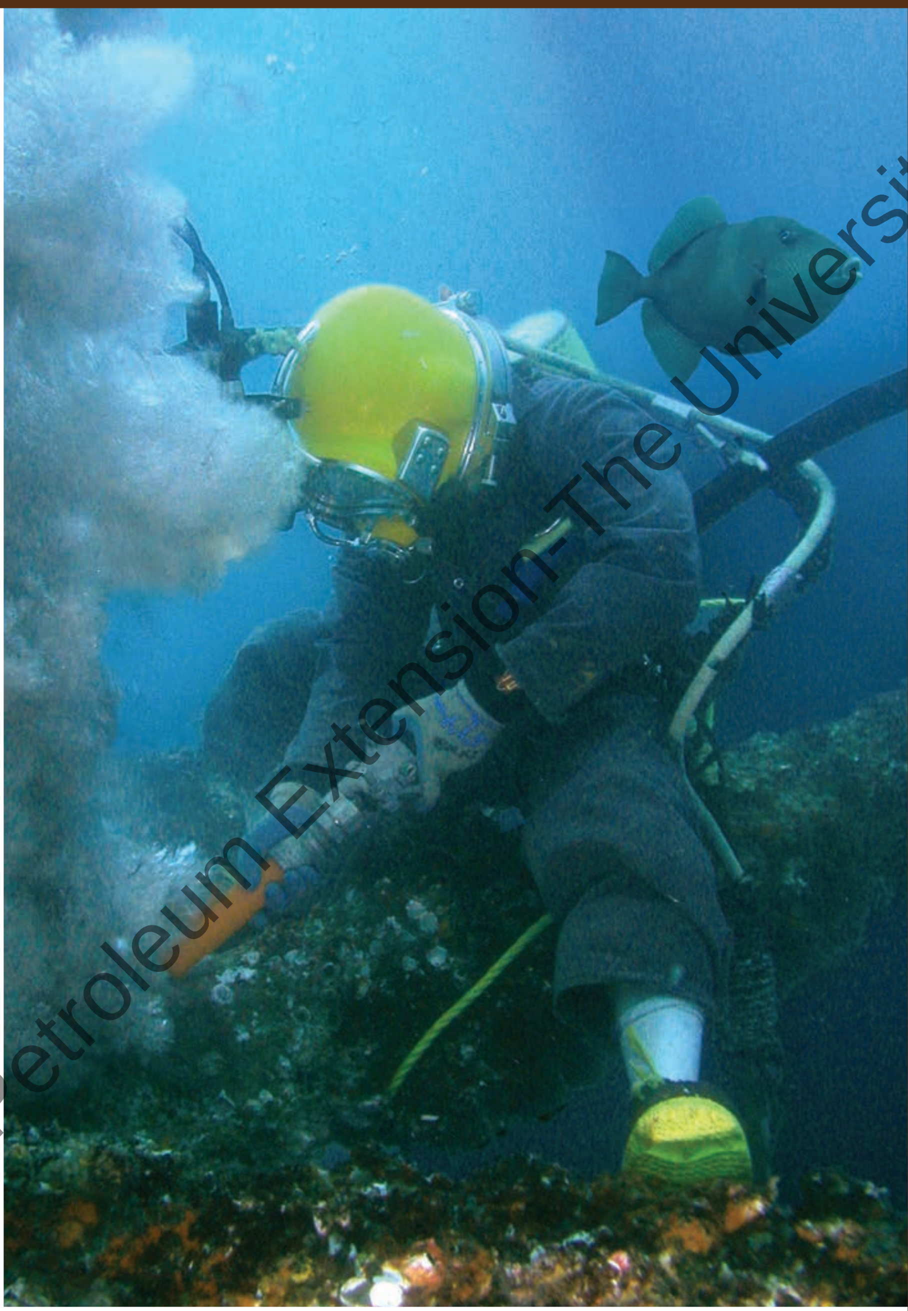
ROTARY DRILLING

DIVING AND EQUIPMENT



Third Edition

UNIT V • LESSON 5

Petroleum Extension-The University of Texas at Austin

ROTARY DRILLING SERIES

Cover photo
Grit blasting
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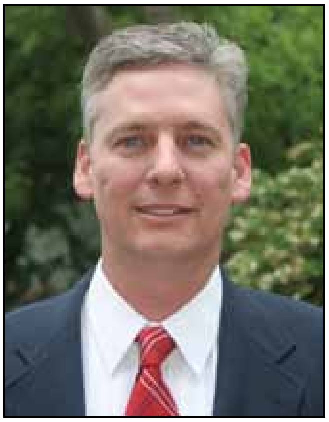
About the Authors



John Herren
Senior Director
Epic Divers and Marine Services

John Herren began his career in the commercial diving industry in 1990 after graduating from the College of Oceaneering in Los Angeles, California. He moved to the Gulf of Mexico and joined SubSea International where he worked as a tender, diver, and saturation diver in the Gulf of Mexico and West Africa.

