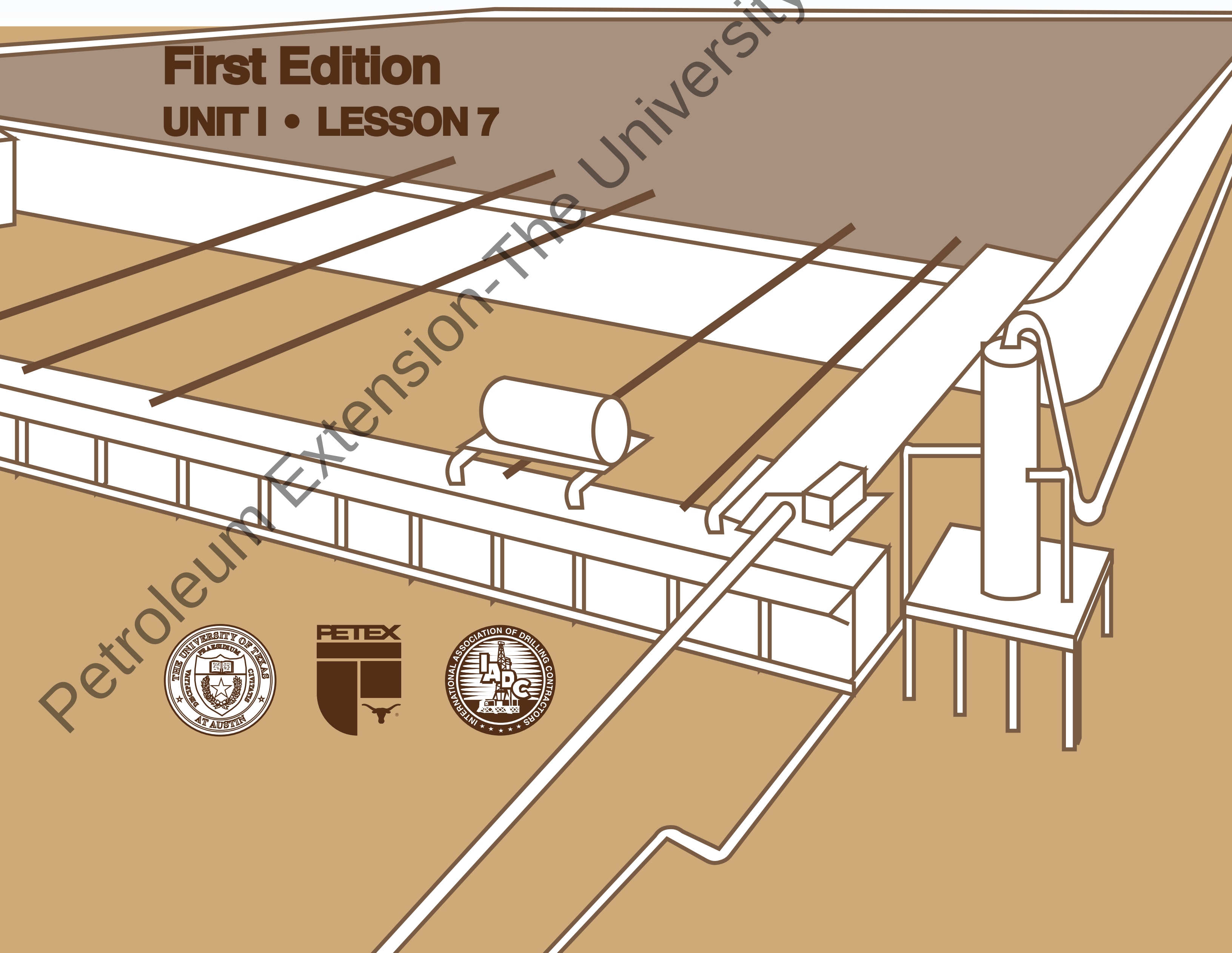
ROTARY DRILLING

# DRILLING FLUIDS, MUD PUMPS, AND CONDITIONING EQUIPMENT

**First Edition**

**UNIT I • LESSON 7**



# 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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A rotary drilling operation uses three systems that work together to make hole:

1. a rotating system that turns the bit,
2. a hoisting system that raises and lowers the drill stem and adds weight to the bit, and
3. a circulating system that moves a fluid down the drill stem, out of the bit, and back up the hole to the surface.

