INSTRUCTOR GUIDE

POI TITLE: **Drilling and Workover-101 (D&WO-101)**

MODULE NO.: **1**

MODULE TITLE: **Orientation to Drilling Operations (OTDO)**

D&WO Training Division

July 2019

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Module 1

Orientation to Drilling Operations (OTDO)

INSTRUCTOR GUIDE

Item	Action	Aid	Time
PREPARATION	Before class, prepare the classroom. Distribute participant handbooks.	Instructor Guide. Participant Handbooks.	
INTRODUCTION	Identify and explain the module objectives. Explain new words.	Information Sheets. Glossary.	0.5 hr.
OBJECTIVE 1.1	State the Roles and Responsibilities of Rig Personnel. Have participants complete the exercise.	Information Sheets, part I. Exercise A.	1.5hr.
OBJECTIVE 1.2	State the Safety Precautions on a Rotary Drilling Rig. Have participants complete the exercise.	Information Sheets, part II. Exercise B.	2 hr.
OBJECTIVE 1.3	Identify the Main Systems and Equipment on Rotary Drilling Rigs. Have participants complete the exercise.	Information Sheets, part III. Exercise C.	7 hr.
OBJECTIVE 1.4	Identify the Procedures for Drilling Oil and Gas Wells. Have participants complete the exercise.	Information Sheets, part IV. Exercise D.	7 hr.
REVIEW	Review objectives.	Information Sheets.	1 hr.
FINAL TEST	Administer the final test. Score and record the results.	Test Sheets. Test Answer Key.	1 hr.
	Estimated time for a class of 10 participants.		20 hrs.

DELIVERING THIS MODULE

This module will familiarize the participants with the rig personnel structure and responsibilities, hazards, systems and components on land and offshore rotary drilling rigs, and drilling procedures.

The module consists of four parts. Each part has an exercise at the end to recap the covered information.

The module duration is 3 work days or 24 work hours. These hours will correspond to about 20 instructional hours at the training center due to break time.

The key areas to emphasize in this module are the:

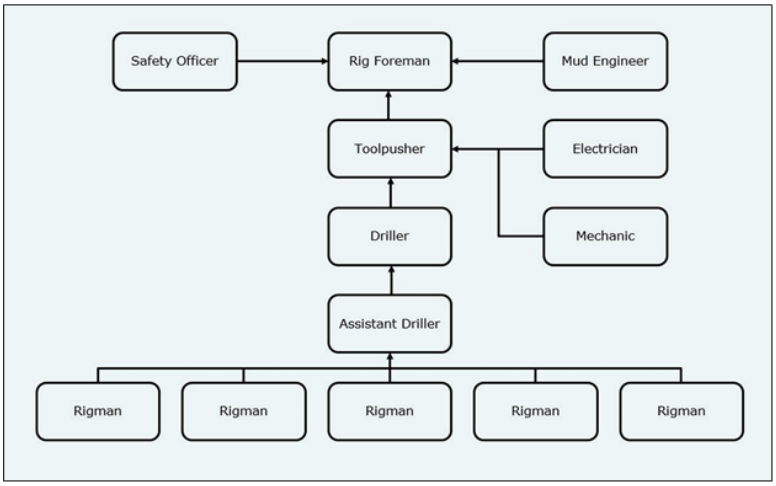
- hazards on a drilling rig
- main areas on a drilling rig
- main systems on a rig
- driller's console and equipment on the rig
- cyber-rig control systems
- drilling procedures

Exercises

Exercises are located at the end of each section. The participant booklet contains the exercises without answers. The answers are listed below.

EXERCISE A

1.



2. Tool pusher.
3. Assistant Driller.
4. Rig Foreman.
5. Rig man.
6. Mechanic.
7. Driller.
8. Electrician.
9. Safety Officer.
10. Rig Foreman and Mud Engineer.

EXERCISE B

1. d
2. a
3. c
4. b

5. d
6. Insulated hook.
7. Hydrogen Sulfide (H2S).
8. SABA or SCBA Respirator.
9. Ear Plugs or Ear Muffs.
10. Fire or explosion.

EXERCISE C

1. b
2. a
3. d
4. b
5. d
6. b
7. a
8. a
9. c
10. c

EXERCISE D

1. b
2. d
3. c

4. Pedestal.
5. Helideck.
6. Cantilever.
7. Desalination.
8. Rack and Pinion Skidding System.
9, b and c.
10. Conductor Tensioner System.

EXERCISE E

1. a
2. c
3. b
4. d
5. b
6. a
7. b
8. d
9. a
10. c

Final Test

This course has a final test located at the end of the instructor guide. Make copies of the final test when ready to administer.

The answers to the final test are in the below table and on the Test Answer Key at the end of this guide.

1.	B	11.	A
2.	D	12.	D
3.	D	13.	B
4.	C	14.	D
5.	A	15.	C
6.	C	16.	D
7.	B	17.	B
8.	D	18.	A
9.	C	19.	B
10.	B	20.	D

CHANGE DATE	REASON
July 2019	First Printing

Terminal Objective

Given information, identify rotary drilling rig personnel and responsibilities, safety hazards, systems and components, and procedures with 70% accuracy.

Enabling Objectives

1.1 State the Roles and Responsibilities of Rig Personnel

1.2 State the Safety Precautions on a Rotary Drilling Rig

1.3 Identify the Main Systems and Equipment on Rotary Drilling Rigs

1.4 Identify the Procedures for Drilling Oil and Gas Wells

INTRODUCTION

In this course, you will learn about the main drilling systems, equipment and drilling operations. You will also learn about the roles of people that work together to drill the well safely and efficiently.

The area where a well is drilled is called a lease or location. The size of the lease depends on how deep the well is going to be, the size of the rig and the size of the pits to be dug out of the ground. The location will be prepared before the rig's arrival.

Drilling rigs come in many sizes. The smallest ones are portable. They can drill only a few hundred feet into the ground (as in drilling water wells). Larger rotary rigs can drill holes over 12 kilometers deep.

PART I	**OBJECTIVE 1.1**

State the Roles and Responsibilities of Rig Personnel

The rig is made up of multiple systems. The drilling rig is a large machine with many processes that must work together correctly to successfully drill the well. Each member of the rig crew performs an important function to ensure that the rig is working correctly and that the well is drilled efficiently.

Key Personnel on a Rotary Drilling Rig

Currently, Saudi Aramco (SA) drilling operations are performed by joint-venture companies in partnership with SA. The well belongs to Saudi Aramco and the rigs belong to the drilling company. SA is the client of the rig company and SA representative (rig foreman) on the rig coordinates with the rig manager (tool pusher) who is in charge of all rig operations, personnel and systems.

Key SA personnel on the rig

- Rig Foreman (days) and Assistant Rig Foreman (nights) (often referred to as the company men)
- Safety Officer

Key joint-venture rig personnel

- Tool Pusher (days)/Assistant Tool Pusher (nights) (sometimes referred to as night pusher)
- Driller
- Assistant Driller
- Derrick man
- Rig men (rig crewmembers) (known as roustabout, roughneck, floor man)
- Electrician

- Mechanic
- Mud Engineer

As well as the drill-crew, who performs the actual drilling operations, there are other personnel who provide specific services. These include crane operators, welders, caterers, security, and employees from service companies.

Rig Foreman

The rig foreman is the Saudi Aramco representative is responsible ensuring the correct construction and completion of the well. The rig foreman has a great understanding of the drilling process and oversees all rig operations, such as drilling, casing, testing, etc. to support the drilling operations.

The rig foreman follows SA requirements and makes decisions in critical circumstances based on SA standards and his experience and training. He gives company-approved instructions to the tool pusher regarding the well and approves corrective actions taken.

Safety Officer

The Safety Officer, also a SA employee, oversees safety and reports directly to the rig foreman. The main roles and responsibilities of the safety officer are to ensure rules and procedures on the rig are up to date, enforced and practiced at all times.

The safety officer is responsible for:

- assisting in conducting all rig site safety meetings
- rig safety orientations for visitors, contractors, and new rig employees
- on a daily basis, rig safety inspections, personnel roster, maintenance of safety equipment, crew safety observations, management of the rig site safety program and on-site safety training
- informing the rig foreman of safety near miss/ incidents

- keeping a schedule of all emergency response drills to ensure compliance with drill schedule
- mentoring all other crew members to promote a safety first culture
- maintaining compliance with all company health, safety and environment (HSE) policies and procedures

Tool Pusher

The tool pusher, also sometimes called the Rig Manager, is the senior supervisor for the rig and its crew. He has progressed from being a driller after gaining years of experience. He has expert knowledge of well drilling, rig machinery, tools, and equipment. In regards to the rig equipment, the tool pusher takes his orders from the rig superintendent (from the joint-venture company) or area manager in town.

The tool pusher coordinates with the rig foreman and directs the actual operation of the drilling rig, and the work performed by the drill crews. To keep the rig operating, the tool pusher orders all the supplies and spare parts for the rig.

The tool pusher at night (known as the “night pusher”) is typically a driller promoted as a tool pusher in training. He performs tool pusher duties at night and as directed by the tool pusher. He also interacts and takes direction from the SA night foreman.

Driller

The driller (figure 1) is in charge of the drilling operations and operates the main equipment that is used to drill the well. He started his career as a rig man and progressed through the levels of responsibility and has good understanding of the drilling operation.

The driller gives instructions concerning work on the rig to his crew members. The driller is under the direct supervision of the toolpusher and is the overall supervisor of the drilling crew. He is responsible for the safety and performance of his crew.

Figure 1
Driller and Assistant Driller

Assistant Driller

The Assistant Driller (AD) (figure 1) is a junior driller in training. He is an experienced rig man that has proved he is competent and has shown good attitude, skills and knowledge.

The AD will give work instructions to the rigmen. He organizes the movement of pipes and other equipment on the site. He ensures that the drill string and other drilling tools are measured and ready for the driller to add to the drill string in the hole. He ensures that everyone is working safely and using the proper tools.

Rig Man

Rig Man is a general term Saudi Aramco uses to describe crewmembers who perform various tasks to support the drilling process. Based on their experience and function, and the particular rig on which they work, they are sometimes referred to as Roustabouts or Roughnecks, Floor Hands, and Derrick Men.

- The Roustabout is the first position (or entry-level) for inexperienced rig workers. They perform general housekeeping tasks, prepare tools for use and assist more experienced workers in performing rig operations

- Roustabouts can progress to becoming floor men. They work on the rig floor to help the driller perform the drilling function

- After gaining more experience, they can become derrick men working on the stabbing board, or “monkey board”. There, high above the rig floor, they will position pipes for lifting and connecting to the drill string by the floor hands working below

They will also be responsible for managing the mud tanks and mud pumps to maintain proper circulation of the drilling fluids (mud) in the bore hole. In this case they would have other rig man assist them. These crewmembers could be called mud men or pit men (due to the mud being stored in pits dug into the ground).

Regardless of their function, all rig men (figure 2) work under the direction of the driller and assistant driller to keep the rig running properly.

Figure 2
Rig Men

Electrician

The electrician (figure 3) on the rig must be trained and certified. The electrician is in charge of all electrical maintenance. This may include repairs and installations of electrical equipment and appliances on the rig.

Figure 3
Rig Electrician

Mechanic

The rig mechanic (figure 4) must be trained and certified. The mechanic is responsible for all the preventive maintenance, repairs, and installation of mechanical equipment on the rig. This includes for example: diesel engines, high pressure equipment, the rig water and hydraulic systems.

Figure 4
Rig Mechanic

Mud Engineer

The mud engineer is in charge of the drilling fluid on the rig and in the hole. He coordinates with the rig foreman to plan a recipe of mud to drill the well. He also orders all the chemicals required for the mud.

The mud engineer directs the rig man as to which chemicals to mix into the mud system. The mud engineer regularly tests (figure 5) the mud to determine whether chemicals need to be added.

Figure 5
Mud Viscosity Test

Rotary Drilling Rig Reporting Structure

Figure 6 shows the reporting structure for the day shift on a rig. The night shift will have the same personnel, but normally supervised by an assistant rig foreman.

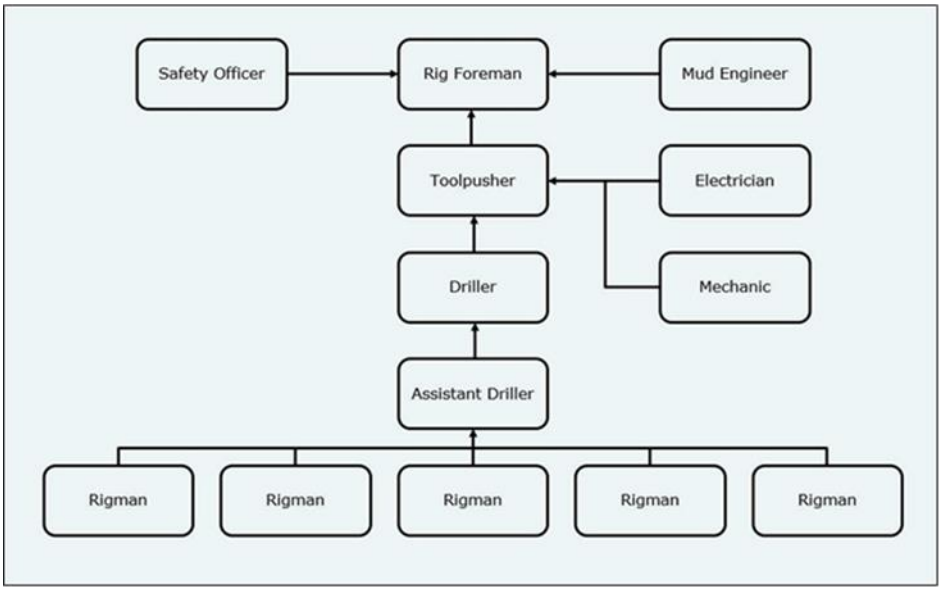


Figure 6
Rotary Drilling Rig Reporting Structure

SUMMARY

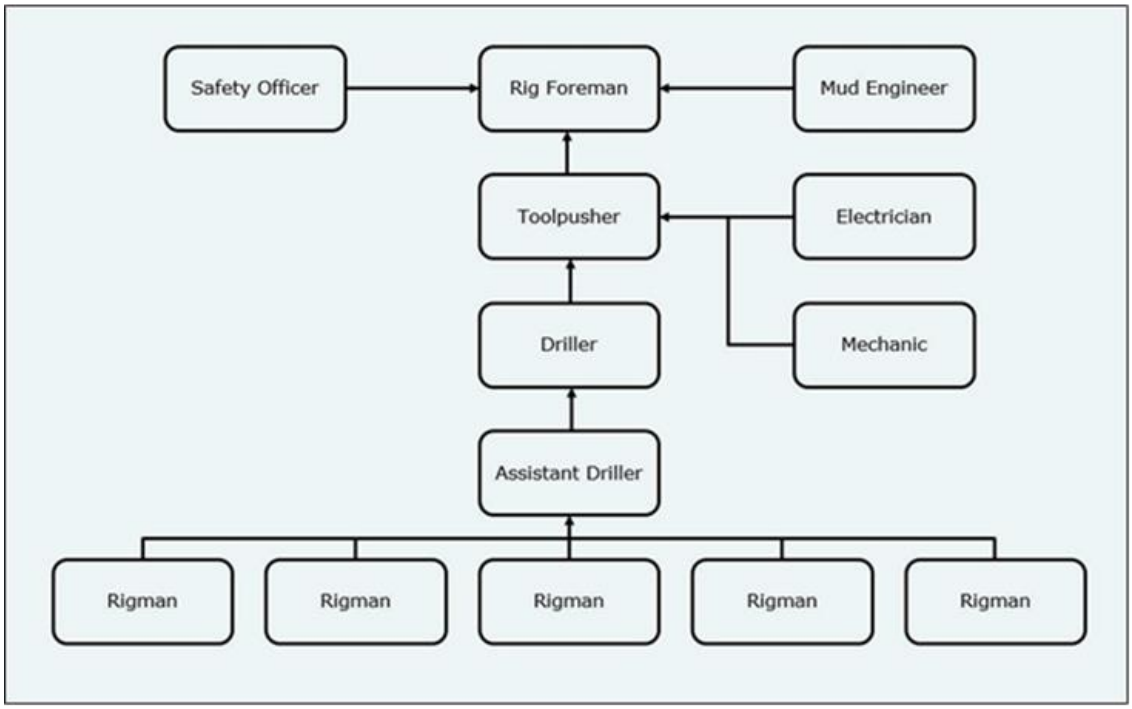
You now know the roles of the key personnel on the rig responsible for drilling the well. The reporting structure begins with the rig foreman, who is responsible for all operations on the rig. The toolpusher reports to the rig foreman and supervises drilling operations. The driller reports to the toolpusher and operates the main equipment that drills the well. The assistant driller supervises the rigmen and ensures that all the required equipment is ready for drilling the well.

The rig man is responsible for the housekeeping on the rig and around the location. He works in all areas of the rig to gain experience. He helps the electrician, mechanic, and the mud engineer in a range of tasks.

EXERCISE A

Directions: Answer all of the below questions.

1. Complete the rig crew reporting structure in the figure below:



2. Who is the day-to-day supervisor of the rig crew?

Toolpusher

3. Who gives instructions and assigns tasks to a rig man?

Assistant Driller

4. Who is responsible for the well and all operations?

Rig Foreman

5. Who assists in drilling operations and performs maintenance?

   Rig man

6. Who must be trained and certified to maintain hydraulic equipment?

   Mechanic

7. Who operates the main drilling equipment?

   Driller

8. Who must be trained and certified to maintain generator equipment?

   Electrician

9. Who ensures that rules and procedures are up to date, enforced and practiced?

   Safety Officer

10. Who is responsible for planning the recipe for the drilling fluid?

    Rig Foreman and Mud Engineer

PART 2	**OBJECTIVE 1.2**

State the Safety Precautions on a Rotary Drilling Rig

Safety always comes first in the oilfield. Working on a drilling rig is a hazardous job as many hazards are confined in a small area. Rigs have heavy machinery, high pressure fluids, and suspended loads overhead, with many people working in the same area.

Some jobs require work at height above the ground. Other tasks require entering hazardous confined spaces.

During drilling operations of an oil or a gas well, the crew may be exposed to gases that are toxic and/or explosive.

Hazards on Drilling Rigs

A hazard is anything that has the potential to harm people. Hazards can include objects in the workplace, such as machinery or dangerous chemicals. Other hazards maybe from the way work is carried out.

On a drilling rig, the work involves heavy equipment moving in a limited space on the rig floor and in the derrick. The rig floor and catwalk areas are the places where most injuries occur because of the work performed in these areas.

All areas around the rig have the potential to cause injury if workers do not pay attention or follow the appropriate safety precautions. Some of the hazards on the rig include:

- pinch points
- manual handling
- slips and trips
- working at height

- chemical exposure
- sudden release of pressure
- struck by objects and suspended loads
- exposure to gas
- fire and explosion
- noise
- equipment failure
- environmental hazards

Pinch Points

Hand injuries are the most common type of injury on the drilling rig. Most hand injuries on the rig are caused by pinch points. A pinch point is a place where your hand or another part of your body can become trapped. Most rig equipment is heavy and made of steel, and can easily crush any part of your body. Pinch points can be found between moving parts that have a hinge, or between heavy loads (figure 6).

