ROTARY DRILLING

The Auxiliaries

Third Edition, Rev.

UNIT I • LESSON 9

ROTARY DRILLING SERIES

Unit I: The Rig and Its Maintenance

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Cover photo
Parallel Column Racking System

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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 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 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)

Introduction

While much of the equipment on a rig site is the huge machinery that does the main work of drilling, many other tools and pieces of equipment round out the typical drilling operation. Besides the drilling equipment are the tools that allow the crew to work with pipe, the instruments that monitor drilling, the equipment that provides water and electricity, and the equipment that makes the job safer.

The drilling industry continuously improves both primary and auxiliary equipment. In particular, recent increases in deep offshore drilling and in directional and horizontal drilling have motivated numerous changes. Advances in automation have been especially dramatic. Automation on the rig is the use of automatic mechanical or electronic devices to replace human observation, labor, and decisionmaking. Automation replaces manual, repetitive tasks with machines, which removes people from hazardous work and locations. It allows more precise control of processes, and produces more consistent quality. Moreover, it allows one person to control several functions simultaneously, and it can make a company or an industry more competitive by reducing costs and waste.

Other lessons in this series go into detail about many of the auxiliary tools used on a drilling rig. This book covers equipment that is not mentioned in other lessons or is mentioned only briefly.

Types of auxiliaries:
- Pipe tools
- Monitoring instruments
- Water and electricity equipment
- Safety equipment

Pipe-Handling Equipment

In this chapter:

- Automation of pipe-handling equipment
- Purpose of automated pipe-handling equipment
- Operation and care of kelly spinners
- Operation and handling of spring slips and power slips
- About automatic pipe handlers

Automation has changed, and in some cases eliminated, many manual tasks on the rig floor. On rigs that have automatic equipment, handling pipe and slips is no longer the heavy work it used to be. In many ways, automation has transformed the floorhand from a laborer to an operator. From the pipe handling side of the operation, automatic equipment includes kelly spinners, spring slips and power slips, and automated pipe-handling and racking systems.

Pipe-handling equipment:
- Kelly spinners
- Spring slips
- Power slips
- Pipe-handling/racking systems

Kelly Spinners

On rigs using a kelly-and-rotary-table system (instead of a top drive) to rotate the bit, kelly spinners are great labor saving devices. A *kelly spinner* (fig. 1) is a pneumatic (powered by compressed air) or hydraulic (powered by a liquid called hydraulic fluid) motor attached to the top of the kelly or to the bottom of the swivel (fig. 2). The kelly spinner's job is to rapidly turn, or spin, the kelly, mainly when making a connection—that is, when adding a joint of drill pipe to the string after the kelly has been drilled down.

Rig Instruments

In this chapter:

- What drilling parameters are
- Functions of sensors, indicators, and recorders
- Operation and care of weight indicators, wire rope, and wireline monitors
- Operation and care of rotary torque indicators
- About RPM and SPM indicators and recorders

A drilling rig instrument measures drilling parameters, equipment function, or formation characteristics; displays the measurements on a panel or a readout device; records the measurements; controls equipment within set limits; and stops operation if control fails.

Instruments on a rig include sensors, gauges, recorders, and various tools to control the machinery. Instruments can be bought and used independently of each other, but manufacturers also offer instrumentation systems where many instruments feed data to a central computer.

Some drilling parameters:
- Rate of penetration
- Pump rate
- Rotary revolutions per minute
- Weight on bit

Sensors, Indicators, and Recorders

Sensors measure *drilling parameters*, which are factors that affect a drilling operation, such as the rate of penetration, pump rate, rotary revolutions per minute (rpm), weight on bit, and the like. The sensors send signals to an analog or digital readout, or gauge, which displays the information. An analog display is usually a needle on a dial (fig. 10). A digital display may be a liquid crystal display (LCD) or an electronic graphic representation on a cathode ray tube (CRT), which is similar to a standard TV screen. In either case, the display shows numbers and words or graphs (fig. 11).

Drilling Tools

In this chapter:

- How pressure in the well is maintained with a drilling choke
- How automatic drillers facilitate the job of human drillers
- Purposes of MWD and LWD tools

Adjustable Choke

- A kick occurs when the drilling fluid does not exert enough pressure on the formation.
- After a kick, back-pressure must be maintained on the drilling fluid column to prevent a blowout.

A drilling choke allows personnel involved in controlling a kick to maintain a predetermined amount of back-pressure on a well while circulating the kick out of the well. A kick can occur when the pressure in the hole opposite a porous and permeable formation is less than the pressure of the fluids in the formation. When pressure in the hole is less than formation pressure, the hole is said to be underbalanced. When the hole is underbalanced, formation fluids can enter the hole. Pressure in the hole can be less than formation pressure when the weight, or density, of the drilling mud is not great enough to develop enough pressure to balance formation pressure. An alert drilling crew promptly notices that a kick has occurred and takes steps to control the well—that is, to prevent further entry of formation fluids and to increase pressure in the wellbore to balance formation pressure.

Actions crewmembers take on noting a kick include stopping mud from circulating by stopping the mud pumps and shutting in (closing) a *blowout preventer*, which closes in the well and prevents the further entry of formation fluids. But they cannot open the blowout preventer until the mud weight has been increased and circulated throughout the well; otherwise, formation fluids could re-enter the well.