## Drilling Fluids and Equipment

A typical circulating system on a rotary drilling rig includes the fluid that moves (called *drilling fluid*), equipment to move the fluid, and equipment to clean and *condition* the fluid. To condition the fluid means to circulate it through the circulating system so that all the additives in the fluid are distributed evenly throughout the system.

### Drilling Fluids

A fluid is any substance that flows, so drilling fluid may be either a *liquid* or a gas. If in a liquid form, drilling fluid may be water or a mixture of water and oil with *additives*. Most oilfield workers call this mixture *drilling mud*. A gaseous drilling fluid may be either dry air or *natural gas*. Or it may be air or gas mixed with water and a foaming agent to form mist or foam.

About 95 percent of all drilling operations use fresh or *salt water* (water-base muds) as the drilling fluid. Water-base muds are relatively inexpensive to prepare because a water source is usually nearby, either as fresh groundwater or seawater. Oil muds are more expensive than water-base muds. Also they are harder to dispose of because of their possible detrimental effects on the environment. Air or gas drilling has advantages for certain formations, but its disadvantages limit its use.

# Circulating Systems

Drilling with a liquid and drilling with air or gas serve the same purposes, but each has advantages and disadvantages. The *operator* chooses the best system for a given drill site based on experience with previous wells in the same area.

## Functions of the Circulating System

Circulating a fluid while drilling—

1. cleans the bottom of the hole;
2. transports cuttings to the surface;
3. cools the bit and lubricates the drill stem;
4. supports the walls of the wellbore;
5. prevents entry of formation fluids into the well, which can cause kicks or, if not controlled, leads to blowouts;
6. transmits hydraulic power to downhole equipment;
7. reveals the presence of oil, gas, or water that may enter the circulating fluid from a formation being drilled; and
8. reveals information about the formation, through the cuttings.

Not all types of drilling fluids handle these functions equally well. Air and gas have particular advantages and disadvantages compared to drilling muds. In the same way, not all muds are equal.

# Pumps on the Rig

The mud pumps, or slush pumps, are the most important pieces of equipment in a circulation system that uses liquid drilling fluid. If they break down during drilling, the operation comes to a halt. They must therefore be reliable. One pump might be sufficient under some conditions if the other stopped working, but safety requires at least two working pumps at all times. Therefore, mud pumps are extremely sturdy, capable of handling heavy loads, and can tolerate abrasive fluids. Most drilling rigs also have several small auxiliary pumps, usually centrifugal pumps, to move mud in and around the circulating system. Generally, these small pumps do not develop pressures higher than about 150 psi (1,034 kPa).

The derrickhand, working with other crew members, is responsible for making sure that the pumps work efficiently, maintaining them, and repairing them when needed.

Rotary rigs use two types of pumps: reciprocating and centrifugal. Most auxiliary pumps are centrifugal pumps, and the mud pumps are reciprocating.

# Other Circulating Equipment

Drilling fluid returning from the wellbore contains drilled cuttings, sand, other particles from the hole, and solids added purposely. Almost all circulation systems use a shale shaker to remove cuttings from the mud, but removal of finer solids is up to the operator. Mud with too many solids—drilled solids plus additives—becomes too heavy, or dense, which slows the drilling rate. Drilled solids can also increase the mud's thickness (viscosity). It takes high pump pressures to move thick, viscous mud. Also, muds that are too viscous may create other downhole problems that interfere with efficient drilling.

To control the viscosity at the level that is best for the drilling conditions, the operator may thin the mud. The three options for thinning mud are to use a chemical thinner, to add water, or to use equipment to remove the unwanted solids. The decision is based on cost. In a weighted mud, which may cost ten times more than an unweighted mud, operators usually employ mechanical equipment to remove solids. Mechanical equipment is usually the least expensive option.

Removing the most solids possible makes it easier to keep the mud in good condition. The cost for mud chemicals is less, and the overall cost of operation is lower when fine solids are not left in the mud. To this end, after passing through the shale shaker, drilling mud may pass through a desander, desilter, mud cleaner, and centrifuge to clean out smaller particles. The drilling contractor may also need to use a degasser to remove entrained gas.