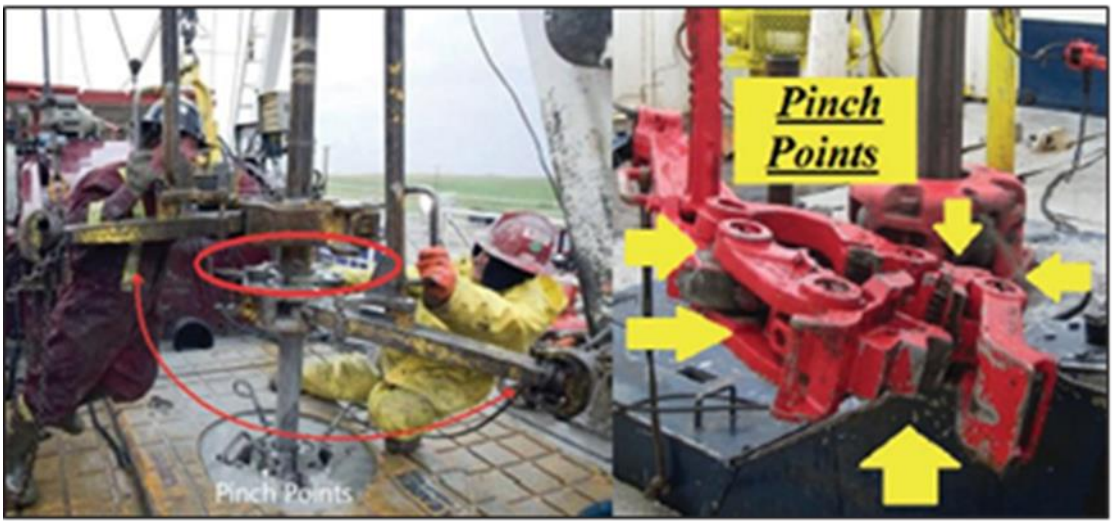


Figure 7
Pinch Points

Manual Handling

The next most common injury after hand injuries are manual handling injuries. Manual handling relates to the moving of items either by lifting, lowering, carrying, pushing or pulling. Manual handling injuries are injury, damage or disorder of the upper/lower limbs or the back.

These injuries are often caused by not using the correct method for lifting or carrying a load. Trying to lift a load that is too heavy can cause strains or sprains to the limbs or the back. A back injury can cause weeks, years, or even a lifetime of pain and suffering.

Slips and Trips

Slip hazards can be found anywhere around a rig. The most common slip hazard areas are around the bottom of the mud tanks or around the rotary table. Spilled drilling mud is very slippery on the metal of the rig floor (figure 8). Certain chemicals in the mud can make it more slippery than a water spill.

Trip hazards can be found all over the rig. Trip hazards are often caused by poor housekeeping. One example is stretching the pressure washer hose across stairs instead of running it under the stairs.

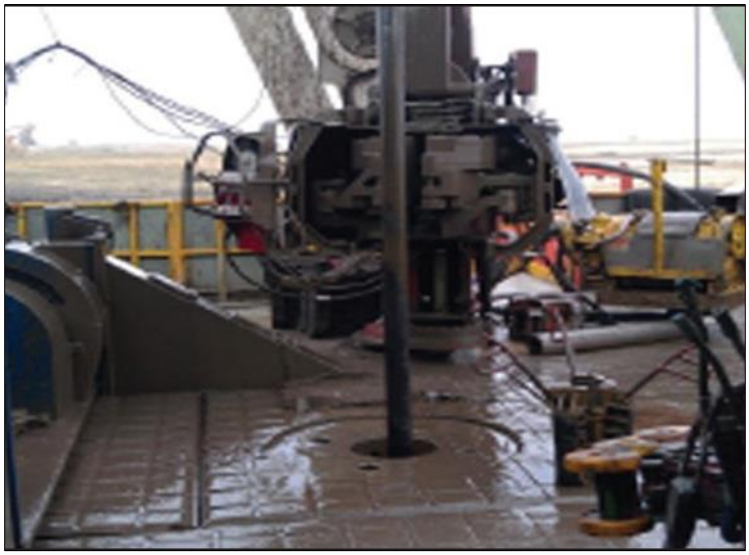


Figure 8
Slip Hazard

Working at Height

Rigmen often work at a height that is higher than two meters above the ground or rig floor. Their tasks may include hooking up cables under the top of the substructure, or working in the derrick (figure 9). Personnel are lifted on personnel hoists to reach the working height.

Figure 9
Working at Height

At heights above 1.8 meters, or six feet, personnel must wear a safety harness, tied off at a secure point. This also applies when working around open holes or walkways without handrails.

Another method of working at height is to use a man-basket or a mobile elevated working platform (MEWP) (figure 10). These raise personnel to work on hard-to-reach areas. Anyone riding a man-basket or MEWP must wear a safety harness and be tied off to the basket or platform.

Figure 10
Man-basket and Mobile Elevated Working Platform (MEWP)

Chemical Exposure

There are many chemicals that are used on a drilling rig. The drilling fluid that is pumped down the pipe has chemicals mixed into it. Chemicals are also used on the rig for cleaning purposes.

Chemicals can be hazardous if they get on your skin (figure 11), in your eyes, or if you swallow them. Personnel working with chemicals must wear the correct Personal Protective Equipment (PPE) while working on the rig.

Figure 11
Chemical Injuries/contact dermatitis

Hazard Communication

All chemical containers must have a “Hazard Communication Label” or HAZCOM label attached (figure 12). The HAZCOM label provides information on the hazards of the chemical. Saudi Aramco uses a HAZCOM label in English and Arabic. Read the label before handling the chemical.

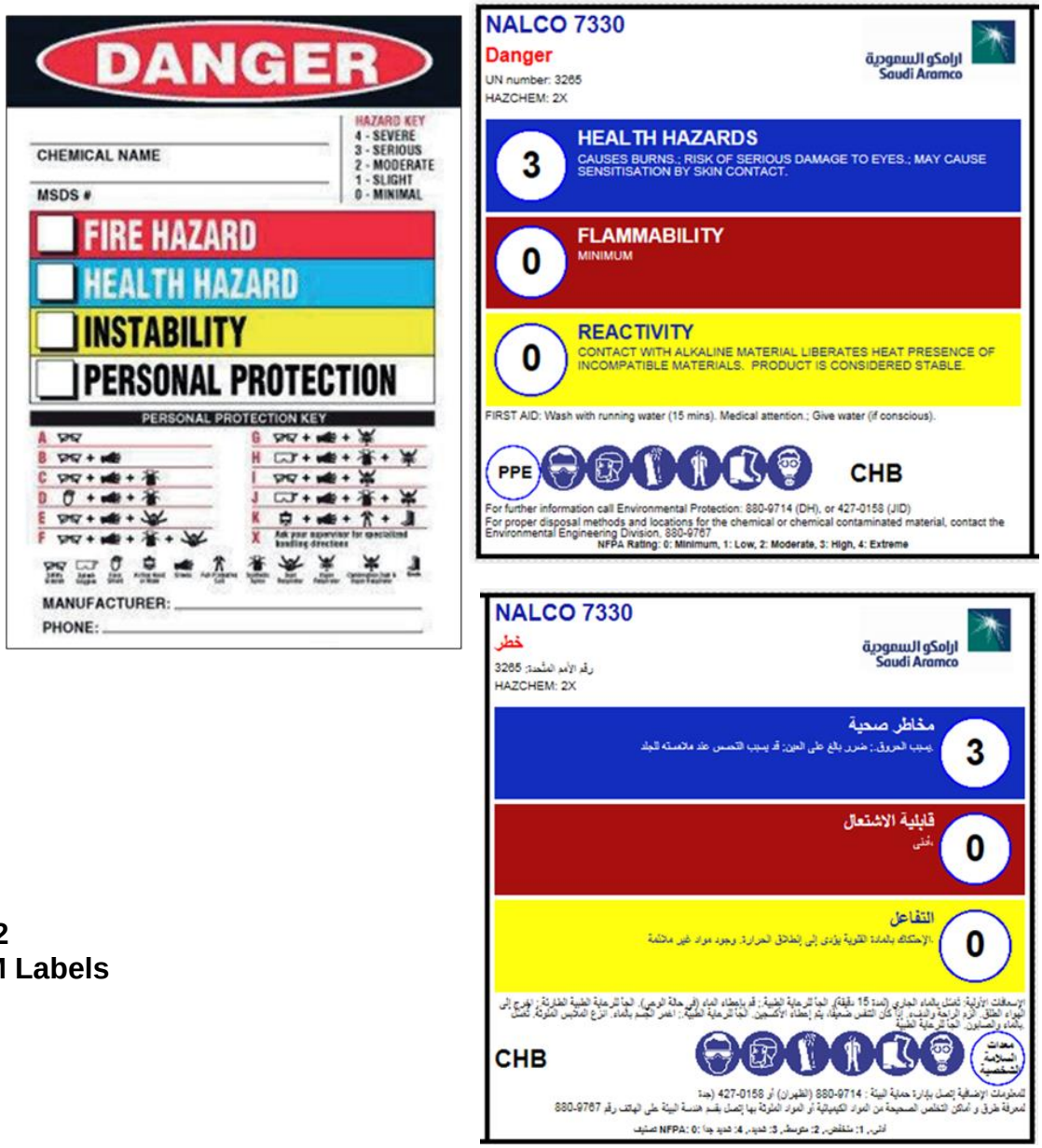


Figure 12
HAZCOM Labels

Sudden Release of Pressure

Rig crews can also be exposed to chemicals through a sudden release of pressure. An example of sudden pressure release is when the kelly is disconnected from the drill pipe. Drilling mud sprays out from the connection in all directions if there is trapped pressure in the drill pipe.

A sudden release of pressure can also be due to equipment failure. An example is a pipe getting a hole in it (washing out). Also, if a hydraulic line is damaged, it sprays high pressure fluid out of the opening (figure 13).

Figure 13
Hydraulic Hose Pin Hole

Struck by Objects and Suspended Loads

Being struck by an object on the rig can cause serious injury. One example of this type of hazard is the movement of the tongs on the rig floor. Safety lines on the tongs limit their movement to help reduce the hazard. Tongs (figure 14) can move suddenly and quickly when the driller activates the tong or the rotary table.

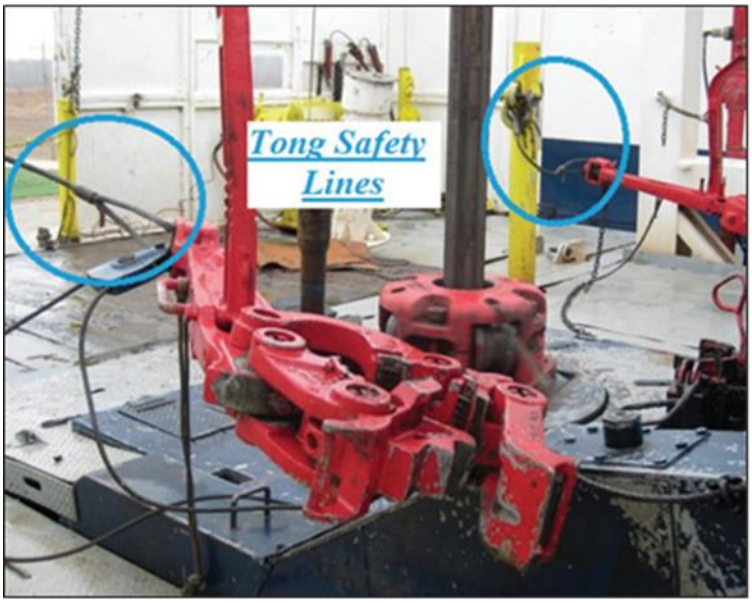


Figure 14
Tong Safety Lines

Suspended loads (figure 15) are also a hazard. A moving or dropped load can cause serious injury or death. Use caution when near a crane or a truck while moving a large load that blocks the operator's line of sight. Never walk under suspended loads.

Figure 15
Suspended Load

Exposure to Gas

When drilling for oil or gas, it is possible for hazardous gas to reach the surface from the rock formations underground. Gas from the wellbore can be toxic and flammable. If toxic gas reaches the surface, you may need to use breathing apparatus. Exposure to gas is possible when cleaning the mud tanks. Gas testing must be performed before entering the mud tanks.

Fire and Explosion

If flammable gas reaches the surface, it can cause a fire or explosion if it is ignited. Fires are also a hazard in the onsite camp for the people living on the rig. Another fire or explosion hazard is welding work. Sparks from the welding machine or from cutting with a grinder can ignite flammable material and start a fire (figure 16).

Figure 16
Fire and Explosion Hazards

Noise

Noise-induced hearing loss (NIHL) is one of the world's most widespread occupational diseases. It accounts for 75 per cent of all occupational disease claims. Long-term and repeated exposure to harmful noise levels result in deafness, ringing in the ears or other hearing problems. Hearing personal protection equipment should always be worn in high noise environments.

Equipment Failure

Rig equipment is designed to perform a certain amount of work before it needs to be, inspected, maintained or removed from service. Equipment failure is one of the least common causes of accidents on the rig. Even though people are almost always injured by equipment, it is not equipment failure, but operator error that causes the injury.

However, equipment can come from the manufacturer damaged or assembled incorrectly. Most equipment failures are due to fatigue. Fatigue failures occur when the equipment is over-used or maintained incorrectly (figure 17).

Figure 17
Fatigue Failure

Environmental Hazards

Working outside on a rig is hard physical labor with many environmental hazards (figure 18). The weather is an environmental hazard especially in the summer months with high temperature and humidity. Sandstorms can make working on the rig particularly hazardous.

The sun can cause sunburn, dehydration and even burns from equipment that gets heated from the sun. Other hazards can come from rain, making the metal on the rig slippery.

Another environmental hazard is the wildlife around the work site in the desert. Spiders, scorpions and snakes like to hide under objects during the day and can bite you if they are disturbed suddenly. Always check for insects carefully when reaching under equipment, and when putting your boots on.

Figure 18
Environmental Hazards

Personal Protective Equipment

Personal Protective Equipment (PPE) is equipment that users wear to protect against health or safety hazards at work. It can include items such as safety helmets and hard hats, gloves, eye protection, safety footwear and safety harnesses. Figures 19 to 26 show PPE used on drilling rigs.

Figure 19
Hard Hat for Head Protection

Figure 20
Gloves for Hand Protection

Figure 21
Eye Protection

Figure 22
Hearing Protection

Figure 23
Rubber and Leather Steel-toed Boots for Foot Protection

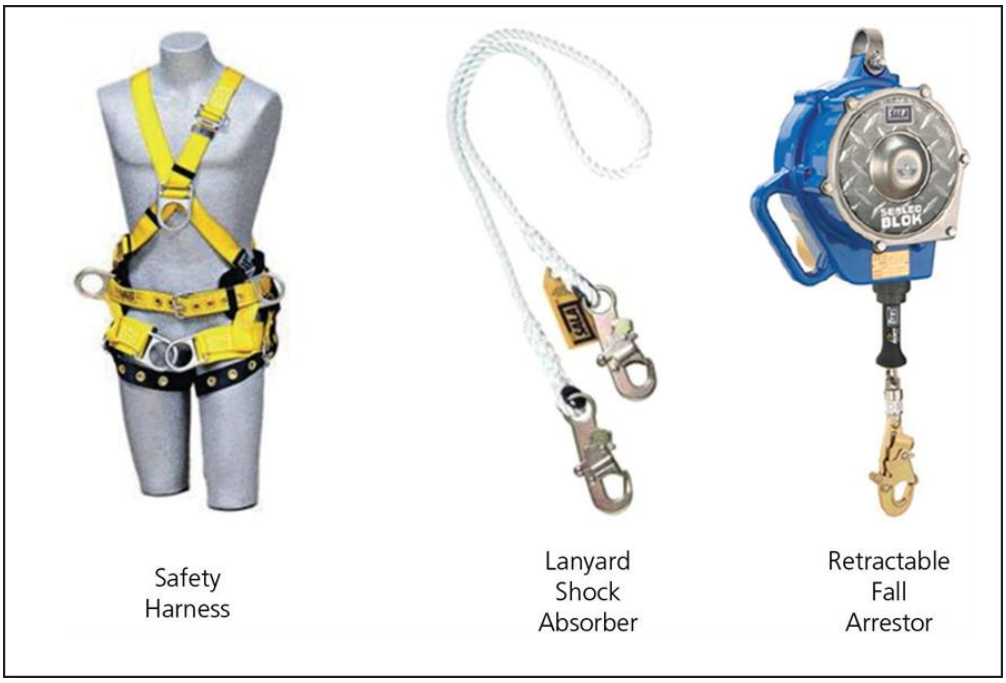


Figure 24
Fall Protection Equipment

Figure 25
Dust/Chemical Protection

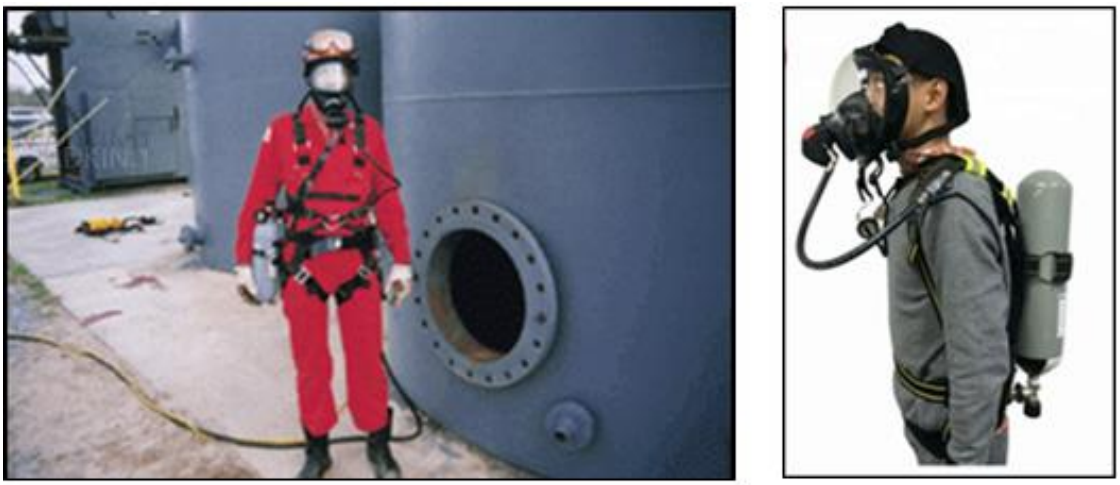


Figure 26
Supplied Air Breathing Apparatus (SABA) (left) and Self-Contained Breathing Apparatus (SCBA) for Gas Leak Protection

Emergency Response

On any drilling rig, emergency or hazardous situations can arise. Emergencies can occur due to environmental issues, such as severe weather, or due to man-made problems.

Rig crews are required to participate in regular safety meetings and emergency drills. The drills are ongoing training that helps to prepare the crew for real emergency.

Emergency routes, plans, and procedures are specific to each rig. Every crew member on the rig is given a detailed procedure and response plan as part of his safety orientation.

In this part you will learn about:

- emergency situations
- emergency responses
- emergency response equipment

Emergency Situations

The five main emergency situations that may be encountered on a rig include:

- fire
- man down
- gas
- evacuation
- terrorist attack

Fire

A fire on a rig is a major hazard and must be dealt with immediately. There are many flammable substances on a rig. Sources of ignition for starting a fire do not need to be a direct spark or flame. A fire can start when a heated object touches a fuel source. Flammable materials have a designated storage area on all rigs.

Man Down

A “man down” is when there has been a person injured, or has suddenly been found unconscious. Anyone missing from the crew during an emergency situation may be considered as a man down. The man may have fallen down from exposure to gas, injury or to illness.

Gas

A gas release is when poisonous or explosive gases escape from the well. Toxic gases can cause health problems or even death. H2S is one example of a hazardous gas that you may encounter at the rig. H2S is both toxic and flammable.

The rig is equipped with gas detectors to alert the crew if gas is present in the air. The gas detectors measure the amount of gas in the air, and identify the type of gas. There are fixed and portable gas detectors on the rig (figure 27).

Figure 27
Fixed and Portable H2S Detectors

Evacuation

The rig may need to be evacuated during a hazardous situation. A gas release or a severe fire could endanger the lives of the crew. Rig management is responsible for ordering a rig evacuation when the crew is at risk.

Terrorist Attack

A terrorist threat is when there has been a threat to harm, or stage an attack on the rig crew. The crew must evacuate under the supervision of trained personnel or the military.

Emergency Responses

The response to an emergency situation is directly related to the nature and severity of the emergency. Rig management and Saudi Aramco have an emergency response plan for each rig. The plan describes the appropriate steps to contain the situation, and the required people to call for help.

In an emergency, the rig crew and other personnel are notified of the emergency by one or more of the following:

- siren/emergency horn
- warning lights
- intercom system
- smoke alarms
- horns and sirens

Emergency Response Equipment

Emergency equipment is located on every rig ready for use at any time. The main safety equipment available on a rig includes:

- firefighting equipment

- rescue equipment
- evacuation equipment

Firefighting Equipment

The firefighting equipment on the rig is located at designated points. Some equipment is stored in a locker or container. Firefighting equipment includes:

- fire extinguishers
- fire blankets
- emergency water pump and hose
- fire suits
- self-contained breathing apparatus (SCBA)

Rescue Equipment

In a man down emergency, a co-worker may require rescue. The rescue method depends on the location of the person and the circumstances of the incident. If there is the possibility of a neck or back injury, the victim must be secured in a stretcher or back board (figure 28).

