Rotary Drilling Series • Unit V, Lesson 1

Wind, Waves, and Weather

Third Edition

THE UNIVERSITY OF TEXAS
CONTINUING EDUCATION
PETROLEUM EXTENSION SERVICE
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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 one of only a few countries 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, 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.

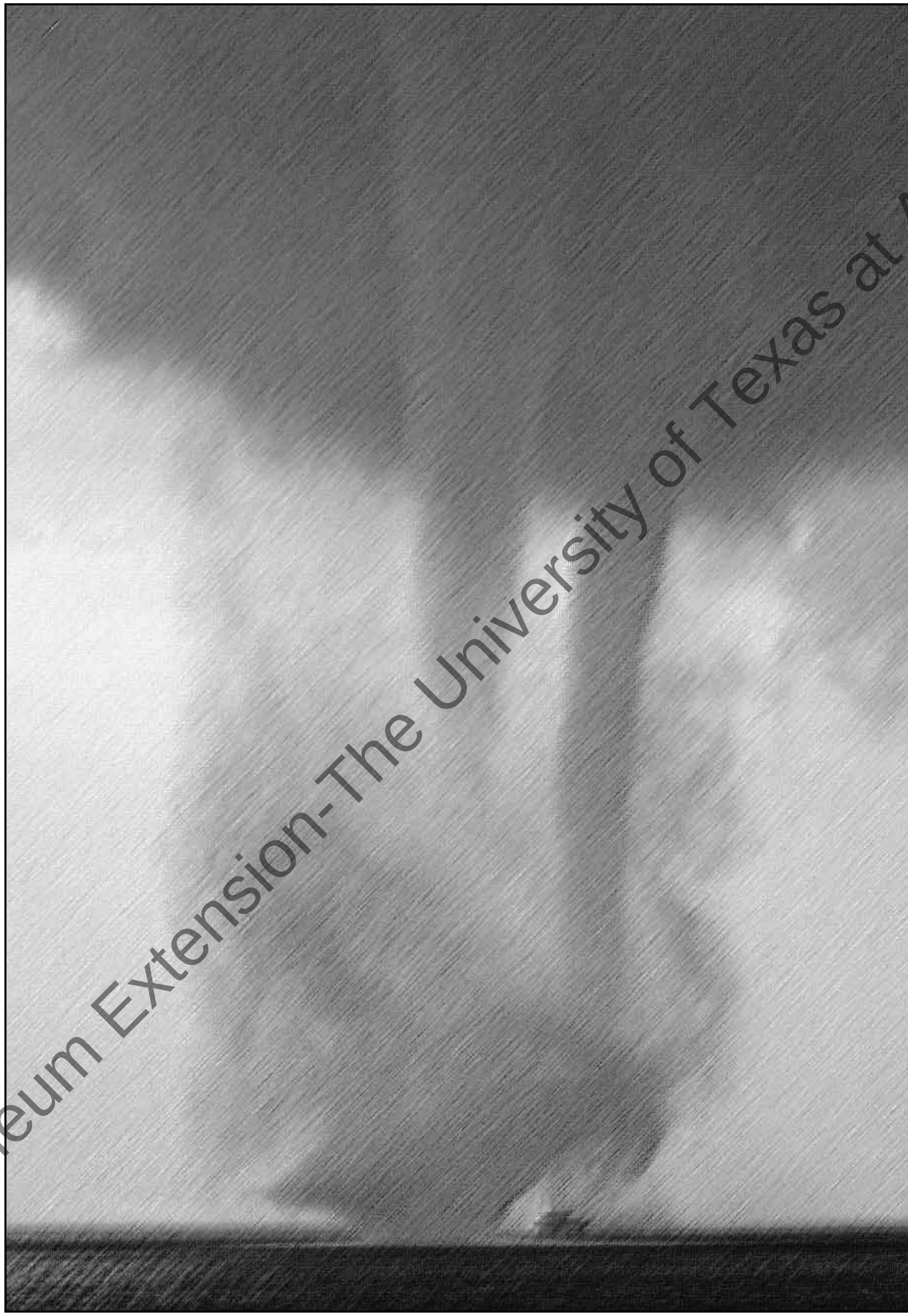
In the late 1970s, the Eleventh General Conference on Weights and Measures described and adopted the Système International (SI) d'Unités. Conference participants based the SI system on the metric system and designed it as an international standard of measurement.