Integrated Drilling Systems

In this chapter:

- Performance of an integrated drilling system
- How it improves rig safety and efficiency
- Operation of computerized integrated drilling systems

When a rig is equipped with conventional drilling instruments, the readout for each instrument is usually mounted on the driller's console (fig. 19). With conventional instruments, the driller, in order to maintain optimum drilling conditions, must continuously look at all the information, from mud flow rate, to WOB, to ROP. The driller must then determine how all the information interrelates and affects drilling efficiency. Mistakes can be dangerous, costly, or both.

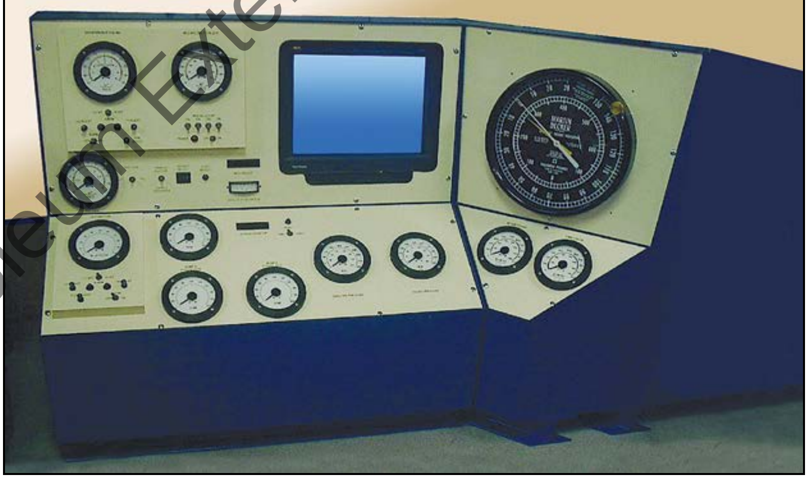

Figure 19. The driller's console has space for many analog and digital readouts.

Utilities

In this chapter:

- Types of utilities needed on a rig
- Fuel systems that supply rig engines
- Compressed-air and hydraulic systems that supply auxiliary components
- Systems that supply water for operating and drinking

A drilling rig, like any other isolated plant or factory, demands the convenience of various utilities—fuel for the engines, water for auxiliary equipment and for human use, and compressed air and hydraulic systems to power auxiliary equipment. Electricity also powers much of the auxiliary equipment. Since most modern rigs are diesel-electric, the generators not only power the motors to drive the equipment, but also provide electricity to light and perhaps heat or cool the rig. Mechanical rigs require auxiliary electric generators, often called light plants, to provide power for auxiliary equipment.

- Most rig engines use diesel fuel.
- Some engines use natural gas or LPG (when one of those is readily available).
- Some small engines for auxiliary equipment use gasoline.

Fuel Systems

Fuel systems may provide natural gas, liquefied petroleum gas (LPG), gasoline, diesel oil, crude oil, or any combination of these fuels. Today, except in rare instances, most engines that power the rig run on diesel fuel. Diesel is easier to transport and store than natural gas or LPG and it is not as volatile as gasoline. In a few instances, however, where a rig is operating near an easily tapped and abundant supply of natural gas or LPG, these fuels may be used. Similarly, in a few instances, where a small engine is required to operate a piece of auxiliary equipment, the only type available may be fueled by gasoline.

Rig Cleanup Equipment

In this chapter:

- Cleaning the rig for safety and the environment
- Use and maintenance of pressure washers, steam cleaners, and vacuums
- How used cuttings are cleaned
- Waste management on a rig

Cleaning dirt, oil, and other liquids from the rig site is important for safety and for the environment. A pressure washer or steam cleaner cleans oil and dirt from rig equipment, and a special vacuum cleans up spilled liquids.

Cleaning cuttings is also a consideration on rigs that use oil-based drilling mud. Environmental regulations usually do not allow the rig operator to dump them without washing them first.

Equipment for cleaning oil and dirt on rigs:
- Pressure washers
- Steam cleaners
- Vacuum cleaners
- Cutting cleaning systems

Pressure Washers

Pressure washers (fig. 31) use a high-pressure spray of water to clean anything on the rig that is oily or dirty. If a cleaning agent is required, the units provide a place to install a bottle of an environmentally safe detergent to mix with the water. The crew may also use a pressure washer to clean shaker screens, using water or base oil, depending on the type of drilling mud in use. Pressure washers are pneumatic—an air motor powers a triplex pump to pump the water or oil through a hose and wand assembly.

Fire Detection and Suppression

In this chapter:

- Training in fire prevention and suppression
- How fires burn
- How different types of fires are extinguished
- Operation and care of fire suppression equipment
- How fire detection equipment works
- Personal fire safety equipment on a rig

Flammable materials are all over a drilling site—oil and grease, natural gas, solvents, rubber hoses, cloth, and paper. Ignition sources are common as well—lit cigarettes, welding torches, and sparks from motors, for example. So fire prevention, detection, and suppression are crucial to safe operation of a drilling rig.

Everyone on a drilling rig should have training in fire prevention and take every precaution to prevent fires—where you see a no smoking sign, for instance, don't smoke. Anyone servicing or operating equipment that involves sparks or flames must know when and how to work safely.

All persons on a drilling rig should know what to do if they see a fire, and know exactly what to do and where to go when a fire alarm sounds. Everyone should know where the rig's fire extinguishers are and how to operate them. Especially offshore, every crewmember depends on each other for safety in the event of a fire.

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