Figure 28
Stretcher

Another tool for rescue is the insulated hook (figure 29). This tool is used for pulling people away from an electrical hazard. The insolated hook does not conduct electricity.

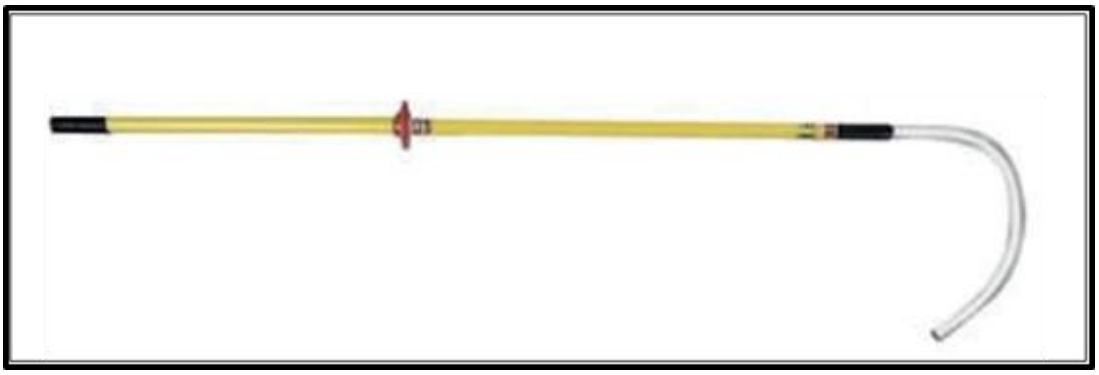


Figure 29
Insulated Hook

Evacuation Equipment

Offshore rigs need the same safety equipment as land rigs. They also need equipment to help personnel evacuate the rig in an emergency. The special offshore evacuation equipment includes:

- life boat
- life raft
- life jacket

Life Boat

If a helicopter evacuation from the rig is not possible, the life boat (figure 30) is the main method of emergency escape. The boats are located on two sides of the rig, to allow for a secondary escape route. Life boats are equipped with a motor to move away from the rig after they are lowered onto the water.

Figure 30
Life Boat

Life Raft and Life Jackets

The life raft (figure 31) is an emergency escape vessel. The life rafts are used if the life boat is damaged or unreachable in an emergency. Life jackets (figure 32) must be worn during evacuations when entering the life boat, the life rafts or a helicopter.

The raft self-inflates when activated, or can be inflated with a mechanical pump.

Figure 31
Liferafts

Figure 32
Lifejackets

SUMMARY

You have learned about some of the main hazards that can be found on the drilling rig. You now know that most injuries are caused by human error, and most injuries are to the hands. Most hazards can be avoided by paying attention, and good housekeeping. PPE helps protect against hazards, and is mandatory on all Saudi Aramco rig sites.

Fire alarms, horns and sirens are located throughout the rig to inform crews of an emergency situation.

Every rig has its own emergency response plans and routes that must be learned by everyone on the rig.

EXERCISE B

Directions: Circle the correct answer to items 1 - 5 below.

1. Where do most injures occur on the rig?

   a. Shower rooms

   b. Rig floor

   c. Catwalk area

   d. Both b & c are correct

2. What is the most common injury on a drilling rig?

   a. Hand injury

   b. Manual handling injury

   c. Slips and trips

   d. Chemical exposure

3. What is it mandatory to wear when travelling to a rig by boat or helicopter?

   a. Hard hat

   b. Ear muffs

   c. Life Jacket

   d. Safety glasses

4. What is the height above which you must wear a safety harness?

   a. 2 meters or 6 feet

   b. 1.8 meters or 6 feet

   c. 1 meter or 3 feet

   d. 5 meters or 15 feet

5. What is a man down emergency situation?

   a. A person who is only injured

   b. A person who is only unconscious

   c. A person who is injured or unconscious

   d. A person who is injured, unconscious or missing

6. What is used to pull people away from an electrical hazard?

   Insulated Hook

7. Which gas on the rig is both toxic and flammable and must be detected with a gas detector?

   Hydrogen Sulfide (H2S)

8. What equipment could be used to protect against respiratory or breathing hazards?

SABA or SCBA Respirator

9. Which equipment would protect the wearer against noise hazards?

Ear Plugs or Ear Muffs

10. What type of hazard is created by welding too close to flammable gases or liquids or solids (H2S, gasoline, or oily rags)?

Fire or Explosion

PART III	OBJECTIVE 1.3

Identify the Main Systems and Equipment on Rotary Drilling Rigs

Some drilling rigs work over water and others on land but the basic tools and equipment are the same. Most of the machinery is identical except that the size, weight and power of the machines increase with larger drilling rigs.

For the purpose of this course, our focus will be mostly on land rigs with some exposure to offshore jackup rigs. In this part you will learn about:

- drilling rig areas
- main systems of a rotary drilling rigs
- main equipment used on a rotary drilling rig
- offshore drilling rigs
- main systems specific to jackup drilling rigs

Drilling Rig Areas

A drilling rig site (figure 33) has different tools, machines and equipment. The rig drills a hole to access oil or gas that is deep under the ground.

The drilling rig is assembled or ‘rig up’ onsite in preparation to drill a well. Once it has finished the job, it is dismantled or ‘rig down’ into smaller pieces for moving to the next site (rig move).

Figure 33
Drilling Rig Site

A rig is made up of six main work areas:

- substructure
- derrick
- rig floor
- catwalk and pipe racks
- mud tanks and pits
- generator area

Substructure

The substructure (figure 34) is the base of the whole drilling rig. It is placed over the exact location where a well is to be drilled.

Most of the work on a rig is performed on top of the substructure. Special safety equipment for well control is located under the substructure.

Figure 34
Rig Substructure

Derrick

The steel derrick, or mast (figure 35) stands on top of the rig floor directly above the well. The derrick supports the hoisting equipment for drilling the well. It is also where drill pipe can be stored vertically on the rig floor. A mast is smaller than a derrick and is more portable. A mast is carried as a complete unit and stands in position by means of hydraulic cylinders.

Figure 35
Derrick and Mast

Rig Floor

The rig floor or drill floor is installed on top of the substructure (figure 36). This is where the drill bit and drill pipe for drilling the well are assembled. To begin drilling, the drill bit is attached to the bottom of the drill pipe. The drill pipe is then lowered to the ground through a hole in the rig floor called a rotary table or a rotary support table.

Figure 36
Rig Floor

Catwalk and Pipe Racks

The drill pipe is prepared, cleaned, and measured at the ground level on the pipe racks. The racks are set up beside a large steel platform called the catwalk. Drill pipe is moved from the pipe racks on to the catwalk. The drill pipe is then hoisted up to the rig floor along a large metal ramp called the pipe ramp. The opening at the top of the pipe ramp is called the V-Door. Drill pipe is lifted through the V-Door (figure 37).

Figure 37
Pipe Racks, Catwalk, Pipe Ramp, and V-Door Mud Tanks and Pits

Mud Tanks

The drilling fluid for the rig circulating system is stored and handled in the mud tanks and pits. The drilling fluid is also known as mud.

The mud tanks (figure 38) are steel walled tanks divided into compartments. They are used to monitor, prepare, and store the drilling fluid. The fluid that is needed to drill the well is produced in the mud tank area. The mud has chemicals in it to help drill the well. The chemicals are added in a mixing area.

Figure 38
Mud Tanks

Mud Pits

The pits are usually dug into the earth (figure 39). They are usually separated into three different kinds of pits. The purpose of each pit is listed in table 1.

PIT	PURPOSE
Cuttings Pit	Receives the dirt and cuttings removed from the hole as it is drilled deeper.
Reserve Pit	Storage for water for making up drilling fluid.
Cement Pit	Storage for any excess cement pumped out of the well on cement jobs.

Table 1
Pit Types and Purpose

Figure 39
Mud Pit

Generator Area

The equipment that powers the rig is set up in the generator area (figure 40). The diesel engines, generators, and the electrical switches are all in the generator area. This area is the highest noise area on the drilling rig because of the large diesel engines. These operate 24 hours a day to power the rig.

Figure 40
Generator Area

Drilling Rig Systems

There are five main systems on a rotary drilling rig. These systems work together to drill the well:

- circulating system
- rotating system
- hoisting system
- well control system
- power system

These systems are controlled by the driller using:

- driller's console on the rig floor or
- automated systems from a cyber chair

Circulating System

The circulating system (figure 41) pumps drilling fluid into the hole during drilling and collects the fluid as it comes out of the hole. The rock cuttings are taken out from the returning fluid. The cleaned fluid then gets pumped into the hole again.

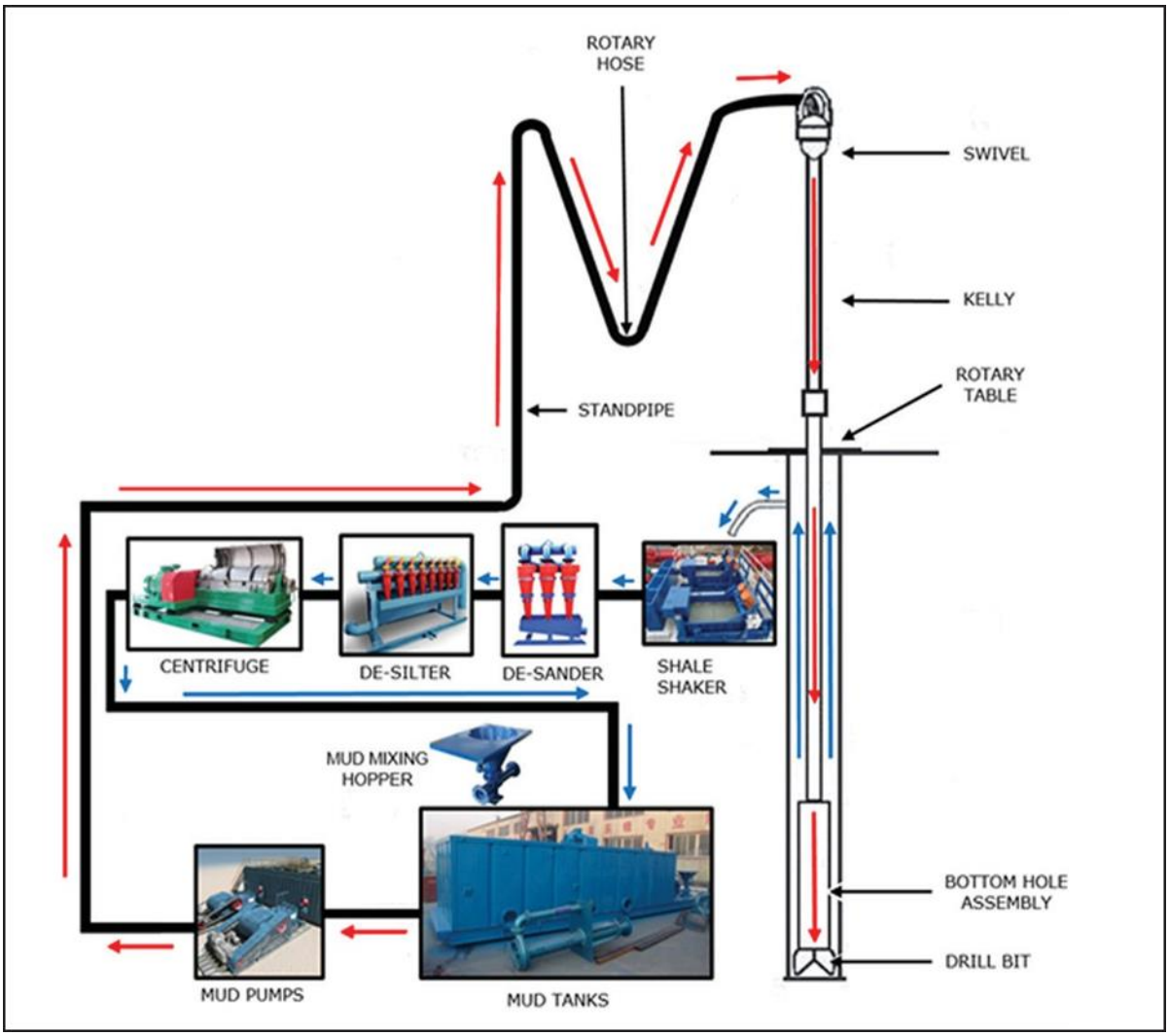


Figure 41
Circulating System

The shale shaker vibrates and removes cuttings from the mud. The de-sander removes sand-sized or coarse particles from the mud. The de-silter removes the smaller silt-sized, or fine, particles from the mud. The centrifuge motor spins a cylinder and the heavier and denser solids will go to the outside of the bowl and fall out of the bottom.

Mud Pumps

The mud pumps are large pumps (figure 42) with pistons that move the drilling fluid through the circulating system. The mud is pumped up a pipe in the derrick and then flows down through the inside of the drill pipe. At the bottom of the hole, the mud comes out through the drill bit and up to the surface around the outside of the drill pipe.

Figure 42
Mud Pumps

Rotating System

The rotating system on the rig includes all the equipment that uses rotation to drill the well. The system includes:

- drill string
- kelly bar
- swivel
- rotary table
- top drive
- rotary support table

Drill String

The drill pipe, drill bit, and any other equipment that goes in the hole to drill is what makes up the drill string (figure 43). To drill the well, the drill string is rotated by the rig from the surface.

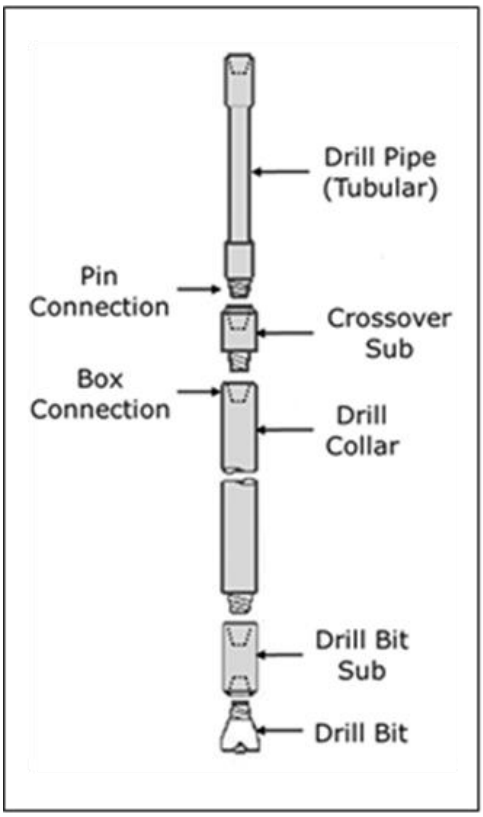


Figure 43
Drill String

Drill Pipes

The drill pipes, or tubulars, are long steel pipes that have a threaded connection (figure 44) on the top and bottom so they can be joined together. As the hole is drilled deeper, more drill pipes are added to the drill string on the rig floor.

Figure 44
Drill Pipe Threads

Drill Bit

The drill bit cuts the rock as it rotates at the bottom of the hole. The mud coming out of the bit cleans the cuttings away as the bit rotates. Drilling fluid is pumped down through the drill pipe to the bit at the bottom of the hole, where it helps to cool and lubricate the bit. The drill pipe comes in different sizes, strengths, and weight for drilling different sizes and depth of hole. A larger diameter hole requires a larger diameter drill pipe. The diameter of the bit determines the diameter of the hole. If the well is deeper, then the drill pipe needs to be stronger.

Bottom Hole Assembly

The bit is screwed onto heavy pipe called drill collars. The bit and drill collars are called the “Bottom Hole Assembly” or BHA (figure 45). The drill collars provide the weight needed to push the drill bit into the rock as it is rotated.

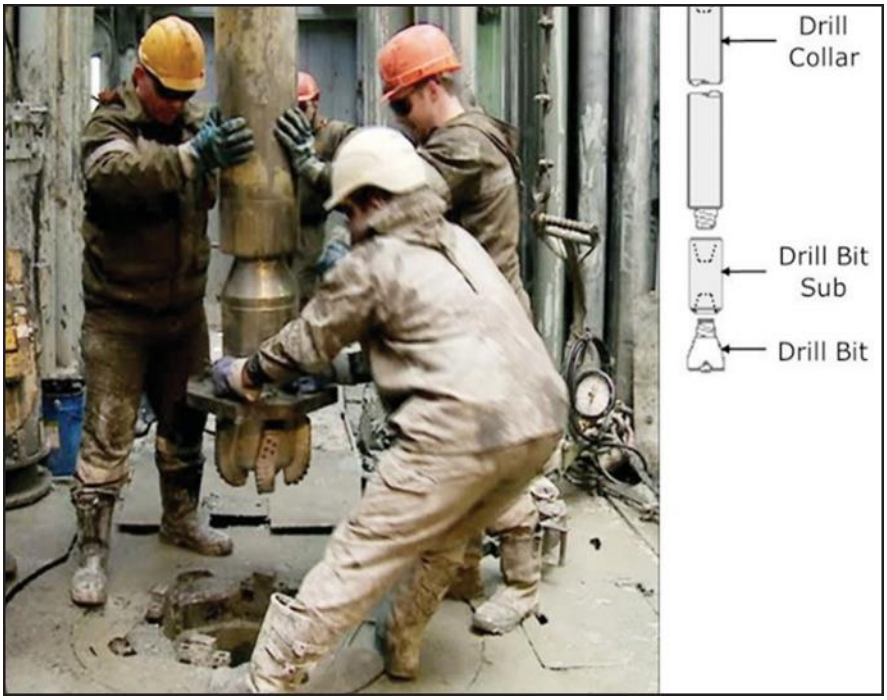


Figure 45
Bottom Hole Assembly (BHA)

Kelly Bar

The kelly bar transfers rotation from the rig to the drill string. The drill string is connected to the bottom of the kelly bar (figure 46). The drilling fluid pumped by the circulating system flows through the inside of the kelly bar into the drill pipe.

Figure 46
Kelly Bar and Bushing

As the hole is drilled deeper, the kelly is lowered until the top of the kelly rests on the kelly bushing. Then the kelly is pulled up, and another drill pipe is added to the drill string to continue drilling deeper. The new drill pipe is connected between the top of the drill string and the bottom of the kelly.

Kelly Bushing

The kelly bushing (figure 47) is an adapter that connects the rotary table to the kelly. As the kelly bar moves up and down it slides through the kelly bushing. The kelly bushing is inserted into the rotary table.

Figure 47
Kelly Bushing

Rotary Table

The rotary table (figure 48) is the rotating section of the drill floor that provides power to turn the drillstring. The rotary table is driven by a motor and rotates the kelly and drill pipe. As the rotary table turns the kelly bushing, the rotation is transferred to the kelly bar. The rotation of the kelly bar rotates the drill string to drill the hole.

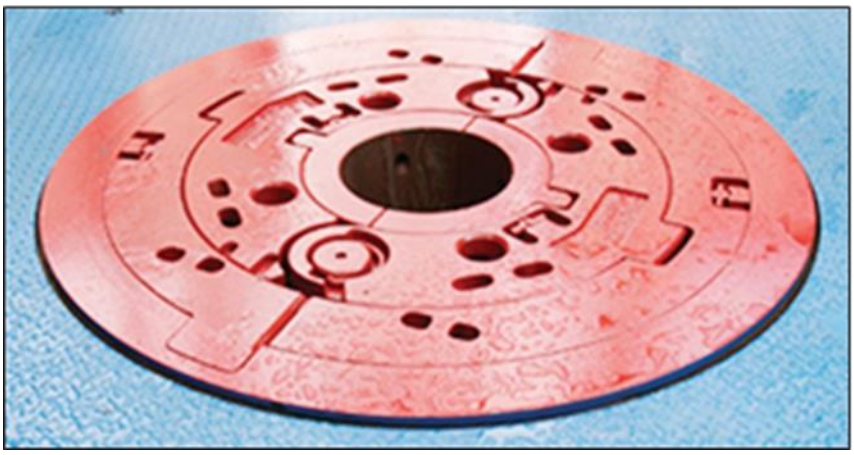


Figure 48
Rotary Table

Slips

The slips grip and hold the pipe suspended in the hole when the kelly is disconnected. The rotary table accommodates the slips (figure 49).