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)	$\frac{°F - 32}{1.8}$	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

Oil companies drill for oil and gas in oceans and seas all over the world (fig. 1). No matter where an offshore rig operates, weather affects it. In some places, reasonably clement weather occurs most of the time. But, even in moderate climates, severe *thunderstorms* and *hurricanes* or *typhoons* can occasionally wreak havoc. And, where bad weather prevails, as in the North Sea, off the east coast of Canada, and in Alaska (fig. 2), it is a constant threat. Thus, offshore oil companies and drilling contractors pay a great deal of attention to the weather and its effect on personnel and equipment.

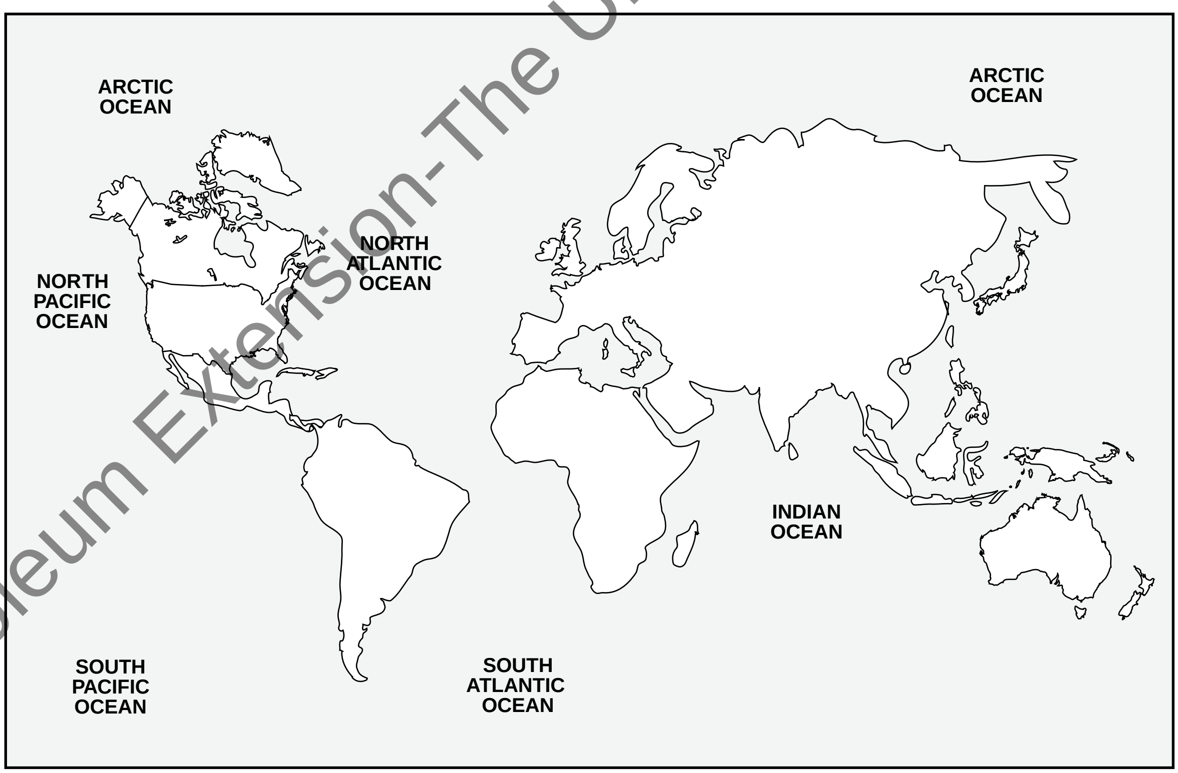


Figure 1. Offshore operations are being carried out over a large part of the earth.

Wind

The sun *radiates*, or gives off, energy that strikes the earth. Much of this energy is in the form of light and heat. This solar energy, however, does not affect areas of the earth equally. Instead, the sun heats the earth's surface unevenly. For example, the Arctic and Antarctic receive less solar energy than the equator. Because the earth's axis is tilted in relation to the sun, solar energy hits polar areas at an angle. The poles do not get as much solar energy as the equator, where the sun's energy strikes head on. Therefore, it is cold at the poles and hot in the tropics. Scientists call this temperature difference *differential heating*.

Another factor in differential heating is that some regions on earth absorb more heat than others. For example, because polar regions are covered with ice, they reflect a great deal of heat back into the air. On the other hand, tropical areas, with their massive amounts of dark green foliage, absorb more heat than they reflect. Thus, the sun heats the earth unequally. Consequently, the earth heats the air in its atmosphere unequally. The resultant mixture of warm and cool air in the atmosphere causes *wind*. Wind is the horizontal movement of air in the earth's atmosphere.

