Weight on bit	pounds (lb)	0.445	decanewtons (dN)
Nozzle size	32nds of an inch	0.8	millimetres (mm)
Volume	barrels (bbl)	0.159	cubic metres (m^3)
		159	litres (L)
	gallons per stroke (gal/stroke)	0.00379	cubic metres per stroke (m^3/stroke)
	ounces (oz)	29.57	millilitres (mL)
	cubic inches ($in.^3$)	16.387	cubic centimetres (cm^3)
	cubic feet (ft^3)	28.3169	litres (L)
		0.0283	cubic metres (m^3)
	quarts (qt)	0.9464	litres (L)
	gallons (gal)	3.7854	litres (L)
	gallons (gal)	0.00379	cubic metres (m^3)
	pounds per barrel (lb/bbl)	2.895	kilograms per cubic metre (kg/m^3)
	barrels per ton (bbl/tn)	0.175	cubic metres per tonne (m^3/t)
Pump output and flow rate	gallons per minute (gpm)	0.00379	cubic metres per minute (m^3/min)
	gallons per hour (gph)	0.00379	cubic metres per hour (m^3/h)
	barrels per stroke (bbl/stroke)	0.159	cubic metres per stroke (m^3/stroke)
	barrels per minute (bbl/min)	0.159	cubic metres per minute (m^3/min)
Pressure	pounds per square inch (psi)	6.895	kilopascals (kPa)
		0.006895	megapascals (MPa)
Temperature	degrees Fahrenheit (°F)	$\frac{°F - 32}{1.8}$	degrees Celsius (°C)
Mass (weight)	ounces (oz)	28.35	grams (g)
	pounds (lb)	453.59	grams (g)
		0.4536	kilograms (kg)
	tons (tn)	0.9072	tonnes (t)
	pounds per foot (lb/ft)	1.488	kilograms per metre (kg/m)
Mud weight	pounds per gallon (ppg)	119.82	kilograms per cubic metre (kg/m^3)
	pounds per cubic foot (lb/ft^3)	16.0	kilograms per cubic metre (kg/m^3)
Pressure gradient	pounds per square inch per foot (psi/ft)	22.621	kilopascals per metre (kPa/m)
Funnel viscosity	seconds per quart (s/qt)	1.057	seconds per litre (s/L)
Yield point	pounds per 100 square feet (lb/100 ft^2)	0.48	pascals (Pa)
Gel strength	pounds per 100 square feet (lb/100 ft^2)	0.48	pascals (Pa)
Filter cake thickness	32nds of an inch	0.8	millimetres (mm)
Power	horsepower (hp)	0.75	kilowatts (kW)
Area	square inches ($in.^2$)	6.45	square centimetres (cm^2)
	square feet (ft^2)	0.0929	square metres (m^2)
	square yards (yd^2)	0.8361	square metres (m^2)
	square miles (mi^2)	2.59	square kilometres (km^2)
	acre (ac)	0.40	hectare (ha)
Drilling line wear	ton-miles (tn•mi)	14.317	megajoules (MJ)
		1.459	tonne-kilometres (t•km)
Torque	foot-pounds (ft•lb)	1.3558	newton metres (N•m)

1 LESSON

Controlled Directional Drilling

In this lesson:

- Overview of controlled directional drilling
- Well pattern types
- Developing the well plan
- Directional survey tools
- How computers plot survey results

Depending on the application, wells, or *wellbores*, can be drilled vertically or at an angle. *Directional drilling* is a special drilling operation employed to intentionally curve, or deviate, a well from vertical. Once the drilling operation is complete, a deviated well will follow a preplanned path from the surface to the subsurface targets.

Today, most wells are drilled directionally. Directional drilling is implemented for a number of reasons. For example, a reservoir might be located under an obstruction, such as a building or lake, which prevents the installation of a rig directly above the target. Directional drilling might also be necessary to reach multiple reservoir locations from a single, fixed location at the surface (fig. 1). If a section of an existing well becomes blocked by fragmented drilling tools, the well can be *sidetracked* using directional drilling tools, thus allowing the operation to continue. Directional drilling can also be implemented to reach a more productive portion of a reservoir, and when wells are drilled directionally, a longer section of the reservoir is exposed to production. In many applications, reservoirs produce more efficiently when intercepted by wells that curve 90° or more, dubbed *horizontal wells*.

2 LESSON

Deflection Tools and Bottomhole Assemblies

In this lesson:

- Why deflection tools are used
- Whipstocks and jet deflection bits
- Downhole motors
- Rotary steerable tools
- Bottomhole assemblies and their significance

A directional drilling operation requires some means of changing the course of the hole. To do so, a deflection tool can be employed to adjust the angle and direction of the well's trajectory. Alternatively, the portion of the drilling assembly below the drill pipe, referred to collectively as the bottomhole assembly or BHA, can be adjusted so that the bit progresses in a desired direction.

A deflection tool is a device that is made up in the drill string that causes the bit to drill at an angle to the existing hole. To drill in a specific direction, the tool face of the deflection tool is turned, or oriented, to deflect the hole. The complexity of BHAs, on the other hand, ranges. A BHA might simply comprise the bit and a series of drill collars, or it might include highly sophisticated drilling tools, depending on the needs of the operation. This lesson highlights a number of deflection tools available to directional drillers as well as the BHAs that are commonly employed in the field.