Figure 49
Slips Holding Drill Pipe in Rotary Table

The Swivel

The kelly bar is connected to the bottom of the swivel. The swivel lets the kelly rotate. Drilling fluid also passes through the swivel (figure 50) into the kelly on its way to the drill pipes. A high pressure rotary hose attaches to the swivel. This hose connects the circulating system to the rotary system. The swivel has a rotating seal assembly that prevents mud from leaking. The swivel is suspended by the hoisting system.

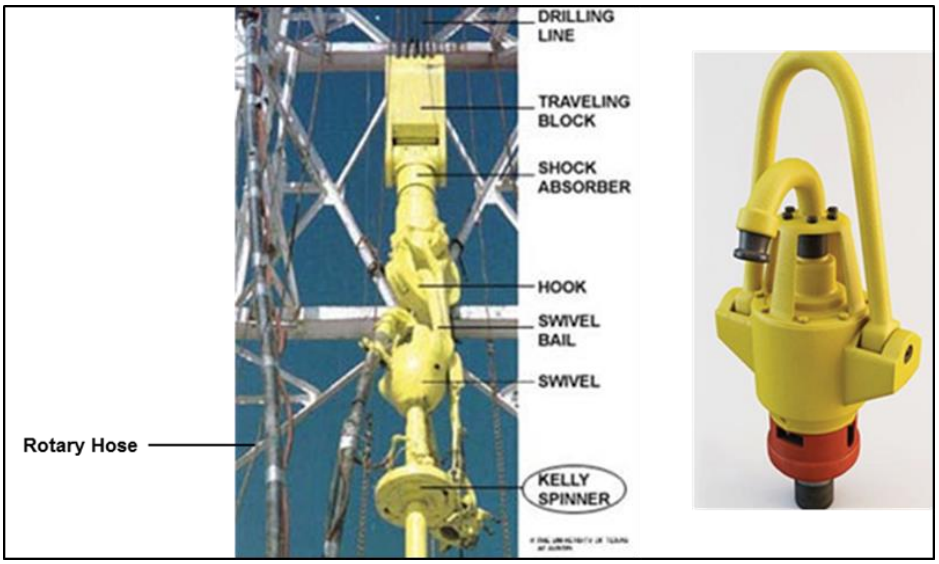


Figure 50
The Swivel

Top Drive

On some rigs, a top drive (figure 51) is used instead of the kelly bar, swivel, and rotary table. The main difference is that the top drive rotates the drill string, not the rotary table. The top drive is also suspended by the hoisting system.

The top drive is suspended but runs on tracks on the derrick. It rotates the drill string and allows drilling fluid to flow down the drill string. A top drive is comprised of one or more motors connected to the drill string using a pipe known as the quill.

A top drive increases safety and efficiency, as it is capable of drilling with three stands of tubular, instead of just one pipe at a time.

Figure 51
Top Drive

Rotary Support Table

The RST or rotary support table (figure 52), like a conventional rotary table, is used for supporting the slips and the drill string when making or breaking connections of tubular in the well bore.

The RST is used with a top drive. It has less power and is not normally used to rotate the drill string while drilling. The RST can rotate the drill string to prevent sticking while making/breaking connections. The RST is controlled and monitored by the cyber-rig control systems.

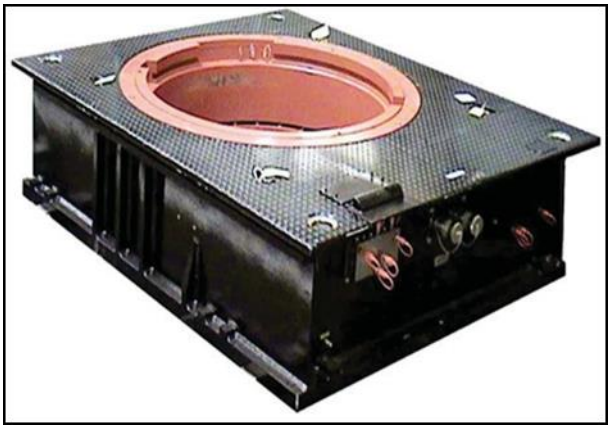


Figure 52
Rotary Support Table

Hoisting System

The hoisting system supports the weight of the drill string. It raises and lowers the drill string during drilling operations. The system works like a large pulley system (figure 53). It includes the:

- derrick
- crown block
- traveling block
- hook

- draw works
- drill line
- dead line anchor
- supply reel

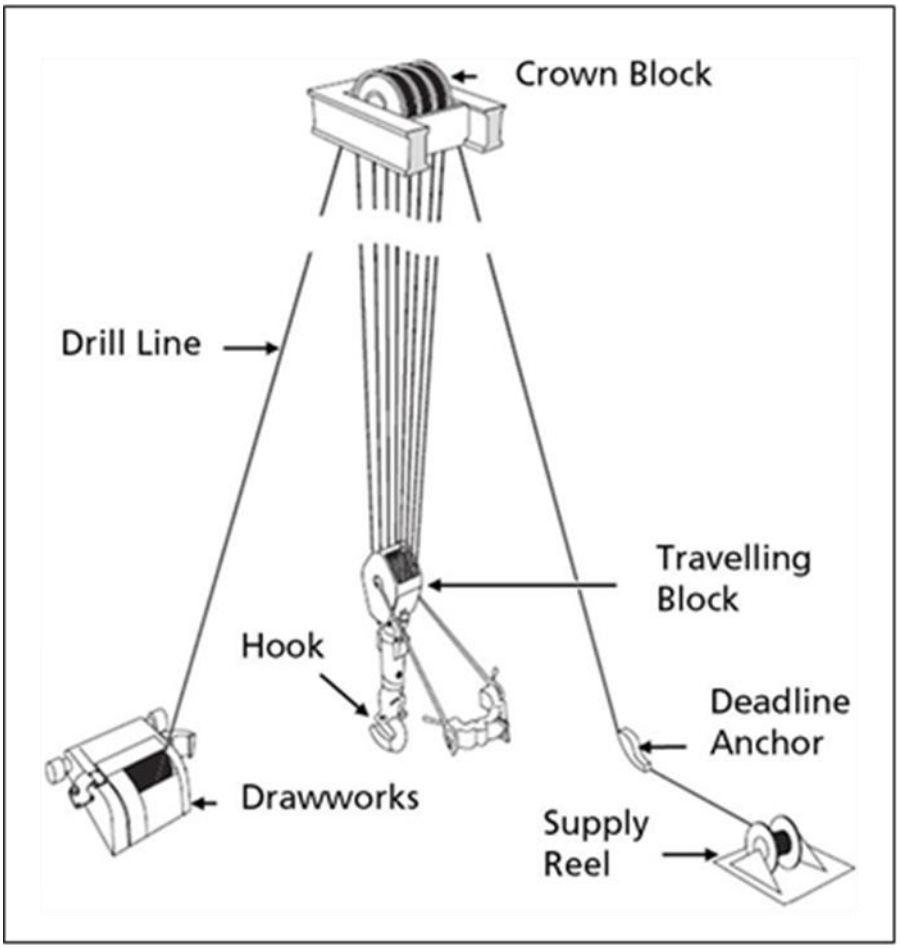


Figure 53
Hoisting System

Derrick

The derrick (figure 54) is installed over the rotary table. The derrick suspends the hoisting system; supporting the traveling block, swivel, and kelly or top drive. It allows the top drive or kelly to be raised.

Figure 54
The Derrick

The Crown Block

The crown block (figure 55) is attached to the top of the derrick. The crown block has sheaves that rotate. The sheaves have grooves that allow the drill line to move through the crown block and spool onto the draw works drum.

The sheaves on the crown block are the top of the working path for the drill line. The crown block and traveling block work together as a pulley system.

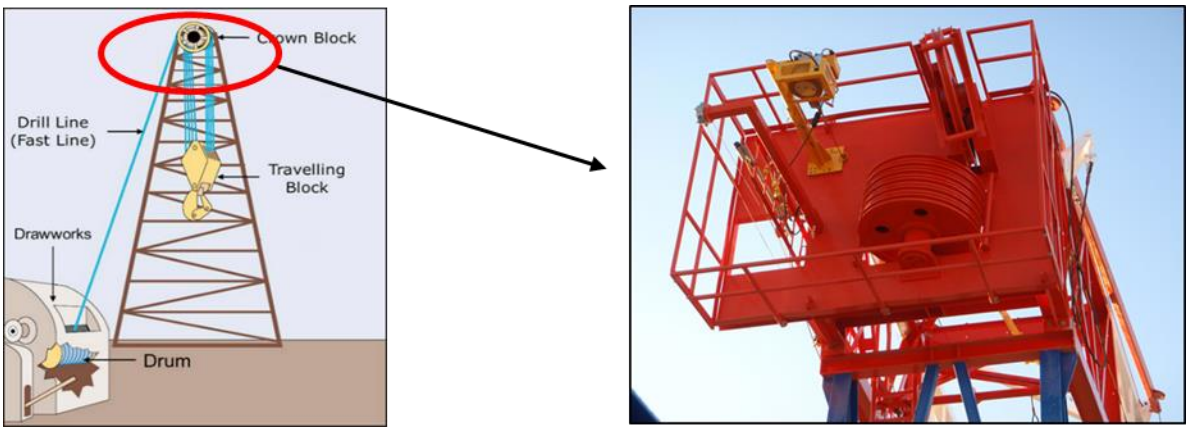


Figure 55
Crown Block

Travelling Block

The travelling block (figure 56) is a set of sheaves that move up and down in the derrick. The wire rope threaded through them is threaded back to the crown blocks located on the top of the derrick. This pulley system gives the wire rope drilling line the ability to lift or lower heavy loads. The traveling block is the lower part of the working path of the drill line. As the draw works feeds out the drill line the traveling block lowers.

Figure 56
Travelling Block

Hook

The high-capacity hook (figure 57) is J-shaped and used to hang equipment, particularly the swivel, kelly, or top drive. The hook is attached to the bottom of the traveling block and provides a way to pick up heavy loads with the traveling block. The hook is either locked (the normal condition) or free to rotate.

Figure 57
Hook Suspended Below Travelling Block

The Draw Works

The draw works (figure 58) is the primary hoisting machinery. The draw works is installed on the rig floor. It has a rotating section called the drum or spool. Its main function is to provide a means of raising and lowering the traveling block.

Figure 58
Draw Works

Drill Line

The drill line (figure 59) is a wire rope that suspends the weight of the drill string and the traveling block. The segment of drilling line from the draw-works to the crown block is called the "fast line". The line winds on the draw works drum to the crown block and traveling block, allowing the drill string to be moved up and down as the drum turns.

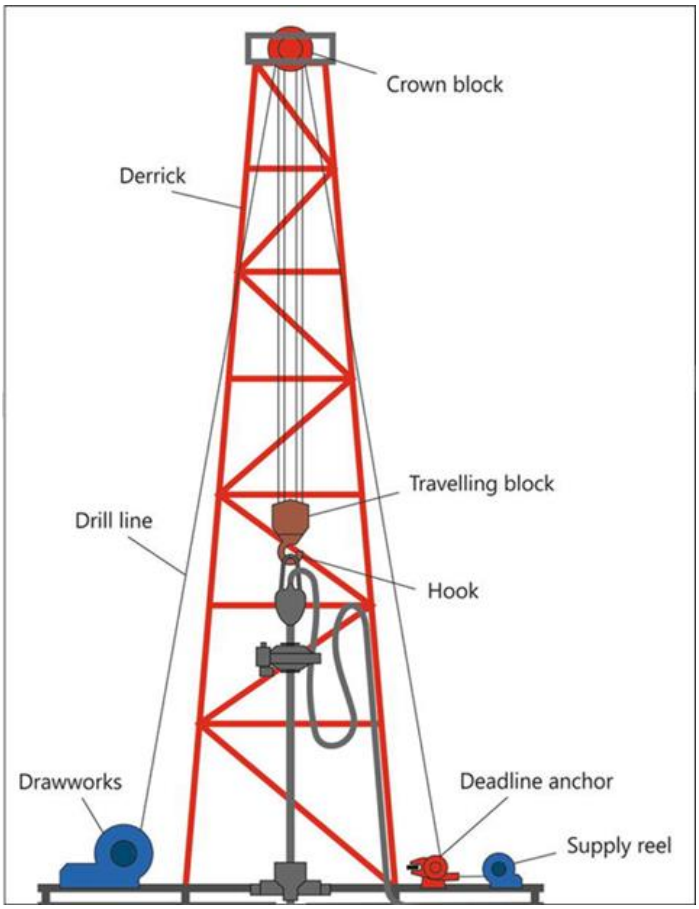


Figure 59
Drill Line

Deadline Anchor

The deadline anchor (figure 60) is at the bottom of the derrick. This is the tie-down spot for the drill line. The deadline anchor secures the wire rope with a set of clamps. A load sensor is installed in the deadline anchor to measure the weight hanging from the hoisting system.

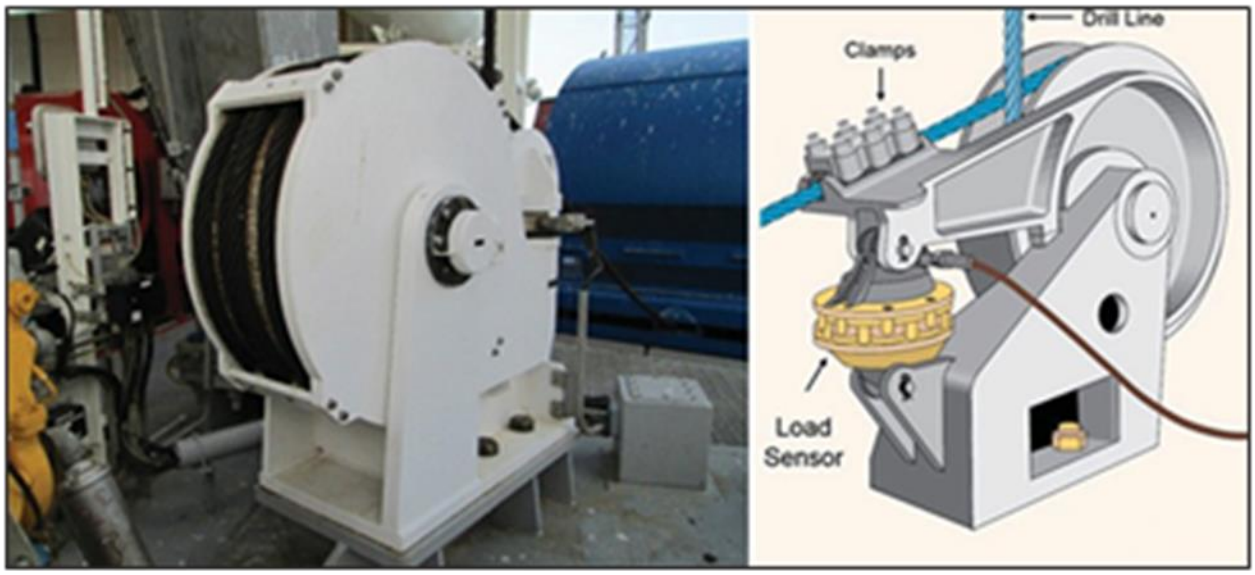


Figure 60
Deadline Anchor

Supply (Storage) Reel

The supply (storage) reel is used to store the unused part of the drill line (figure 61).

Figure 61
Supply Reel

There is other equipment that supports the hoisting system. These include:

- BX elevator
- hydraulic cathead
- pipe racking system
- fingerboard
- iron roughneck
- power slips

BX Elevator

The automated BX elevator (figure 62) is a hydraulic, double-door elevator powered by the top drive hydraulic system and controlled by the cyber-rig control system. The BX elevator latches onto tubular for handling.

Figure 62
BX Elevators

Hydraulic Cathead

The automated hydraulic cathead (figure 63) provides high torque to make up and break out drill pipe and drill collar connections. The cathead is used with the rig tongs for connections that are unsuitable for the iron roughneck and is controlled by the cyber-rig control system.

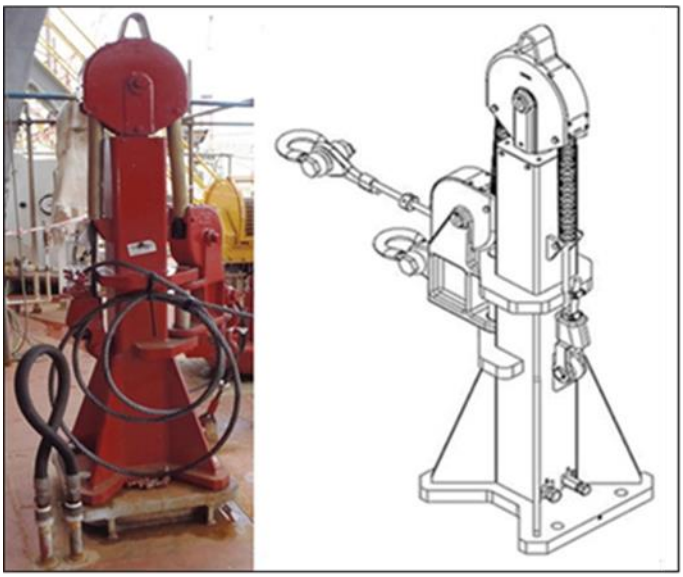


Figure 63
Hydraulic Cathead

Pipe Racking System

The PRS or automated pipe racking system (figure 64), is a vertical pipe-handling system controlled by the cyber-rig. The PRS handles pipe from the fingerboard so it can be added to the drill string while drilling or tripping in the hole. It also racks stands of pipe in the fingerboard as they are removed from the drill string or made up from singles.

Figure 64
Pipe Racking System

Fingerboard

The fingerboard assembly (figure 65) holds the stands vertically in the derrick. The fingerboard allows the stands to be positioned, so that they can be easily picked up by the PRS. The fingerboard assemblies have parallel fixed and adjustable steel fingers attached to the derrick.

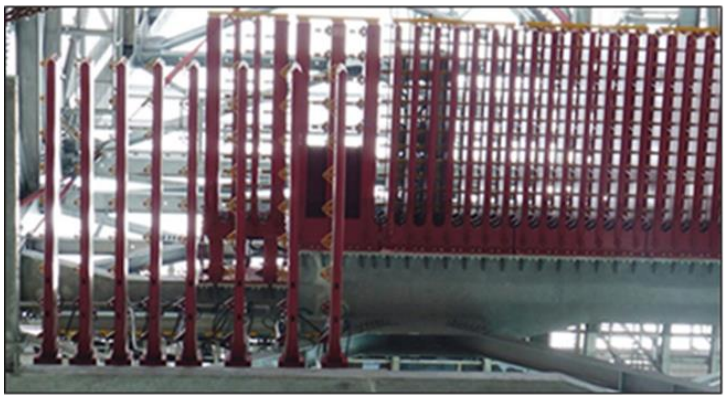


Figure 65
Fingerboard

Iron Roughneck

The automated iron roughneck (figure 66) applies the make-up or break-out torque to tubular connections. It is powered by the hydraulic power unit (HPU) and controlled by the cyber-rig control system. It can handle different tubular sizes depending on the particular model. The iron roughneck is fixed to the rig floor but can rotate, extend, and retract.

Figure 66
Iron Roughneck

Power Slips

The automated Power Slips (PS) fits inside the rotary support table (figure 67). The PS grips the pipe without damaging it and suspends the drill string in the rotary support table. It is controlled through the rig's cyber control system.

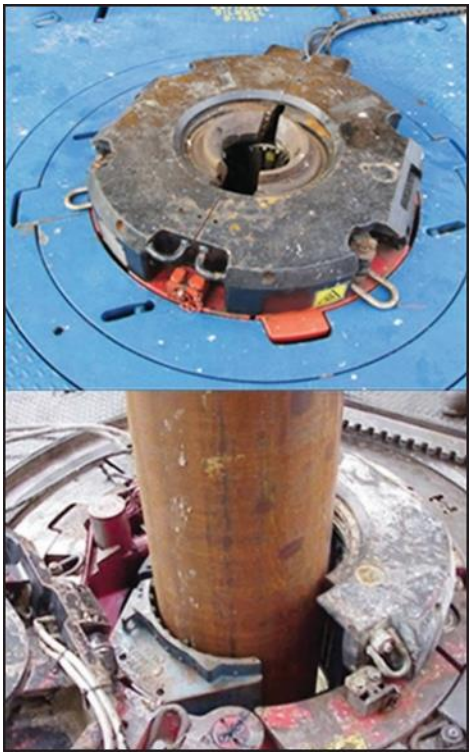


Figure 67
Power Slips

The Well Control System

The well control system is used to prevent fluids (liquid or gas) escaping from the wellbore. A well that is not under control can cause a major incident. Well control equipment closes off the wellbore by sealing around the drill string. The well control equipment traps gas and pressure inside the hole giving the rig crew valuable time to react to, and fix, a problem.