In 1997, Herren worked as a freelance diver and Saturation Supervisor in the United States. Since 1998, he has worked for EPIC Divers and Marine where he supervised divers until he entered management in 2001. He has held positions as Operations Manager, Project Manager, and Director of Diving and is currently Senior Director of Operations.

In addition to his commercial diving credentials, Herren has been certified as a Diving Medical Technician by the National Board of Diving and Hyperbaric Medical Technology, a certified Underwater Bridge Substructure Technician, and is certified by The American Society of Nondestructive Testing in magnetic particle and ultrasonic testing methods. He has a Bachelor's degree in Business Administration from Northwood University and a Master of Business Administration from Tulane University.

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Gene Lo Conte
Diving Superintendent
Epic Divers and Marine Services

Gene Lo Conte has been a leader in the commercial diving industry for over 20 years. After finishing dive school at City College in Santa Barbara, California, he began his career as a tender with SubSea International in the Gulf of Mexico.

He quickly transitioned from tender to diver and started freelancing domestically and internationally. Lo Conte's diving freelance work took him from Africa to Venezuela and included domestic work in the Gulf of Mexico and on the east and west U.S. coasts. In 1999, he joined EPIC Divers and Marine as a diver/supervisor and has been a Diving Superintendent since 2003.

In addition to his work with EPIC, Lo Conte has presented on the subject of commercial diving at oil and gas industry conferences, written articles for trade publications, and taught commercial diving at the Divers Academy in New Jersey. Lo Conte has also acted as subject-matter expert for the development of a subsea-specific Department of Transportation operator qualification program. Moreover, he has consulted with the Association of Diving Contractors International on the development of its diving supervisor certification program.

Lo Conte has a Bachelor's degree in History and Political Science from Mount St. Mary's University and an Associate's degree in Marine Technology from Santa Barbara City College.

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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 conversion to the SI system, we include the following table.

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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)

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Diving History

In this chapter:

- Inception of the concept of diving
- Closed-circuit scuba and recreation of diver's own air supply
- The first deepwater scuba and discovery of decompression
- Causes and effects of decompression sickness
- Decompression tables and advancements in scuba equipment
- Modern closed-circuit scuba systems and saturation diving

Records of first attempts by humans to explore the great unknown depths of waters are nonexistent. The ancient sponge and pearl divers of the Mediterranean and Pacific were thought to be among the first to conduct underwater explorations, although they were probably diving to a maximum 100 feet (30 metres) and could endure the depth pressure for only 2 to 3 minutes. Their initial attempts, however, led to far greater discoveries than the treasures they hunted.

Diving as a military strategy was recorded as early as 400 B.C., but those military divers were more than likely combat swimmers. Xerxes, the King of Persia at the time, used divers to recover treasures on sunken Persian ships, and Alexander the Great put divers to military use when he destroyed the boom defenses at Tyre (Lebanon) in 333 B.C. the Greek philosopher Aristotle believed that Alexander the Great himself descended underwater in an archaic *diving bell.*

The first records of air being supplied to divers from the surface were given by the Roman historian Gaius Plinius Secundus in his book, *Naturalis Historia.* Pliny describes military divers using long tubes through which to breathe while below the surface. This tube device is similar to the modern-day snorkel, but it is impractical when used below about 10 feet (3 metres) because of the pressure differences that occur as the body descends into deeper water.

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Underwater Physics

In this chapter:

- The tendency to rise and float
- Heat loss and hazardous situations
- Liquid, gas, and pressure measurement
- Air supply in relation to depth
- Dalton's law of partial pressure
- Light exposed in an underwater environment
- Sound travel under water

As people walk through their environments every day, they rarely think of the mixture of gases they inhale and exhale or the pressure being exerted on each square inch of their bodies. Only when they are taken out of their safe physical surroundings do people become aware of the environment's life-sustaining qualities. When exposed to an underwater environment, people must understand the changes in physical properties and how to adapt to them to survive.

Buoyancy

Upon entering the underwater world, one of the most immediately noticeable differences is the tendency to rise or float. This elemental water force is known as *buoyancy* and is expressed in Archimedes' principle. This principle states that "a body submerged in a liquid is buoyed up by a force equal to the weight of the water it displaces." Because the densities of water and the human body are almost the same, the human body displaces almost its exact weight when submerged.

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Underwater Physiology

In this chapter:

- Pressure rations between diver and water
- Increased and decreased pressure in descent and ascent
- Halted breath during descent
- Helium's relationship to nitrogen narcosis
- Benefits and detriments of oxygen when diving
- Decompression symptoms and cures
- Interrupted elimination of carbon dioxide in the body
- The effect of rapid descent on the nervous system

The human body is a highly complex and sensitive system of cells, tissues, fluids, and bone that functions normally at sea-level pressure. In different environments, such as in the ocean waters, the body must make adjustments to different pressures to survive.

Subsurface Pressure

Within present diving depth capabilities, human tissues are insensitive to the increased pressures (fig. 6). However, for a diver to be relatively insensitive to pressure changes, his or her breathing gas must have access to all body cavities such as the lungs, middle ear, and sinuses. Trapped gases in these free air spaces are compressed by increasing pressure of water depth and by compliance of the cavity walls. No significant pressure differential can exist between these spaces and the outer environment, or immediate tissue damage will occur.

