ROTARY DRILLING

Drill String and Drill Collars

First Edition

UNIT I • LESSON 3

ROTARY DRILLING SERIES

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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 almost the only country that employs 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, for example, 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 Système International (SI) d'Unités. Conference participants based the SI system on the metric system and designed it as an international standard of measurement.

The *Rotary Drilling 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 to the SI system, we include the following table.

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)	$\frac{^\circ F - 32}{1.8}$	degrees Celsius (°C)
Thermal gradient	1°F per 60 feet	—	1°C per 33 metres
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)

Introduction

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In rotary drilling, a crew rotates a bit that drills a hole through the earth in search of oil or gas. The crew attaches the bit to a hollow length of pipe that serves two purposes: it provides the weight to make the bit dig into the earth's formations, and it provides a passageway to circulate a fluid—drilling mud—to the bit as it rotates. This drilling mud cools and lubricates the bit and carries the rock cuttings from the bottom of the hole to the surface (see fig. 1). Surface equipment removes the cuttings and recirculates the clean mud back down the pipe. As the crew drills deeper into the earth, crew members add more pipe to that which is connected to the bit. Before a well is completed, this drill stem may be thousands of feet long.

Because the drill stem serves two purposes, it consists of, among other things, two basic types of pipe: the drill string and the drill collars. These two types of pipe are similar in that they are hollow lengths joined together to make one long conduit from the surface to the bottom of the hole. They are constructed somewhat differently, however, because they fulfill different functions.

Drill Collars

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Standard Design

Manufacturers design drill collars for guiding, stabilizing, and providing weight on the bit. Drill collars are heavy, thick-walled, metal tubes usually made of steel. They range in weight from 16 pounds to 379 pounds per foot (23.81 kilograms to 564.01 kilograms per metre). Most drill collars are round and are 30 or 31 feet (9.14 or 9.45 metres) long. Drilling crews join the required number of collars by stabbing the pin end of one collar into the box end of another and screwing them together (fig. 4).

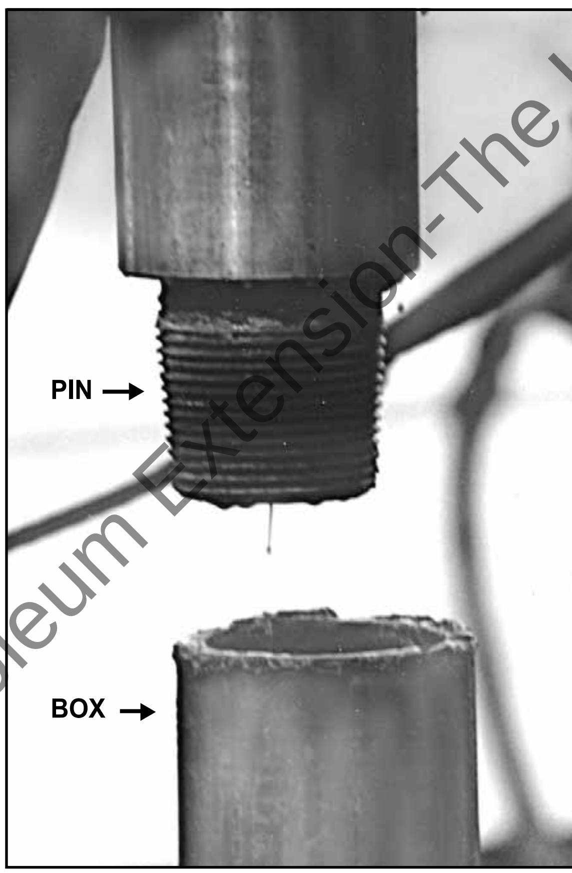

Figure 4. Stabbing the pin of one collar into the box of another

Drill String

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Unlike drill collars, the drill string is not ordinarily used to put weight on the bit. (The drill string is, however, sometimes used to put weight on the bit in horizontal drilling.) The drill string is made of steel or aluminum and is normally used for two basic purposes: to serve as a conduit, or conductor, for the drilling fluid; and to transmit the rotation of the rotary table or top drive to the bit on bottom. Since it is not exclusively used to put weight on the bit, the drill string is smaller and lighter than the drill collars. In addition, in straight-hole drilling, it is suspended in the hole under tension, not compression. It is kept in tension by two opposing forces—the weight of the collars pulling on it from below and the hoist, line, and blocks pulling on it from the surface (fig. 12). Keeping the drill string in tension prevents it from bending and buckling and prolongs its life.

Standard Design

Manufacturers design the drill string so that it can withstand some of the most complex stresses encountered during drilling. Relative to a drill collar, the drill string is small and thin, yet it can withstand powerful forces. Basically, the drill string is a column, or string, of drill pipe with attached tool joints. Most drill pipe is steel that is forged into a solid bar and then pierced to produce a seamless tube. Because the wall of the tube is relatively thin, usually less than ½ inch (12.7 millimetres) thick, the manufacturer cannot cut threads into it. To solve the problem of providing threaded ends so that the pipes can be screwed together, manufacturers produce tool joints.