The well control equipment includes:

- blow-out preventer
- choke manifold
- mud gas separator
- accumulator
- stabbing valve
- non-return valve

Blowout Preventer

The Blow-Out Preventer (BOP) is the largest part of the well control equipment (figure 68). It consists of several parts (annular preventer, ram preventers) that prevent high pressure fluids from escaping from the well and possibly causing a disaster.

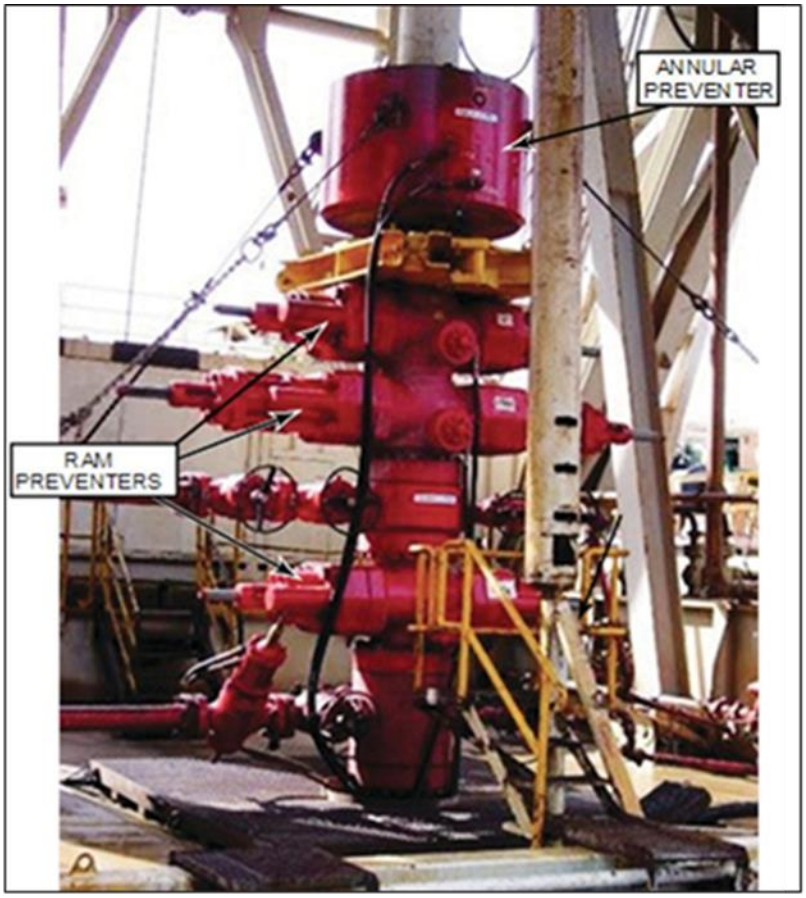


Figure 68
Blowout Preventer

The Choke Manifold

The choke manifold (figure 69) is a set of valves for well control. The valves regulate the flow of gas or liquid escaping from the well through the BOP. The flow is sent to equipment called the mud gas separator that removes the gas from the mud.

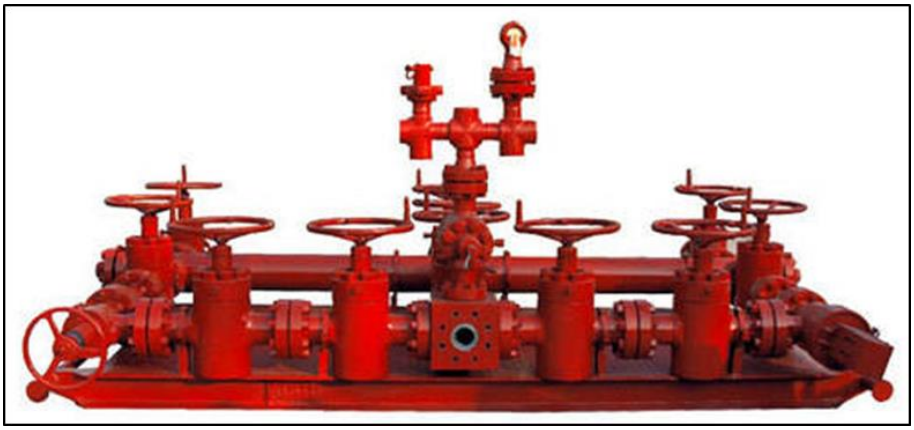


Figure 69
Choke Manifold

Mud Gas Separator

The mud gas separator (figure 70) separates the gas from the mud as it exits the well. The mud flows to near the top of the mud gas separator. As the mud enters, it falls over baffle plates in the body, which agitates the mud, allowing the gas to escape from the mud. The gas will exit the top of the mud gas separator to the Flare Pit.

Figure 70
Mud Gas Separator

Accumulator

The accumulator (figure 71) stores pressurized hydraulic fluid for opening and closing the annular preventer, rams, and valves on the BOP (see figure 68). The accumulator's high pressure pumps pressurize the fluid into vessels called bottles. Handles on the accumulator are used to operate the BOP equipment. The preventers, rams and valves on the BOP can also be operated from control panels located around the rig.

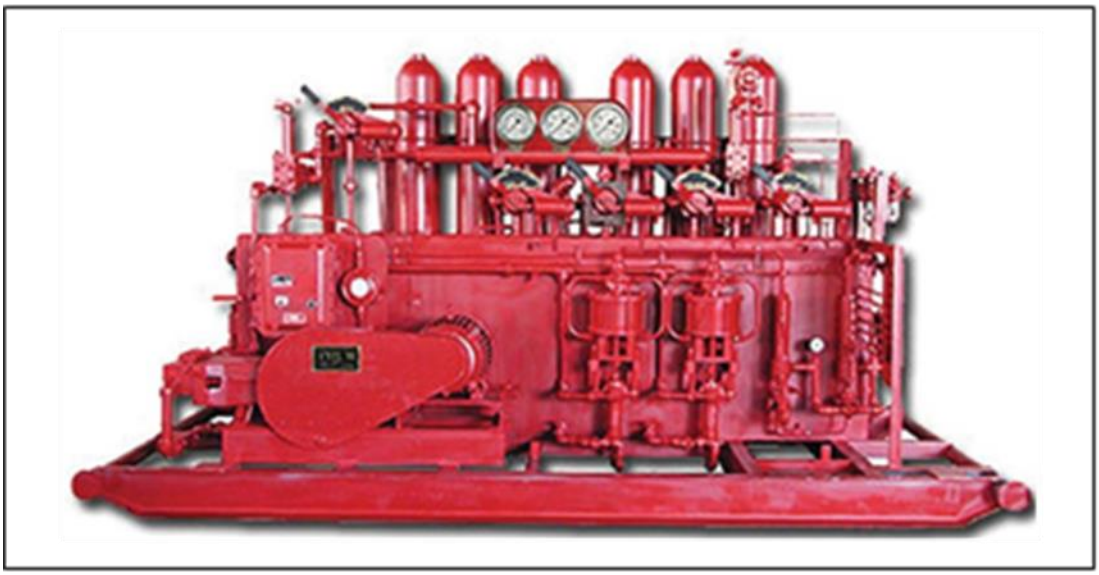


Figure 71
Accumulator

Stabbing Valve

The stabbing valve (figure 72) is a manually operated ball valve that connects to the top of the drill string. It is stored on the rig floor in the open position, ready for use. It is used when there is a sign that there is gas or liquid entering the well.

Figure 72
Stabbing Valve

Non-Return Valve

The non-return valve (figure 73) allows drilling fluid to be pumped down through it, but it will not allow fluid to return back up. This type of valve is also known as a dart type internal blowout preventer.

A spring closes the valve if pumping stops, or if the mud starts to flow back up. The non-return valve is connected to the top of the stabbing valve. Once it is installed, the stabbing valve can be opened so that the driller can pump fluid into the well.

Figure 73
Non-Return Valve

Power System

Power for the equipment that is used to drill the well comes, mostly, from diesel engines. The power goes from the engines to the rig equipment through two types of drive:

- mechanical
- electrical

On a mechanical rig, engines need to be close to the equipment they are powering as the drive power is transferred from the engine to the rig equipment by:

- driveshaft
- belt
- chain
- gears

Electrical rig generates its own electricity using diesel engines and electrical generators. There are DC and AC drive rigs. The engines and generators are located in the generator area.

The electricity is sent from the generators to the SCR (Silicon Controlled Rectifiers) room in DC drive rigs or to the VFD (Variable Frequency Drive) room in AC drive rigs.

The SCR and VFD contain electrical equipment that converts the generator power into usable electricity. The power is distributed to electric motors that run rig equipment.

The power system consists of:

- diesel engines
- generators
- SCR room
- VFD room

Diesel Engines

The diesel engines (figure 74) on a rig can either supply mechanical power to a machine part or power the generator. The size and number of diesel engines depend on the size of the rig.

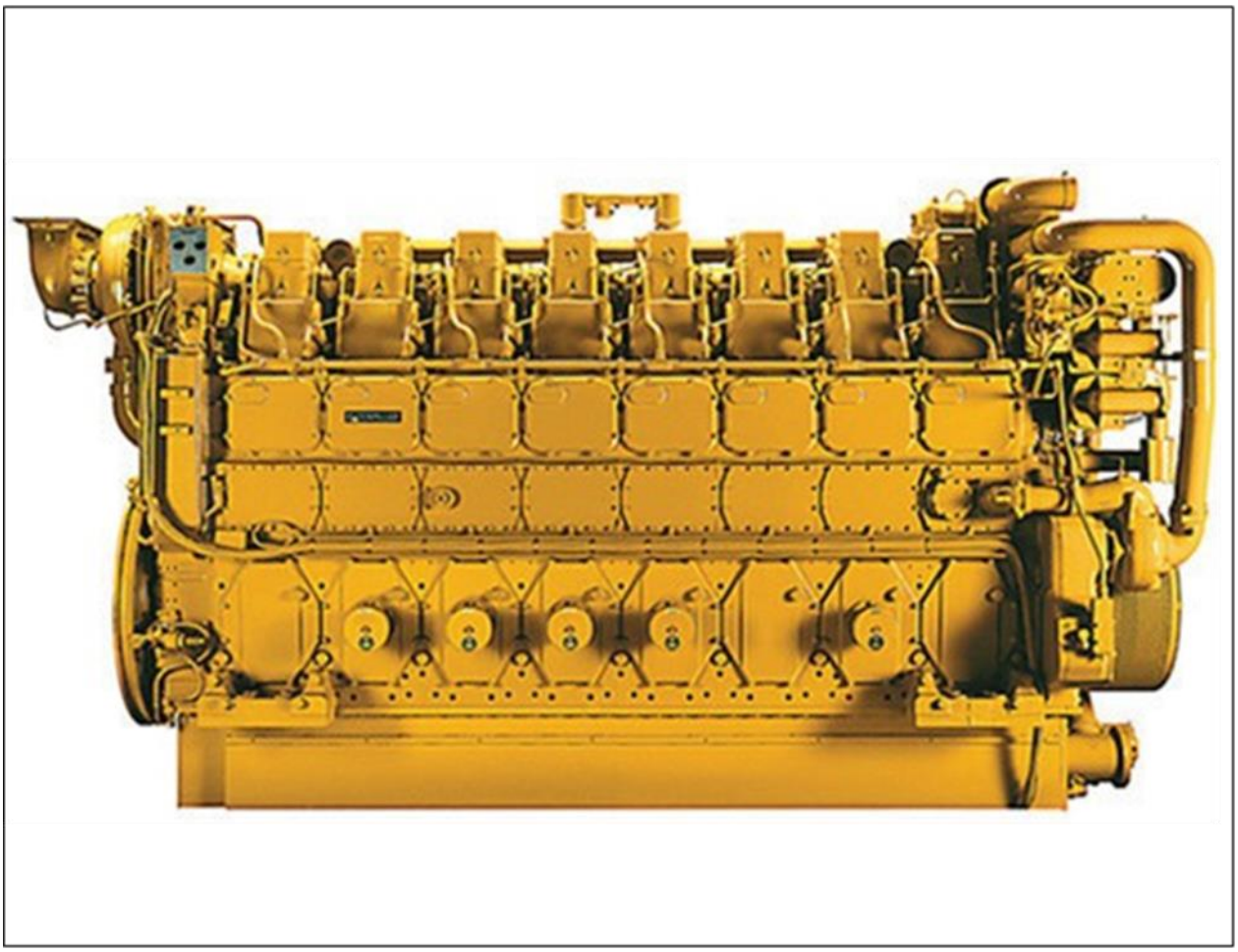


Figure 74
Diesel Engine

Generators

A generator (figure 75) converts the mechanical rotation of a diesel engine driveshaft into electrical energy. On a mechanical rig, the generators are smaller as they do not provide large quantities of power to operate the mechanical equipment. Generators on electric rigs are larger than the generators on mechanical rigs.

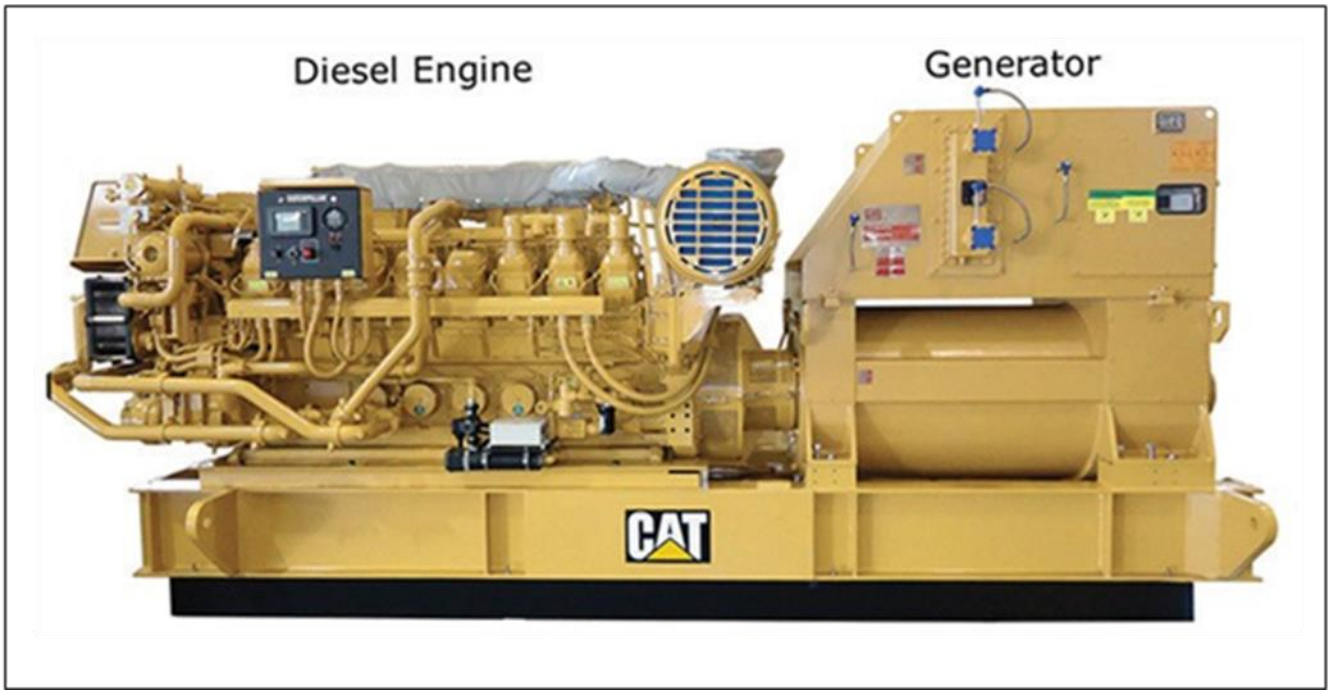


Figure 75
Generator

SCR Room

The SCR room (figure 76) is where the electricity that the generators produce is converted from AC voltage to DC. The DC motors drive the draw works, rotary table, top drive, and the mud pumps in DC drive rigs. The driller can control this equipment by varying the supply voltage to the appropriate motor.

Figure 76
SCR Room

VFD Room

The VFD room (figure 77) performs a similar function as an SCR, but for AC motors in AC drive rigs. It converts the generator output to AC supply that can be adjusted to control the motors. The driller varies the frequency of the AC current to adjust the speed of the equipment. The AC voltage supply to the equipment remains the same. The VFD uses newer technology than for

DC motors. It is cheaper to operate, smaller, and allows more control of the power sent to the equipment.

Figure 77
VFD Room

Driller's Controls

Rotary drilling rigs are classified as conventional or automated.

Conventional rigs use equipment that is controlled manually on the rig floor, either locally at the equipment or from a driller's console. The driller must always look at the gauges and analyze the readings to operate the rig.

Automated drilling rigs use computer-controlled systems that monitor and control the rig's equipment to increase efficiency and safety. The driller uses the information to monitor the condition and status of the equipment, and makes decisions on what action needs to be taken.

Sensors display equipment information on gauges on the driller's console. The sensors measure pressure, temperature, and force. The driller uses equipment on a console on the rig floor (figure 78) to check the above parameters. These include:

- analogue gauges
- digital displays
- driller's controls

Figure 78
Driller's Console Analogue Gauges

Analogue Gauges

Analogue gauges (figure 79) have a needle which points to the value that is measured by the sensor. These gauges allow the driller to monitor the drilling operations parameters.

With analogue gauges, the driller can see how quickly a parameter is changing as the needle moves and it is easier to spot a 'spike' in data. The most common analogue gauges on a driller's console are:

- weight indicator
- pump pressure
- tong line pull

Figure 79
Analogue Gauges Weight Indicator

Weight Indicator

The weight indicator (figure 80) measures the weight of the drill string hanging from the hook. The driller can tell how much of the drill string's weight is on the drill bit down hole by looking at the weight indicator. If too much weight is put onto the drill bit, the drill bit would be damaged. Also, with too much "weight on bit" (WOB), the drill string could become stuck.

Figure 80
Weight Indicator

The driller can also use the weight indicator to tell if the drill string is getting stuck in the hole. If the weight indicator reads more than the weight of the drill string as it is being pulled out of the hole, the drill string may be getting stuck.

Pump Pressure Gauge

The driller checks the pump pressure gauge (figure 81) to see if the pump is working correctly and if the hole is being cleaned. The pressure may go up if the cuttings are not being removed efficiently. The hole will need to be cleaned; otherwise, the drill string may become stuck. If the pressure goes down, it may mean that there is a problem with the pump, the hole, or a part of the drill string.

Figure 81
Pump Pressure Gauge

Tong Line Pull

Tongs are the tools on the rig floor that are used to tighten drill pipe connections. The tong line pull gauge (figure 82) shows the driller how much force he is putting on the drill pipe connections when the tongs are tightening them.

The force is measured by a load cell. The load cell is a hydraulic sensor attached between the tong line and the tong.

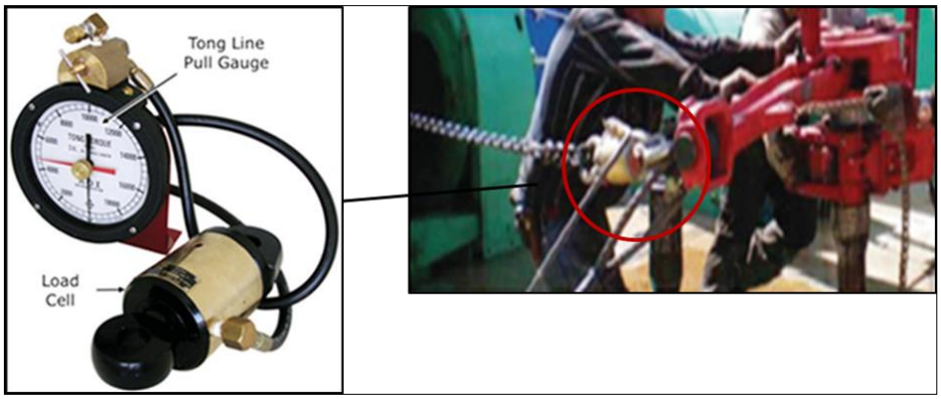


Figure 82
Tong Line Pull Gauge

Digital Display

Digital gauges display sensor readings but in a digital format (figure 83). Digital gauges display numbers, and have a wider range compared to analogue gauges. These displays help the driller make critical decisions that affect the drilling operation.