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Diving Equipment

In this chapter:

- Self-contained equipment provisions
- Types of surface diving
- Proper diver equipment and gear
- Categories of air and gas supplies
- Radio communication for divers
- Equipment contained in the dive control van
- Usage of diving umbilical cords
- On-deck decompression chamber requirements
- Air used in surface-supplied air diving
- Surface mixed-gas diving equipment
- Systems and modules used in saturation diving systems

Self-Contained Equipment

A wide range of equipment is used in today's diving operations. Provisions include self-contained equipment, surface-supplied gear, and deepwater systems and remote-operated vehicles capable of exploring at extreme depths (fig. 9).

Diving equipment has been used in various forms for many decades. However, the advances made in diving apparatus during World War II brought scuba to the forefront as a reliable and available system for underwater use. The introduction of the demand regulator by Frenchmen Emile Gaguan and Jacques Cousteau in 1943 made practical the use of compressed air in a self-contained apparatus.

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Underwater Photo and Video Equipment

In this chapter:

- Digital still cameras and newer technologies
- Underwater video capabilities
- Classification of remotely operated vehicles
- ROV tasks, capabilities, and tools

Advances in digital photography and video equipment have allowed real-time transmissions of critical information (fig. 25). Many vessels have e-mail capabilities, allowing photos to be sent instantly after being captured from live video. It is also quite common to have live streaming video from a diver's camera sent over the internet to share with clients and engineers so they can request the diver to observe specific data.

Digital Still Cameras

Still cameras are used less frequently today because the presence and capabilities of computer equipment on job sites has made digital photography and instant transmission of images more desirable. Still cameras are still used frequently in underwater platform inspection for close visual weld inspection, but the cost and maintenance of these cameras are relatively high for the quality of the photos they produce. Video cameras and computer programs are close to achieving comparable results. Still cameras require waterproof and pressure-proof housings that must be specifically designed for the camera being used. Still cameras also have depth restraints.

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Diving Services

In this chapter:

- Differences between specific diving operations
- Diving platforms and diving-related vessels
- Fixed-platform inspections versus pipeline inspections
- Installation and repair of platforms and pipelines
- Procedures for terminating platforms and pipelines
- Pipeline salvage and removal
- Underwater cutting and welding technologies
- Benefits and detriments of underwater burning and nondestructive cutting

Diving Operations

Commercial oilfield diving has always been seen as a mysterious operation that only a few dare to engage in as a career. Workers on dive vessels or other work platforms often see a diver leave the surface and dive into the unknown, then surface again sometime later to immediately enter a decompression chamber to prevent the bends or to reverse some other adverse effect of being under pressure. A lack of understanding of safe diving has kept many from entering into this occupation.

The fact is, the normal commercial diver performs the same tasks as many others who embark on similar trades, except usually the diver must be well trained in the many different aspects of the offshore oil and gas environment. Because of restrictions to work sites under water, the diver generally works alone on location and therefore cannot call colleagues for immediate assistance. If the diver cannot complete a task or operation due to a lack of skill in a certain area, the operation must be shut down and the diver must return to the surface and complete all required decompression before resuming

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Diving Training

In this chapter:

- Practical and classroom training methods
- Processes to achieve further certification
- In-house training and advanced education

Formal commercial diver training in the United States is offered by nationally accredited vocational schools. Dive School students receive classroom and practical training in commercial diving procedures and techniques during training. This training includes both classroom and practical education.

Proper diver training focuses on:

- Diving physics
- Diving physiology
- Decompression tables
- Industrial and offshore safety
- Diving medicine

After a student understands the science and fundamentals of commercial diving, the education moves to the practical training so that the student can gain experience with the equipment and apply classroom knowledge. Practical training includes:

- Hyperbaric chamber operations
- Rigging
- Seamanship
- Diving equipment, maintenance, and function

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Diving Regulations and Standards

In this chapter:

- Federal agencies and organizations that regulate divers
- Privatized organizations that regulate divers

Inland and offshore commercial diving operations are federally regulated in the United States by two agencies:

- The United States Coast Guard (USCG) regulates offshore diving.
- The Occupation Safety and Health Administration (OSHA) governs inland and coastal diving operations.

These agencies reflect the minimum mandated standards, are similar in content, and often identical. They outline minimum requirements for personnel, equipment, operations, diving mode procedures, testing and inspections of diving equipment, and recordkeeping.

- The USCG Regulation is titled 46 CFR Part 197 Subchapter V-Marine Occupational Safety and Health Standards Subpart B-Commercial Diving Operations. CFR 197 applies to commercial diving operations taking place on the outer continental shelf or from vessels required to have a certificate of inspection issued by the USCG such as mobile offshore drilling units (MODUs). This regulation excludes any diving operation solely for scientific research, public safety, and search and rescue.
- OSHA's 29 CFR Part 1910, Subpart T Commercial Diving Standard is generally applied to inland diving operations. Generally, commercial oilfield diving operations are governed under the USCG regulations.

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