Latitude and Longitude

The sun showers the earth with *shortwave radiation*. This shortwave radiation, or energy, is visible as light, and it provides heat. As stated before, the angle at which the sun's rays strike the earth affects the amount of heat received by areas on the earth. To understand the effect, it also helps to understand *latitude* and *longitude*.

Geographers divide the earth into imaginary lines of latitude and longitude. Latitude is an imaginary line joining points on the earth's surface that are all of equal distance north or south of the equator. Longitude is the angular distance east or west of the *prime meridian* that stretches from the North Pole to the South Pole and passes through Greenwich, England. The prime meridian is the line of longitude that is 0 degrees (°). All other longitudes are measured either east or west of the prime merid-

Waves and Sea States

Waves

Several forces form ocean waves. These forces include the frictional contact between the wind and the ocean, the tidal attraction of the sun and the moon, and the vibration of the earth.

Wind Waves

Formed by the contact of wind with the ocean's surface, *wind waves* are the type of waves that affect offshore operations the most. As wind blows over an ocean, friction occurs between the wind and the ocean's surface. This friction is a form of energy and it moves the ocean's surface. Wind energy only affects the top of the water. However, the top layer of water imparts energy to the water directly beneath it. The water eventually absorbs this energy as depth increases. This transfer of energy through friction forms wind waves.

Wind waves develop and grow where the wind blows from the same direction for a long time. Oceanographers call this area of wave development *fetch*. Fetch is the distance over which the wind blows to generate the observed waves at a given position. A fetch may be hundreds of miles long. Maximum wave heights occur on the downwind boundary of the fetch. Oceanographers call waves that are still in the fetch, and under the influence of its wind, *sea*. They call waves that have moved out of their fetch and into weaker winds *swell*. Swell decreases in height and has regular movement. Sea appears choppy, while swell appears

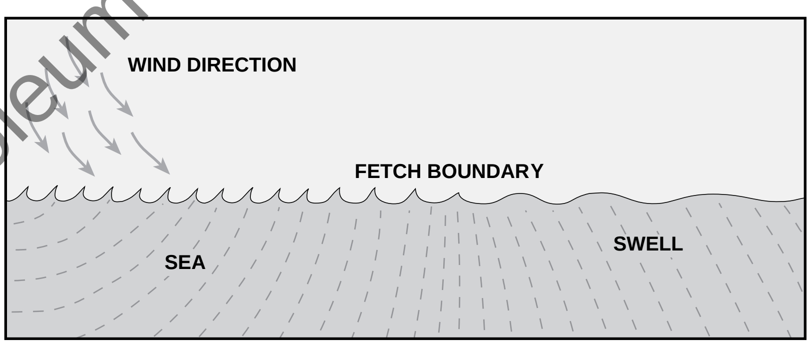


Figure 14. Sea, fetch boundary, and swell

Weather

Climate Versus Weather

Climate is the average course or condition of the weather in a given area over a period of years. Temperature, wind velocity, and precipitation affect climate. The climate of an area may be hot, cold, wet, or dry. And, sometimes, it is referred to as harsh or mild. Often, the latitude of an area affects its climate. For example, lands near the equator are often tropical, which means that they are hot and humid. On the other hand, lands near the poles are usually cold.

Weather, on the other hand, is the state of the atmosphere: is it hot or cold, wet or dry, calm or stormy, or clear or cloudy? Often, the term *weather* identifies rain, storms, and other unfavorable atmospheric conditions.

Because offshore drilling crews usually stay in one region for relatively short periods, changes in climate rarely affect them. That is, climate changes normally take place only over long periods and climate is different only at vastly different locations. An offshore crew usually stays in one area for only a few months or years. Decades or centuries may pass before a recognizable climate change occurs, if then. Of course, weather changes can occur rapidly. Indeed, travel virtually to any temperate zone in the world, and you will likely hear somebody say, "If you don't like the weather, just wait a few minutes, and it'll change."

The truth is that weather can change rapidly and unexpectedly almost everywhere. Rapidly moving weather systems change the weather in minutes or hours. Although the weather can change radically in a short time, meteorologists can usually predict upcoming weather changes as much as 24 hours in advance. Being aware of impending violent weather can give crewmembers time to prepare for it and prevent or limit danger to themselves and the rig.