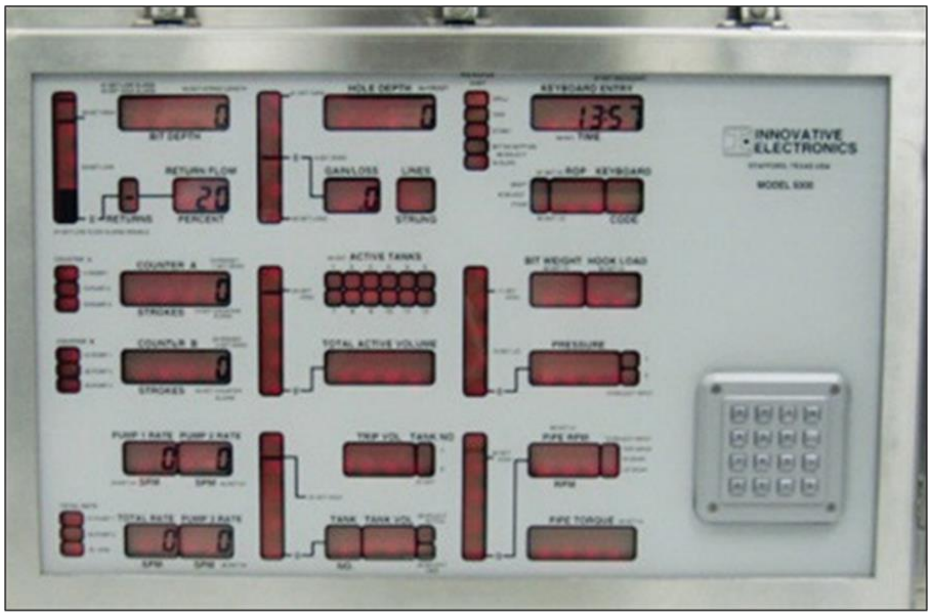


Figure 83
Digital Display

Mud Tank Display

The mud tank display, or pit totalizer, (figure 84) is a separate digital display that the driller uses to monitor the circulation system. There are four features of the mud tank display as listed in Table 2.

Figure 84
Mud Tank Display

DISPLAY	PURPOSE
Volume	Displays the volume of mud in the active tanks; by monitoring the active volume, the driller can see if fluid from the formation is entering the well or mud is being lost into the formation. This is called the pit gain/loss; the driller can set alarms on to notify him if there are losses or gains in the mud volume.
Trip	The trip display monitors how much mud is added when the drill string is pulled out of the well. As the pipe is pulled out, the driller must add mud to keep the well full The trip display shows how much fluid he is adding. When the drill string is being lowered mud will come out of the hole The driller watches the display to make sure that the volume of mud coming out of the hole is as expected.
Flow	A sensor on the mud return line measures the flow rate. The driller monitors this to see how much mud is coming through the mud return line. An alarm can be set to alert the driller of an increase in, or loss of, flow.
Pumps	The display shows the driller the strokes per minute of the pump, or the total strokes that the pump has performed.

Table 2
Mud Tank Display Features

Driller's Controls

The driller's controls (figure 85) are the levers and switches that control the main drilling equipment and include:

- switches
- levers
- brake handle

Figure 85
Driller's Controls

Switches

Switches (figure 86) on the driller's console stop and start the drilling equipment. They operate remote starting equipment such as the hole fill pump, a mixing pump, or a hydraulic pump.

Levers

The driller's control levers (figure 86) operate mechanical equipment on the rig floor. These levers on the console are usually attached to air lines to operate their respective equipment.

Driller's Switches **Driller's Levers**

Figure 86
Driller's Switches and Levers

Brake Handle

The draw works brake handle (figure 87) is also called the "driller's brake". It controls the main brake on the drawworks called the drum brake. The driller pushes down the brake handle to engage the drum brake and lifts the brake to let the drawworks reel in or feed out the drill line. When drilling, the driller uses the brake to control the weight on the bit.

Figure 87
Draw Works Brake Handle

Automated Drilling Rigs

On an automated drilling rig many tools and equipment are computer controlled from the driller's cabin (figure 88). The computer monitors and analyzes data from instruments. Software prevents the driller from exceeding equipment safe operating limits. Integrated computer systems are called cyber-rig control systems. Automated drilling rigs have:

- cyber-rig control system
- computer controlled equipment

Figure 88
Cyber-Rig Control System (Driller's Cabin)

A cyber-rig control system is a fully integrated and networked system. It monitors and controls almost all of the drilling operation, display and archive data (figure 89). The system monitors: temperature, torque, volumes, pressures, and alignment of the controlled equipment.

The three main parts of a cyber-rig control system are:

- operator interface
- tool controller
- controlled rig equipment

Figure 89
Cyber-Rig Control System Equipment

On an automated rig, the driller's cabin, or 'Doghouse' (figure 90) usually has two computer stations called cyber-chairs (figure 91). The driller and the assistant driller operate the control system through:

- touch screens
- joysticks
- switches

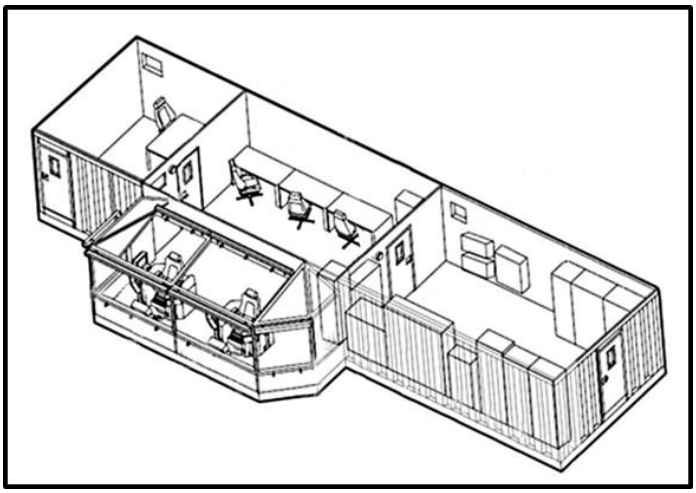


Figure 90
Driller's Doghouse

Figure 91
Cyber-Chairs

Most functions are operated through the touch screens (figure 92). The operator can request a view of any equipment on the network from these screens. The screens will display sensor readings and the status of equipment.

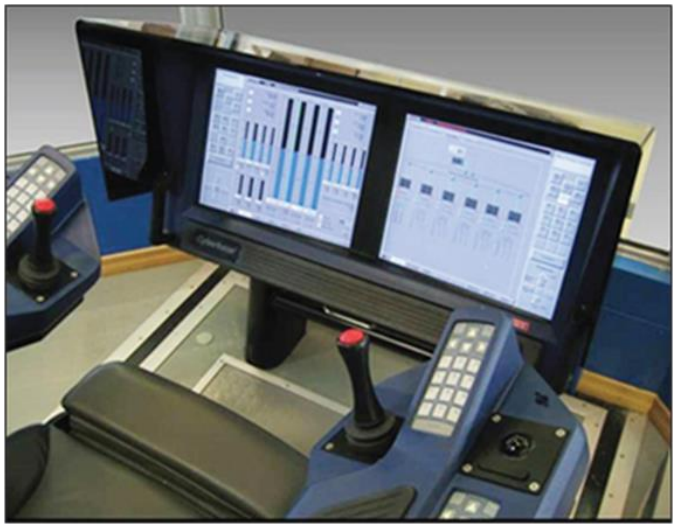


Figure 92
Touch Screens

Joysticks

The driller uses joysticks (figure 93) for tools that require controlled movement.

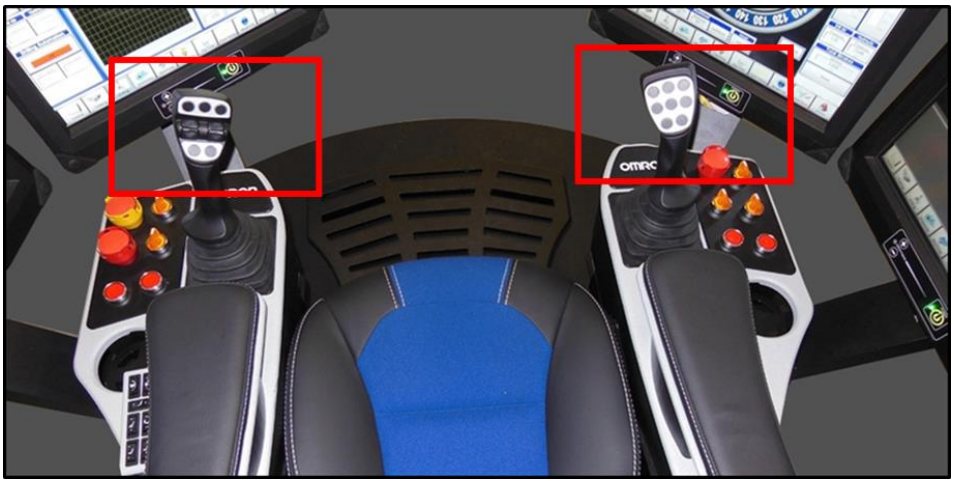


Figure 93
Joysticks

Control Switches

Control switches (figure 94) operate frequently-used equipment.

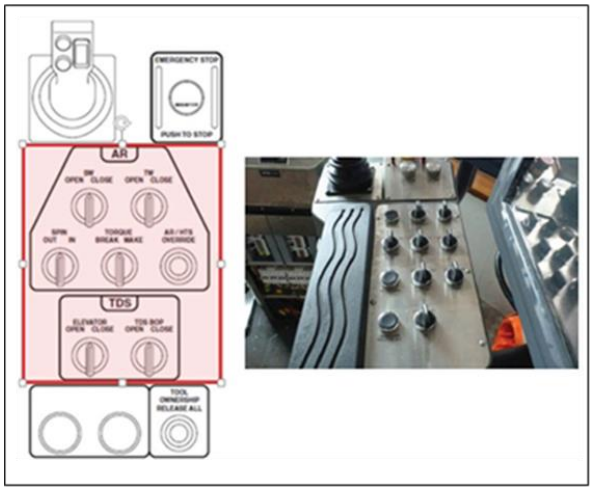


Figure 94
Control Switches

Tool Controller

The tool controller (figure 95) is a computer system that interprets the inputs from the driller's joystick, control switches, and touch screens. It instructs the controlled equipment to perform an action.

Figure 95
Tool Controller

Automated Rig Equipment

The automated rig tools are controlled by the tool controller. The tool controller sends commands to the automated rig equipment based on the driller's input. The equipment responds to the driller's commands. The equipment sensors will send back data to the operator (figure 96).

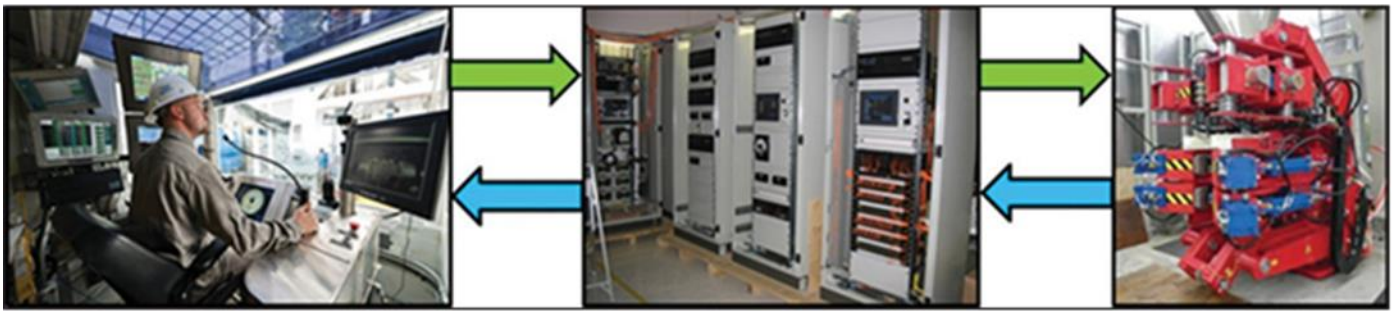


Figure 96
Automated Rig Equipment

SUMMARY

There are six main areas on a rotary drilling rig:

- substructure
- derrick
- rig floor
- catwalk and pipe racks
- mud tanks and pits
- generator area

There are five systems that perform specific functions in the drilling process:

- circulating system
- rotating system
- hoisting system
- well control system
- power system

EXERCISE C

Directions: Circle the correct answer to items 1 - 10 below.

1. Which part of a rotary drilling rig is installed first?

   a. Rig floor

   b. Substructure

   c. Generators

   d. Catwalk

2. What part of a drilling rig supports the crown block?

   a. Derrick

   b. Draw works

   c. Dead line anchor

   d. Hook

3. Where is the highest noise area of a drilling rig?

   a. Catwalk

   b. Mud tanks

   c. Rig floor

   d. Generator area

4. Which system is used to turn the drill string in the well?

   a. Circulating system

   b. Rotating system

   c. Well control system

   d. Hoisting system

5. Where are the drill pipes cleaned and measured before being used?

   a. Generator area

   b. Finger board

   c. Rig floor

   d. Pipe racks

6. Which piece of equipment in a cyber-rig system is used by the driller for tools that require controlled movement?

   a. Touch screens

   b. Joystick

   c. Cyber-chair control switches

   d. Driller’s console

7. Which analogue gauge is used by the driller to indicate if the drill string is getting stuck in the hole?

   a. Weight indicator

   b. Tong Line Pull

   c. Stroke counter

   d. Pump rate

8. Which part of the driller's console is used to control the draw works drum?

   a. Brake handle

   b. Weight indicator

   c. Driller's control switches

   d. Driller's control levers

9. Which piece of equipment connects the rotary table to the kelly?

   a. Slips

   b. Rotary support table

   c. kelly bushing

   d. Power slips

10. Which piece of equipment stores the unused part of the drill line?

   a. Dead line anchor

   b. Draw works drum

   c. Supply reel

   d. Crown block

Offshore Drilling Rigs

Offshore rigs are also called Mobile Offshore Drilling Units or MODUs. Figure 97 shows three different types of offshore rigs. They can be towed or propelled into place.

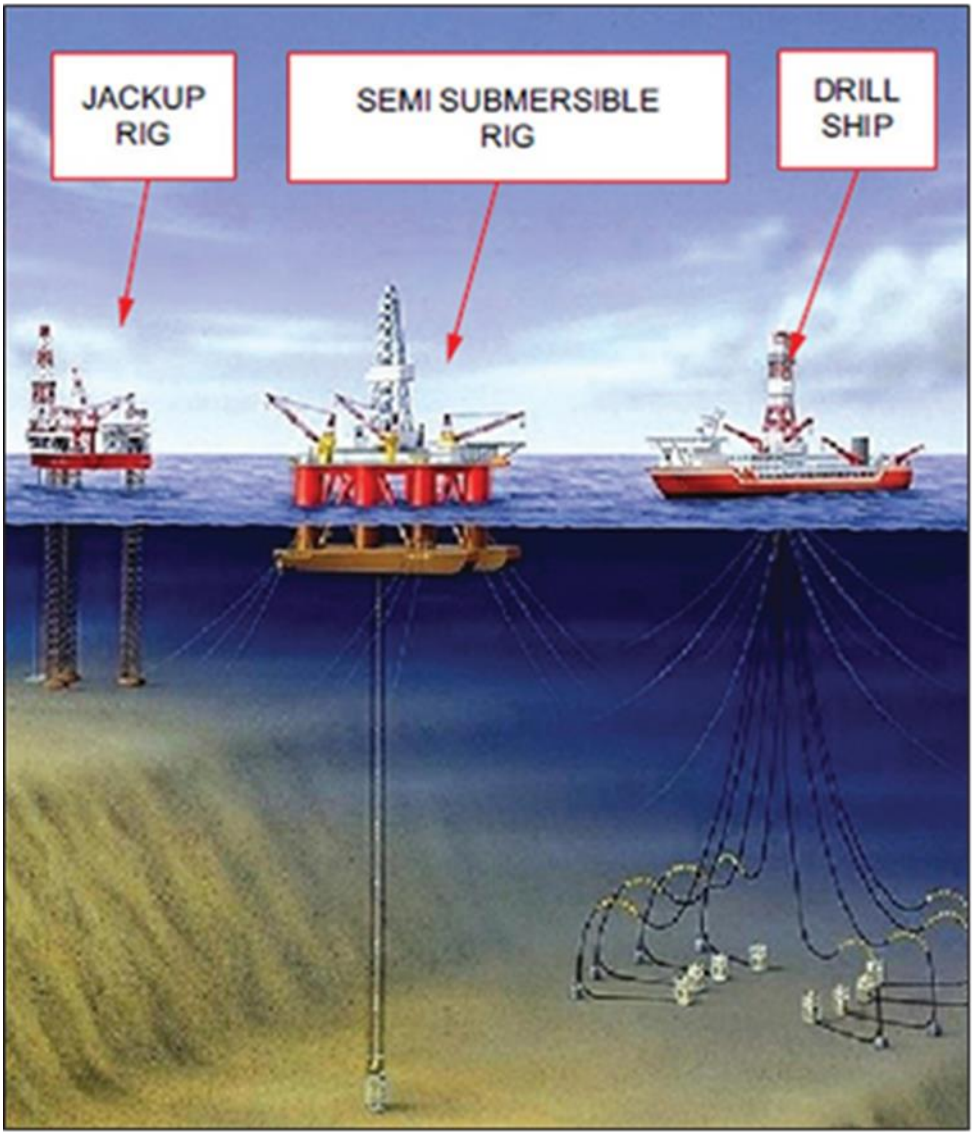


Figure 97
3 Types of Offshore Rigs

This section covers:

- jackup rigs
- semi-submersible rigs
- drill ships
- main systems specific to jackup drilling rigs

Jackup Rigs

The jackup rig is the most common rig in the offshore drilling industry today.

Jackup rigs can only operate in water that is less than 300 feet (100 meters) deep. The rig is towed to the drilling location by tug boats. When on location, the rig's legs (three or four legs) are lowered to the seafloor. The rig is then jacked up above the water to a predetermined height.

Three-legged jackup rigs are the most common for drilling as they are stable while elevated (figure 98).

Four-legged rigs are more stable while floating and are commonly used for construction and maintenance.

Figure 98
Three-Legged Jackup Drilling Rig

Semi-Submersible Rigs

Figure 99 shows a semi-submersible rig, which are used for drilling in deep water.

These rigs are called semi-submersible (or just semi) because they are semi-submerged at the drilling location. To keep them stable during drilling operations, the rigs' pontoons are submerged under the surface of the sea. The main structure, or hull, is supported on columns above the water. These are expensive drilling rigs used for water depths of over 300 feet.

Figure 99
Semi-Submersible Drilling Rig

Drill Ship

A drill ship is a built or remodeled ship that accommodates a complete drilling rig (figure 100).

Once on location, the ship uses its propellers/thrusters to keep the drilling rig over the well. Drill ships are used for deep water drilling at depths of 300 feet or more.

Figure 100
Drill Ship

Main Systems Specific to Jackup Drilling Rigs

The two main systems on a jackup drilling rig are the:

- jacking system
- conductor tensioner system

These two main systems are supported by auxiliary equipment.

Jacking System

A jacking system lifts the rig out of the water and keeps it stable, which must be done before drilling can begin. These self-elevating rigs have three or four movable legs that can be extended, or jacked, above or below the hull. The distance from the sea surface to the rig floor changes constantly due to waves and tidal motion. This affects the drilling operation. Figure 101 shows a jackup leg and a jackup rig jacked out of the water.

Figure 101
Jackup Legs

Jackups are towed to the site with the legs up, and the hull floating on the water (figure 102).