3 LESSON

Open-Hole Fishing

In this lesson:

- Types of fish and fishing operations
- Common causes for fishing operations
- Mechanical sticking versus differential sticking
- Fishing tool types and functionality
- How to allocate time for fishing operations

The term fish refers to an obstruction in a wellbore. There are many different types of fish. Examples include stuck or broken pipe, bits and bit cones that have become detached, and various hand tools that have fallen downhole. In the field, small fish are often called *junk*; much larger materials, such as portions of the drill string, can likewise become lost or stuck in a hole. An operator might choose, in some cases, to bypass the fish. If not, the fish must be retrieved so that normal drilling operations can continue.

Fishing refers to the operation that is performed to retrieve fish. Fishing operations are further subdivided into two categories:

- Open-hole fishing
- Cased-hole fishing

Open-hole fishing is performed as the hole is drilled whereas cased-hole fishing is performed during production or workover. This lesson will focus on the basic techniques and tools associated with open-hole fishing—that is, the retrieval of fish from a hole that has not been cased.

4 LESSON

Blowout Prevention

In this lesson:

- The Lucas well and blowout at Spindletop
- Formation pressure versus hydrostatic pressure
- Causes, signs, and detection of abnormal formation pressure
- Preliminary events that indicate a kick has occurred
- Well-control equipment used to assess and detect a kick

On January 10, 1901, the blowout of the Lucas well at Spindletop near Beaumont, Texas was spectacular and widely publicized. Before the development of *blowout preventers* (*BOPs*), blowouts were common. They were called *gushers* if they produced oil.

The Hamill brothers had started drilling the Lucas well three months earlier using a new tool called a *rotary drill*. Because of their experience using the rotary drill, the Hamills had been hired by Anthony F. Lucas (fig. 99) and his partners to come to Beaumont to try drilling through the sand and rock at Spindletop.

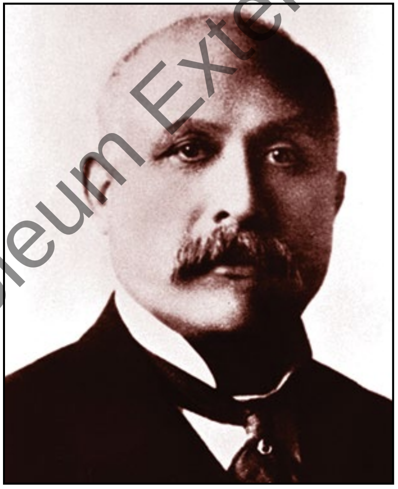

Figure 99. Anthony Lucas, chief engineer at Spindletop

5 LESSON

Well Control

In this lesson:

- Steps to control an onshore well kick
- Steps to control a well kick while making a trip
- Methods, procedures, and calculations used to kill a kick
- Killing a well kick with the pipe off bottom
- Common mistakes made in killing a well kick

By taking immediate action, the driller can minimize the size of a kick. Minimizing the size of the kick can greatly enhance the ability of a drilling crew to handle the kick properly. Quick action can prevent the situation from escalating into a blowout. When a kick is detected, following the proper sequence of steps is critical to successful emergency control. Depending on the cause, differing methods and procedures may be used to kill a well kick.

Lesson 5 includes a number of steps for controlling the different types of well kicks that are known to occur onshore as well as offshore. While these steps capture the sequence of events that usually take place in the field to prevent this type of emergency situation from intensifying, it is important to note that in no way should they replace the unique training and instruction that oil and gas companies might provide their employees, contractors, and associates. Even still, the protocol that has been provided herein references the common equipment, techniques, and terminologies that drilling professionals are encouraged to learn, understand, and apply whenever it is necessary. By becoming familiar with the best practices for preventing a blowout, people are more likely to stay safe, the environment is more likely to be protected, and natural resources are less likely to be wasted.

Conclusion

The five lessons in this segment of the Drilling Technology Series teach the background necessary for someone embarking on a career in drilling technology. This text examines important aspects of special drilling operations, beginning with a detailed look at controlled directional drilling and survey requirements, open-hole fishing tools and techniques, and the equipment and safety measures associated with blow prevention. Upon completing all five lessons, readers will have gained important knowledge of the major facets of drilling. To reinforce learning, an optional online assessment designed as an open-book test is available for purchase with this book. Completion of the test after reading the book provides the opportunity to receive a Completion Certificate and valuable Continuing Education Units (CEUs).

To further your understanding of rotary drilling, consider adding Segment I and II to your personal library. Segment I, *Introduction to Rotary Drilling*, explores the basics of petroleum geology, the rotary drilling process, and key downhole tools, such as the bit. Segment II, *Routine Drilling Operations*, examines important aspects of standard drilling practices, such as surface equipment, bottomhole assemblies, bit and annular hydraulics, drilling fluids, casing runs, and cementing operations. Segment IV is planned for future release; it explores critical aspects of offshore operations.

As a whole, the Drilling Technology Series includes a wealth of information about all phases of drilling. No other program in today's marketplace offers the same breadth of material in one location as this unique, easy-to-use collection. Although primarily designed for industry personnel or college students studying petroleum technology, it is useful for anyone who wants or needs to know more about rotary drilling.

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