The derrickhand usually maintains and adjusts the solids control equipment to keep the mud flowing properly.

*To obtain additional training materials, contact:*


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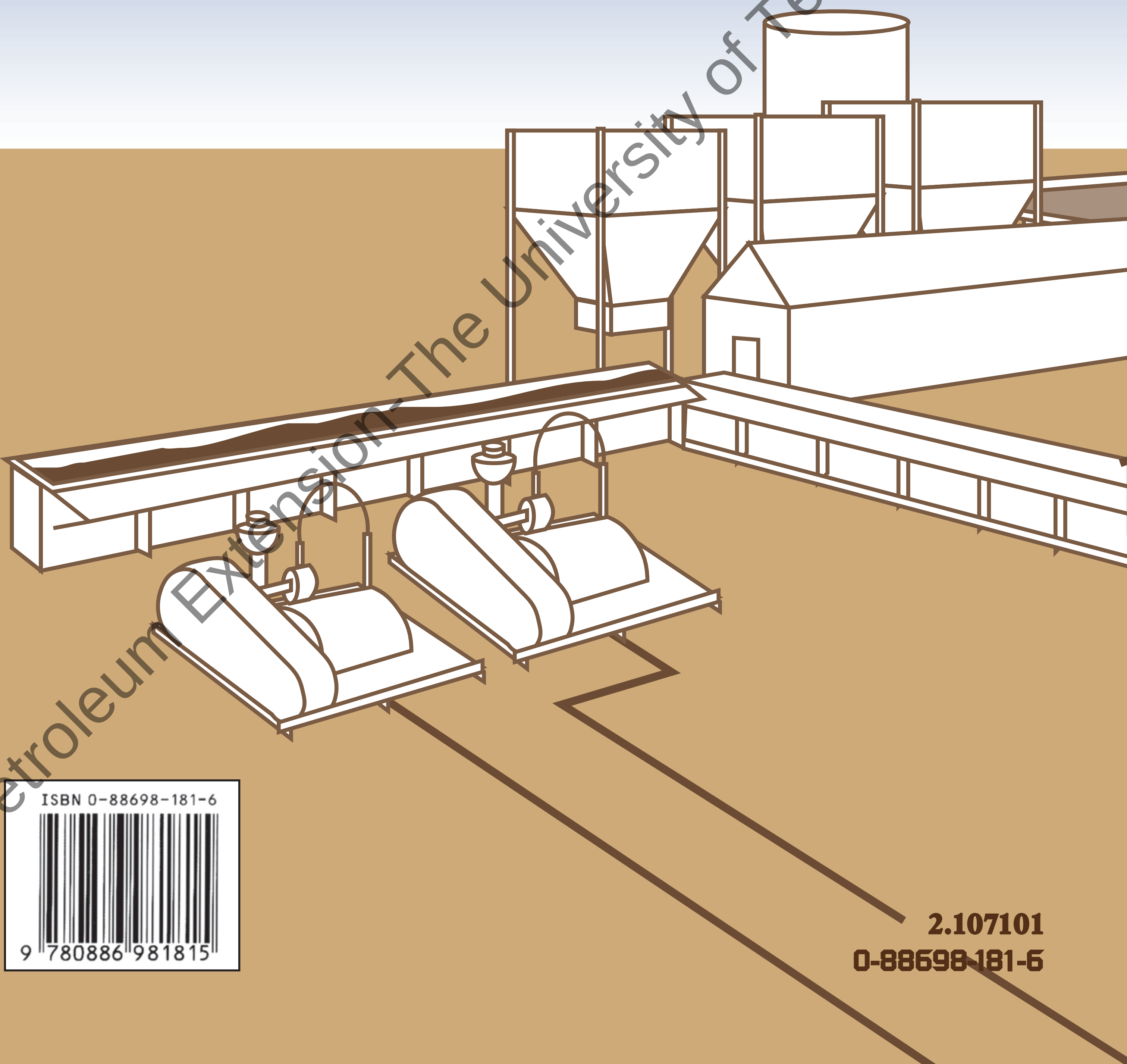



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