Figure 102
Towing a Jackup Rig

The system that moves the legs up or down is called the jacking system. When the rig reaches the drill site, the jacking system lowers the legs to the sea bed. The hull is then raised to the required elevation above the sea surface (figure 103).

Figure 103
Legs on Seabed

Jacking systems use a rack and pinion gears (figure 104). The pinion gears are driven by electric motors and the rack is fixed to the legs.

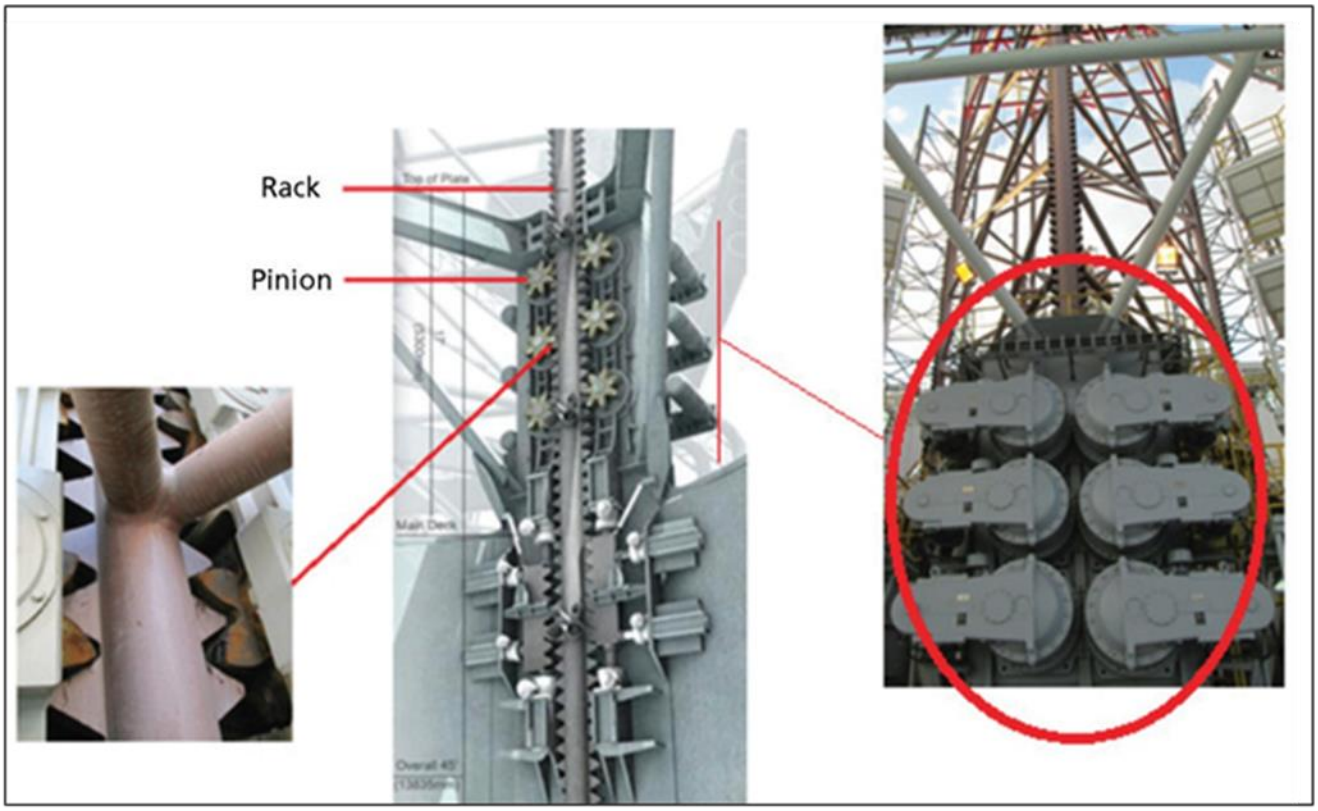


Figure 104
Rack and Pinion Arrangement

The jacking system includes:

- jacking units
- motor control centers
- local control consoles
- central control consoles

Jacking Units

In a three-legged jackup rig there are 54 jacking units. (18 units per leg). Each of the 54 jacking units (figure 105) includes one AC motor, a gearbox, and a pinion shaft. The electric motor has a fail-safe electromagnetic brake.

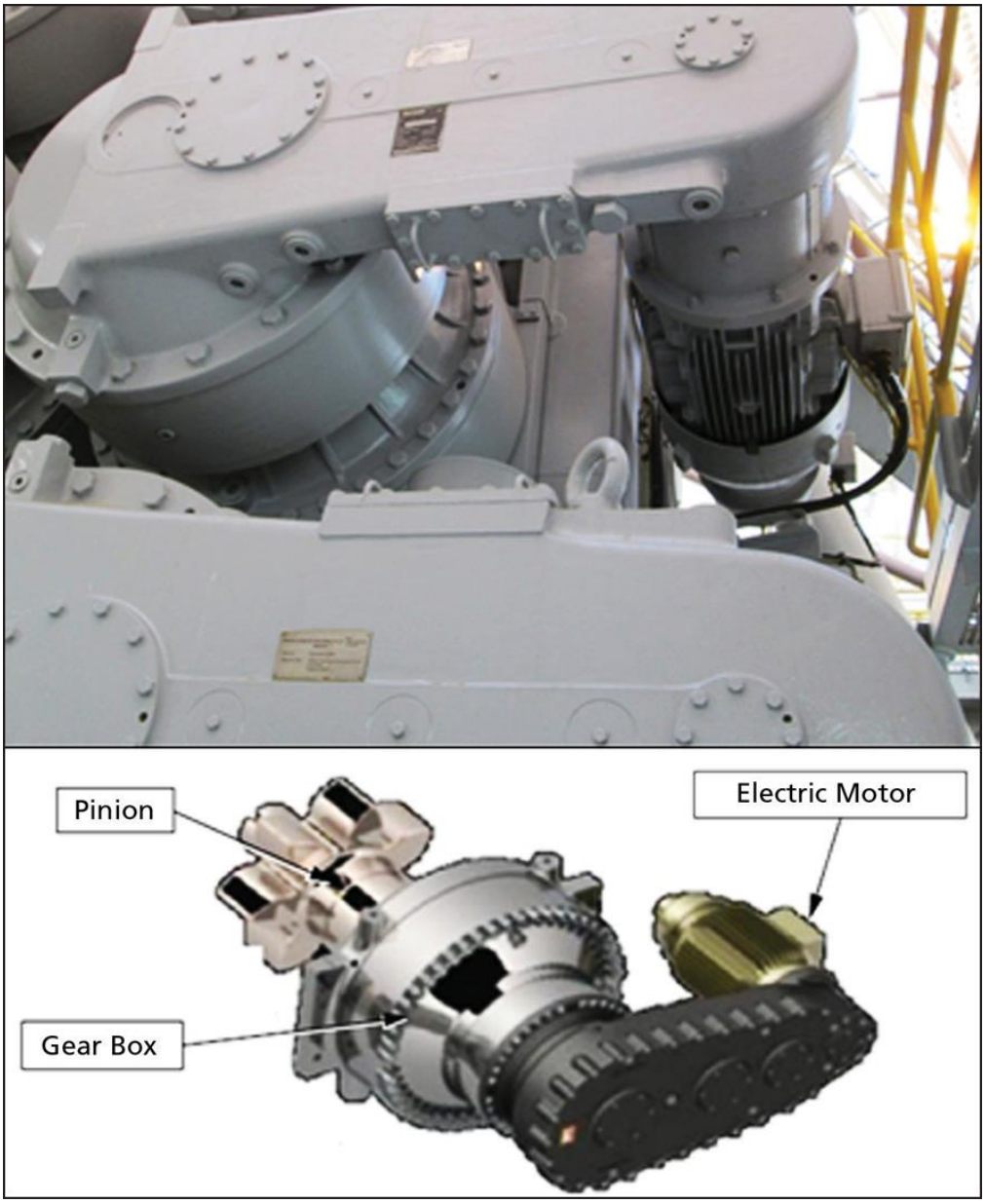


Figure 105
Jacking Unit

Motor Control Centers

Each leg has a motor control center (MCC) to control and protect the electric motors and brakes. Each MCC includes circuit breakers to supply power to each electric motor. They also have an overload relay, and a programmable logic controller (PLC) to communicate with the central console.

Local Control Centers

Each leg has a motor control center (MCC) to control and protect the electric motors and brakes. Each MCC includes circuit breakers to supply power to each electric motor. They also have an overload relay, and a programmable logic controller (PLC) to communicate with the central console.

Central Control Console

There is a central control console in the Jacking Control Room. This can control all legs at the same time or individually. The console (figure 106) controls the full system and displays the system status in real time.

The central console has switches, push-buttons, light indicators, and gauges that monitor and control the jacking operation.

Figure 106
Central Console

Conductor Tensioner System

The conductor tensioner system helps compensate for the constant change of sea height. Drilling conductors or conductor pipes are large-diameter pipes set into the ground to prevent the walls of the well from collapsing on itself.

On offshore rigs, the conductor pipes are set in the sea bed and extend up to above sea level. Above the water, the conductor pipe is connected to a conductor tensioner (CT) which connects to the BOP (figure 107).

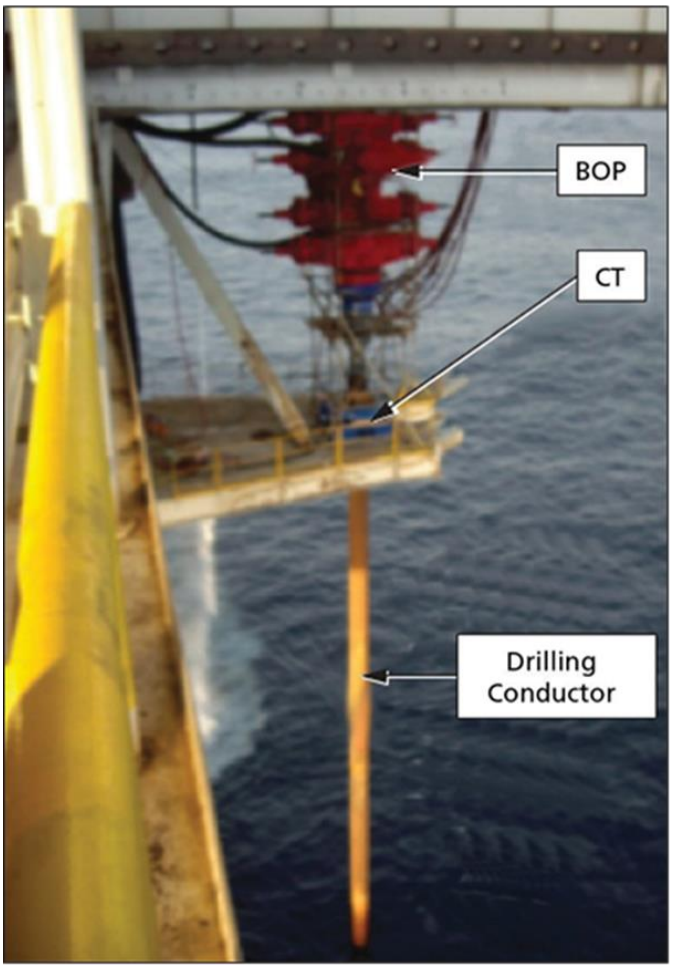


Figure 107
Conductor Pipe Connection to CT and BOP

The CT sits below the BOP on a platform below the drill floor. This platform (figure 108) is known as the tension deck. The CT supports two drilling conductor standard sizes, 30" and 36".

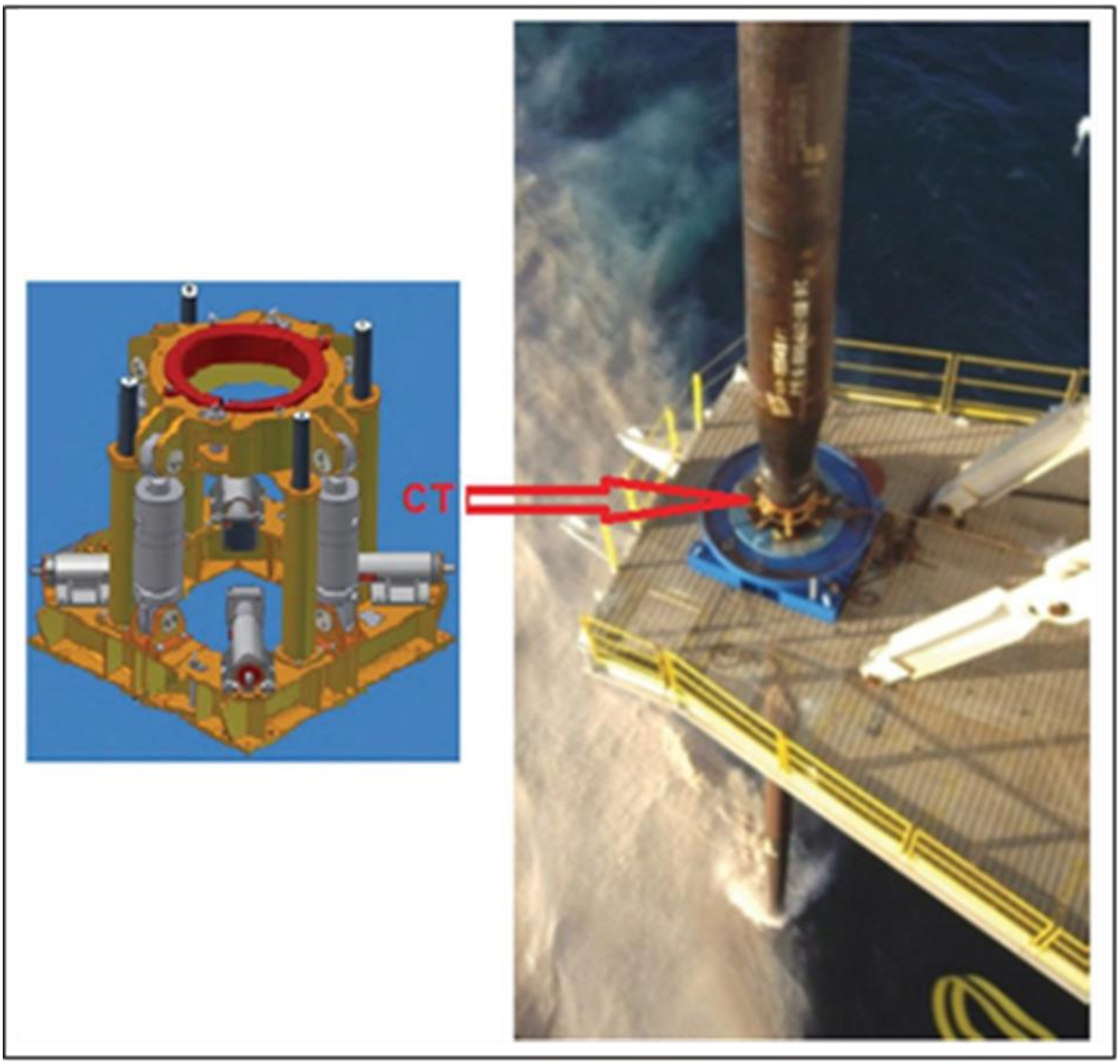


Figure 108
Conductor Tensioner (CT) on Tension Deck

A CT functions as a large hydraulic shock absorber. It maintains tension at the top of the drilling conductor. This helps keep the conductor pipe straight as the sea level changes. The CT also eliminates changing loads on the drilling conductor due to sea waves and currents.

By pulling up on the drilling conductor, the CT stops the conductor pipe from bending under its own weight. The tensioning is done by a conductor tensioner unit CTU (figure 109).

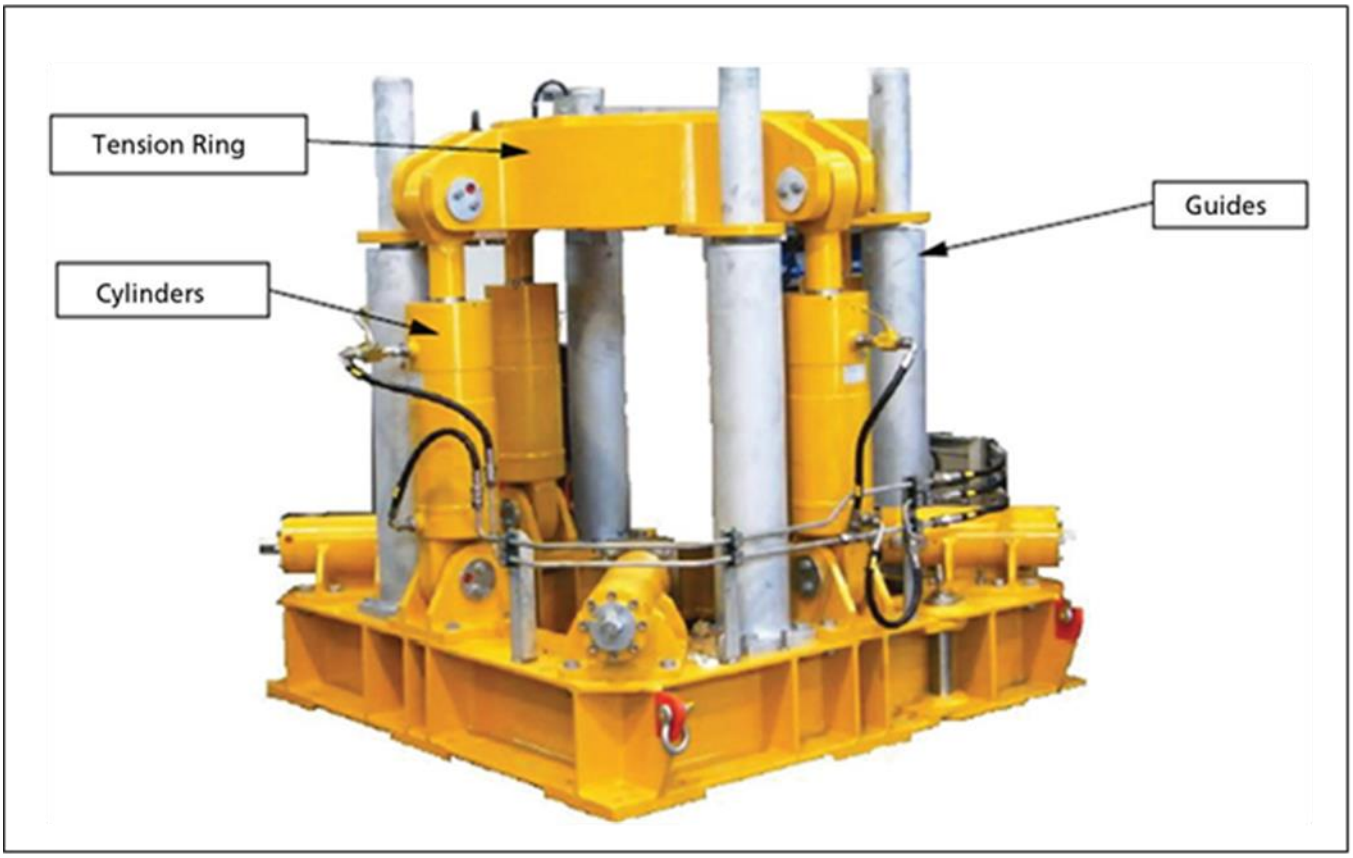


Figure 109
Conductor Tensioner Unit (CTU)

The control skid houses the controls and accumulators for the CT operation (figure 110).

Inside each accumulator there is a bladder filled with nitrogen gas at the top, and tensioner fluid below the bladder. The fluid is connected to the piston lifting side of the CT

cylinders. The accumulators act as gas springs during vertical movements of the conductor and rig.