Offshore Operations

Drilling Units

The location and environment of an offshore drill site plays a large role in the type of rig that an operating company selects. The area's wind, waves, currents, and other forces determine what a rig needs to withstand. Offshore operators broadly divide offshore drilling rigs into two categories: *mobile offshore drilling units* (MODUs) and fixed, or stationary, drilling units. In general, MODUs drill *exploration*, or *wildcat*, *wells*, which are wells drilled to determine whether oil and gas exist in an offshore location. After a MODU drills a single well, the company then moves it to another location where it drills another well. On the other hand, fixed drilling units are placed in position over an offshore reservoir, drill several wells, and are never moved from the location. (For more information about offshore drilling units and offshore operations, obtain the PETEX publication, *A Primer of Offshore Operations*. Log on to www.utexas. edu/cee/petex.)

Mobile Offshore Drilling Units

Today, operating companies and offshore drilling contractors mainly use two types of MODUs: *bottom-supported offshore drilling rigs* and *floating offshore drilling rigs*. With bottom-supported units, part of the rig is in contact with the seafloor during drilling. A bottom-supported unit floats only when being moved from one site to another. On the other hand, a floating rig not only floats while it is being moved, but also it floats over the site while it drills a well.

Glossary

A

abeam *adv*: to or at the side of a ship, vessel, or offshore drilling rig and especially at right angles to the ship, vessel, or rig's length.

ABS *abbr*: American Bureau of Shipping.

absorb *v*: 1. to take in and make part of an existing whole. 2. to soak up gradually or take in gradually something such as heat, liquid, chemicals, nutrients, or other substances.

absorption *n*: in meteorology, the process in which shortwave radiation is retained by regions of the earth.

Ac *abbr*: altocumulus.

advection fog *n*: a fog caused by the movement of warm, moist air over a surface with a temperature less than the dew point of the air. The cold surface cools the warm air to the dew-point temperature and fog occurs. Also called sea fog.

air mass *n*: a body of air that remains for an extended period of time over a large land or sea area with uniform heating and cooling properties. The air mass will acquire characteristics (such as temperature and moisture content) of the underlying region.

air mass source region *n*: an area over which an air mass rests and develops temperature and moisture characteristics typical of that location.

altocumulus (Ac) *n*: a white or gray mid-level cloud that appears as closely arranged rolls. This type of cloud is composed of either ice crystals or water droplets.

altostratus *n*: a bluish or grayish layer of uniform mid-level clouds that cover large portions of the sky. This type of cloud is composed of either ice crystals or water droplets.

American Bureau of Shipping (ABS) *n*: U.S. organization that sets standards and specifications for ships and ship equipment manufactured in the United States. The organization also makes inspections during offshore rig construction and conducts periodic surveys to ensure that requirements for classification are maintained. Its official publications are *Records of the American Bureau of Shipping* and *ABS Activity Report*. Address: ABS Plaza; 16855 Northchase Dr.; Houston, TX 77060; (281) 877-5800; www.eagle.org.

anemometer *n*: an instrument for measuring wind speed in the atmosphere. The most common types are cup, vane, and hot-wire anemometers.

aneroid barometer *n*: a device for measuring atmospheric pressure (a barometer) that consists of a flexible, spring-filled metal cell from which air has been removed and a mechanism that registers the pressure. See *barograph.*

Review Questions

LESSONS IN ROTARY DRILLING

Unit V, Lesson 1: Wind, Waves, and Weather

Multiple Choice

Pick the *best* answer from the choices and place the letter of that answer in the blank provided.

_________ 1. Tropical regions on the earth absorb more heat than other places because—

a. the foliage is light in color and reflects sunlight.

b. the foliage is dark in color and does not reflect sunlight.

c. ice in such areas reflects sunlight.

d. ice absorbs sunlight.

_________ 2. Latitude is an imaginary line that—

a. runs through the center of the earth.

b. runs east and west of the prime meridian.

c. joins points on the earth's surface that are all of equal distance north or south of the equator.

d. determines the sun's distance from the earth.

_________ 3. Solar radiation received at the earth's surface is—

a. isolation.

b. insolation.

c. insulation.

d. none of the above

_________ 4. When clouds cover an area, temperature differences between night and day are less because the clouds reflect the heat and reduce night cooling. This effect is the—

a. greenhouse effect.

b. insolation effect.

c. precipitation effect.

d. cool-off effect.

_________ 5. The retention and transport of water in the earth's atmosphere is called the—

a. radiation cycle.

b. air cycle.

c. hydrologic cycle.

d. motorcycle.

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