Heavy-Walled Drill Pipe

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Design

Heavy-walled (heavy-weight) drill pipe is manufactured with walls that are thicker than those in standard drill pipe. The heavier-walled tube is attached to special extra-length tool joints. The extra length of the tool box allows room for recutting connections when the original ones are damaged and reduces the rate of wear on the OD of the tube by keeping the wall of the tube away from the side of the hole. The OD of the tube is also protected from abrasive wear with a center wear pad (fig. 42).

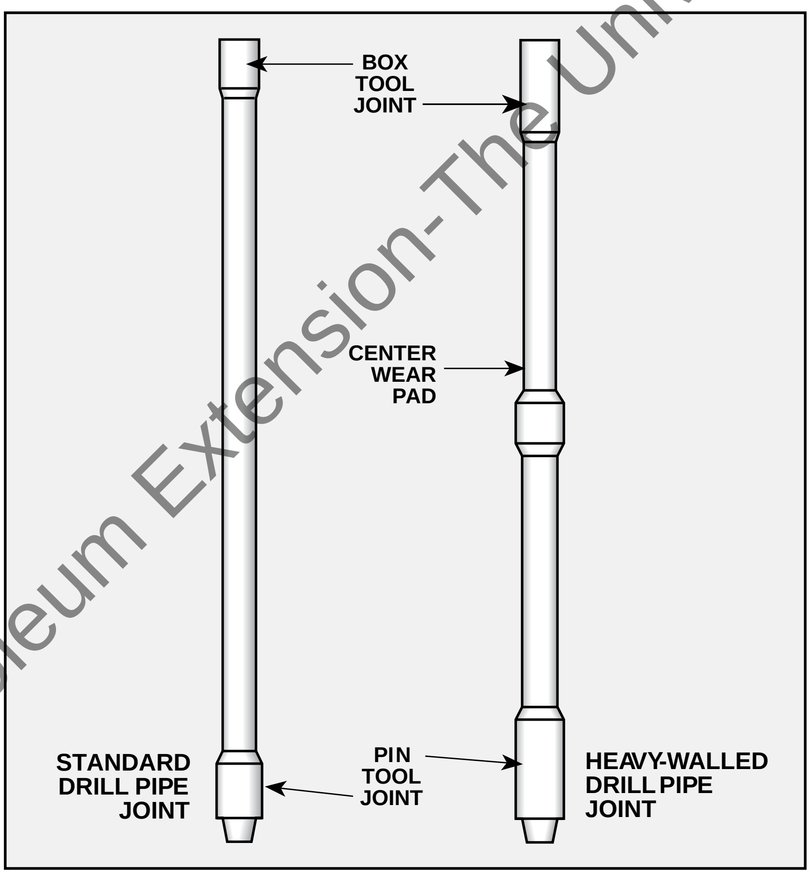

Figure 42. Standard drill pipe joint and heavy-walled drill pipe joint with center wear pad

Drill String and Drill Collar Auxiliaries

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A drilling crew installs additional pieces of equipment, or tools, in the drill string when required. These tools include subs, pup joints, stabilizers, reamers, and special valves. A *sub*, which is short for substitute, is a fitting crew members insert into the string to perform a special function. One commonly used sub is a short fitting with different-sized threads on each end. It allows the crew to screw together components of the drill string that have different-sized or -style threads.

For instance, the crew sometimes uses a *bit sub* between the bit and the drill collar. Bits come with a pin rather than a box; the pin screws into a box. The crew runs drill pipe and drill collars into the hole with the pins pointing down and the boxes facing up to make it easier for the rotary helpers to stab pins into boxes. The crew therefore cannot directly connect the bit to the drill collar, because two pins face each other. A bit sub has a box connection at each end (fig. 45). The crew stabs the drill collar's pin into the box of the bit sub, then the bit's pin into the sub's box. (Many contractors use a special bottomhole drill collar that has a box connection on each end. The box connection on the bottom of the collar allows the crew to directly stab the bit's pin into the collar without having to use a sub.)

Rig crews often use a *crossover sub* to connect the last joint of the drill string to the first drill collar in the drill stem, since the drill string's pin threads usually do not fit properly into the drill collar's box threads. Using the sub helps facilitate a good connection between the drill pipe string and the drill collars.

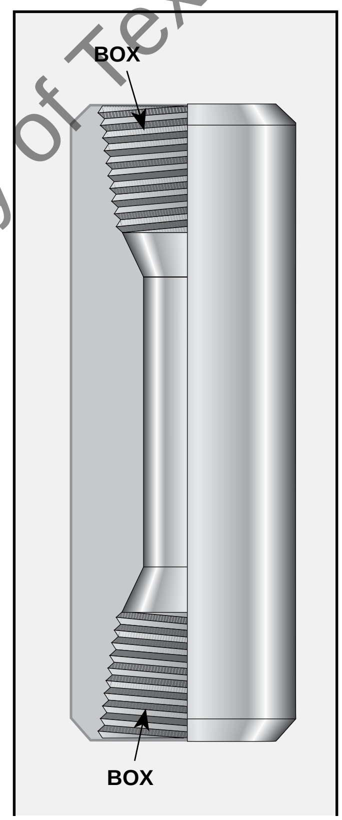

Figure 45. A bit sub; drawing shows a quarter-section taken out to show box threads inside the sub.

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