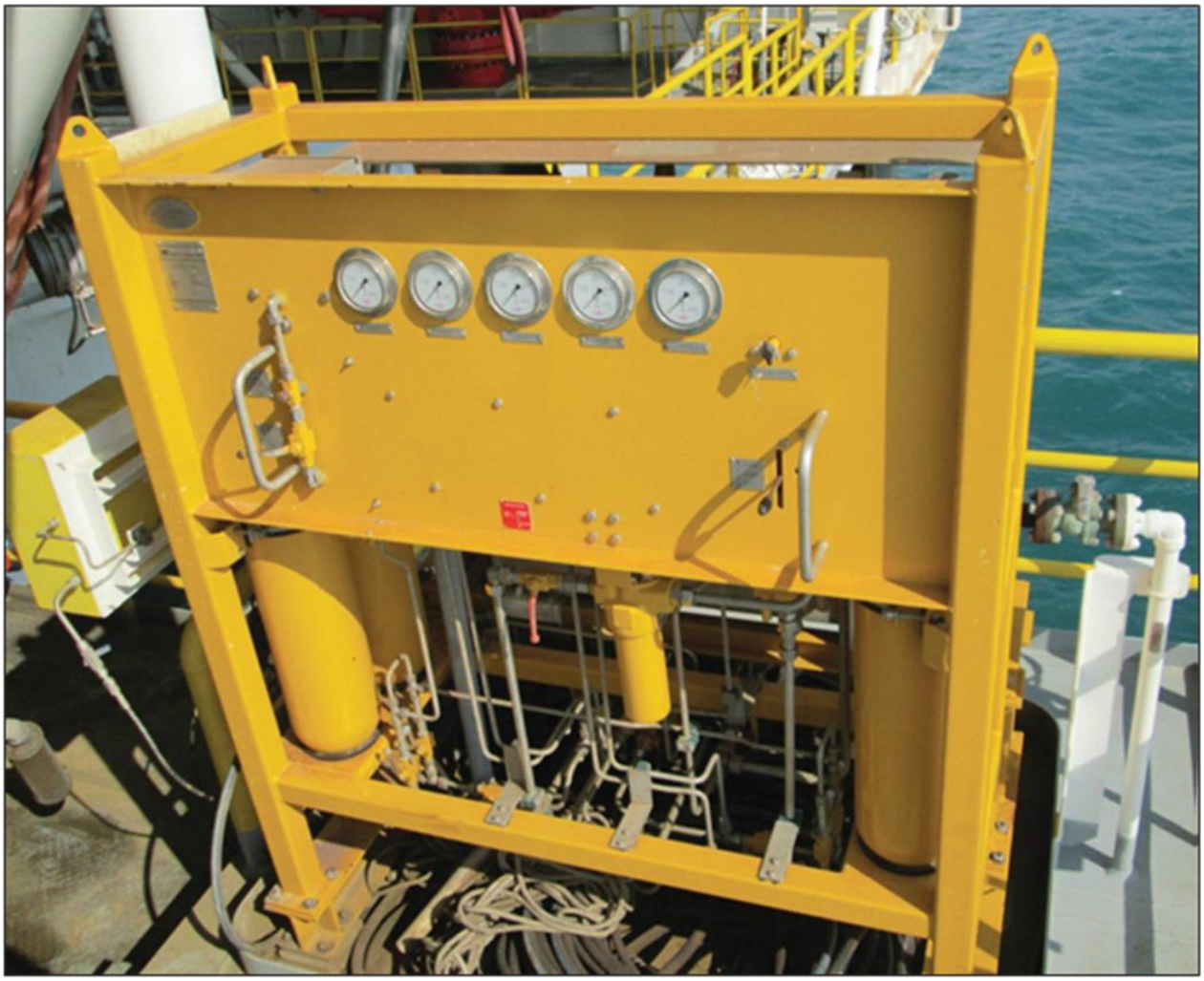


Figure 110
CTU Control Skid

Auxiliary Equipment

Certain job tasks on the offshore rig require auxiliary equipment to make the job easier. In some cases, auxiliary equipment is required to make drilling operations possible. The auxiliary equipment found on the jackup rig may include:

- casing stabbing basket
- pedestal cranes
- helicopter deck
- anchoring equipment
- cantilever and drill floor skidding system
- RO plant
- desalination plant
- waste water treatment

Casing Stabbing Basket

The casing stabbing basket is an elevated basket or platform attached to the derrick and can only travel within a limited area (figure 111). It allows a derrickman to align/guide a tubular joint into another tubular joint for makeup while casing is being run. This function is similar to the stabbing board on a land rig.

Figure 111
Casing Stabbing Basket and its Remote Console

Pedestal Cranes

The offshore stationary crane or pedestal crane (figure 112) is used for the same purpose as a mobile land crane. It uses a block and tackle system to lift heavy loads.

The stationary crane is mounted on the main deck of an offshore rig. It can only rotate on a fixed platform. On an offshore rig, there are usually three cranes to access equipment anywhere on the deck or off the sides of the rig. Materials and supplies are transported from boats to the rig by the cranes.

Figure 112
Offshore Stationary Pedestal Crane

Helicopter Deck

The helicopter deck, referred to as the “helideck”, is part of an offshore rig, ship or installation (figure 113).

The helideck is the landing area for helicopters. The helideck frame is usually made from light steel or aluminum.

On a jackup rig, the helideck is located behind the living quarters and away from main work areas.

Figure 113
Helideck

Anchoring Equipment

Anchoring equipment is used by offshore rigs or barges. The anchor system can be used when the rig is afloat to prevent it from moving, or to turn it on a fixed point for positioning.

Anchoring equipment is used any time that the rig is stopped, or being positioned beside a platform or jacket. The anchoring or mooring system is used mainly for the movement and positioning of the jackup when tugboats and offshore support ships are unavailable.

Anchoring equipment includes:

- winches
- running line tension meter
- fairleader
- anchor

Winches

Winches in the anchoring system store the wire rope and reel the anchor in or out (figure 114). The winches also put tension on the anchors by reeling in the line. This secures the rig in a fixed position, or moves it in the direction of one of the anchors if desired.

Figure 114
Anchor Winch

Running Line Tension Meter

Running line tension meters measure the amount of tension in the anchor line. After the anchors are set on the seabed, the winches apply tension to the anchor lines. The anchor lines run through the tension meter (figure 115). There are also static tension meters, but they are usually used on lines that are fixed (similar to the deadline anchor on the drill line).

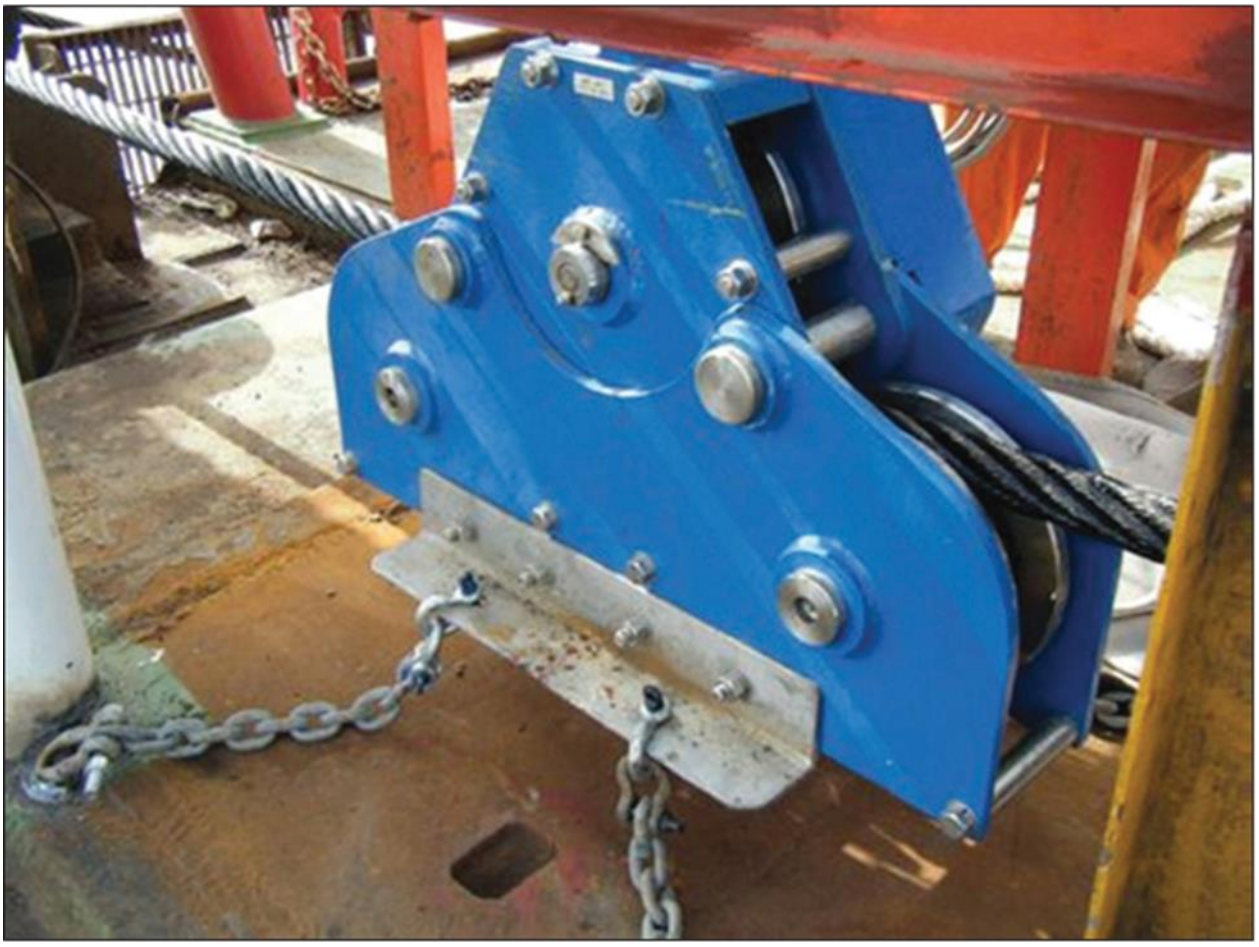


Figure 115
Running Line Tension Meter

Fairleader

A fairleader is usually a ring mounted as a separate piece of hardware or hole in a structure. It guides a wire line or a rope, keeping it clear of obstructions and preventing it from moving laterally so that it is not chafed or cut (figure 116).

Figure 116
Fairleader

Anchors

Anchors (figure 117) are set onto the seabed by anchor boats (also called Anchor-Handling Vessels or AHV) when the rig is positioned. The anchors hold the position steady if needed, especially when jacking down the legs. Around pipelines, there is a possibility that the legs could damage the pipeline when they are lowered, so the rig must be kept steady. The rig is likely to move more in deep water, so the anchors prevent too much movement. The anchors pull the rig into its final position and maintain stability in rough water.

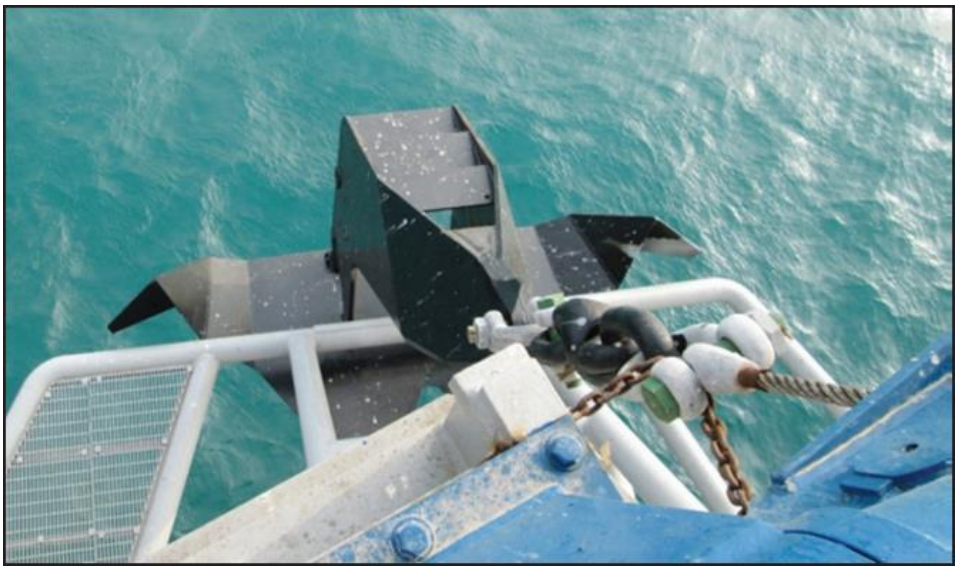


Figure 117
Anchor

All offshore rigs have anchor systems, including jackup rigs. In Saudi Arabia, most offshore drilling is in shallow, calm waters, except in the deep waters of the Red Sea, hence the anchoring system is rarely used.

Cantilever and Drill Floor Skidding System

A cantilever is an extension that is fixed at only one end and carries a load at the other end. It allows for overhanging structures that do not need to be supported from the outside.

After the vessel has been set into its final position, a jackup rig's cantilever system positions the rig's substructure over the well center. It has a hydraulically controlled cantilever and skid system with hydraulic clamps and cylinders (figure 118).

The cantilever system moves the substructure right or left, while the skidding system moves the substructure out from the main deck. This system also allows the drill floor to be moved from one hole to the next on a multiple well system.

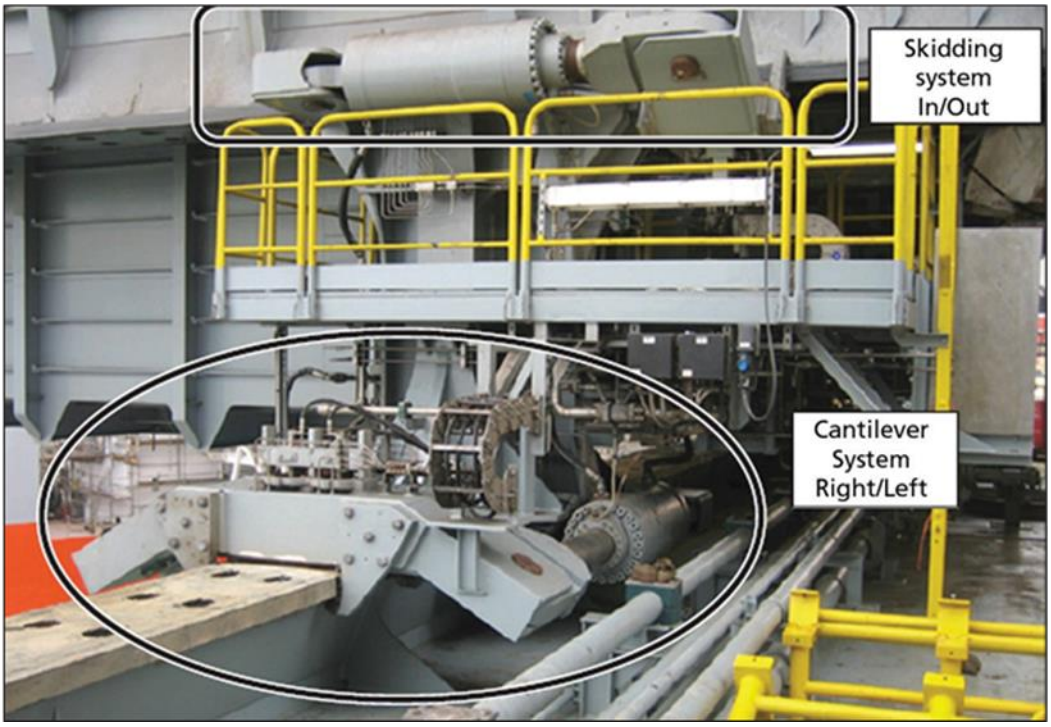


Figure 118
Hydraulically Controlled Cantilever and Skidding System

Rack and Pinion Skidding System

The rack and pinion skidding system uses electric or hydraulic motors (mostly electric motors) and gears to drive the substructure forward, backward, right or left. This extends the substructure out from the main deck and over the platform, or it shifts the rig floor right or left. Figure 119 shows the IN and OUT rack and pinion part of the skidding system.

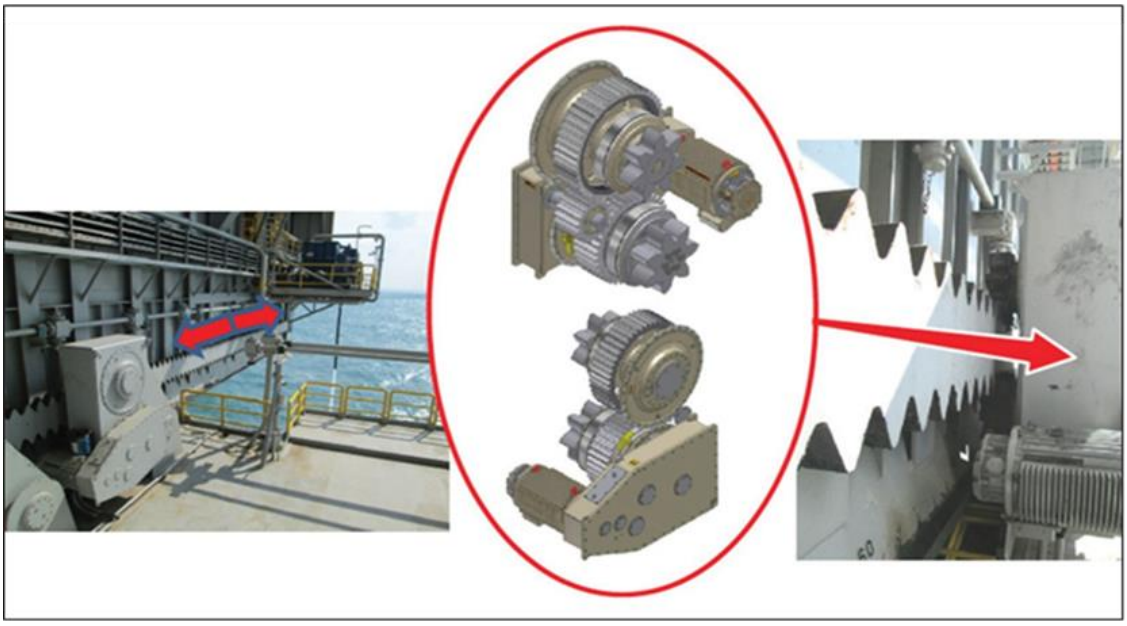


Figure 119
IN & OUT Rack and Pinion Skidding (Double Driving Gear)

Figure 120 shows the drill floor LEFT and RIGHT part of the skidding system.

Figure 120
LEFT & RIGHT Rack and Pinion Drill Floor Skidding (Single Driving Gear)

The motors work the same as the leg jacking rack and pinion system. They use gears and a rail to drive the substructure in the desired direction to position it and/or rig floor over the well center. The motors and gears allow variable speed adjustments without stopping the process, unlike the hydraulic clamps and cylinders system.

Depending on rig design, the skidding system can be fully moved either by hydraulic cylinders or rack and pinions or a mixture of both. Each type would be on one part; either the IN/OUT or LEFT/RIGHT motion.

RO Plant

Offshore rigs may have reverse osmosis (RO) plants to produce clean water (figure 121). An RO plant turns raw or contaminated water into potable (drinkable) water. RO removes most contaminants from raw water by pushing it under pressure through a series of filters and a semipermeable membrane.

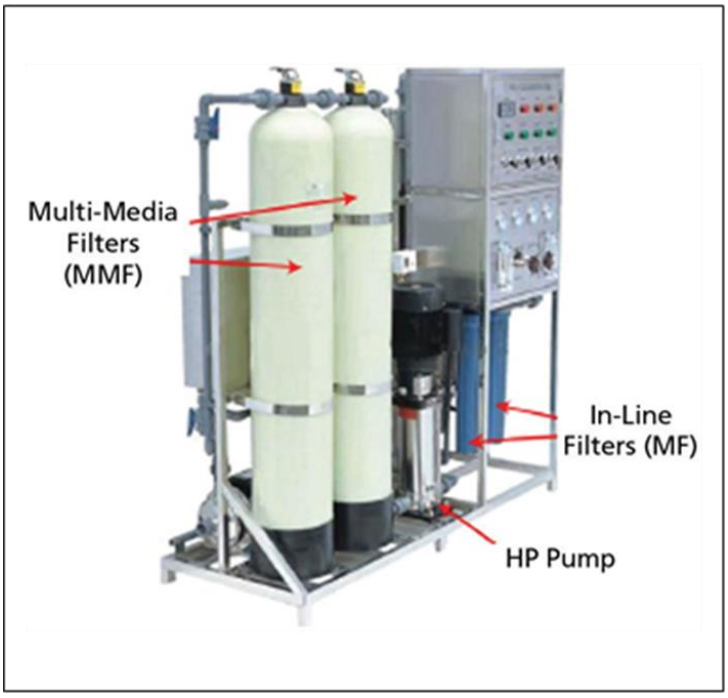


Figure 121
RO Plant

Desalination Plant

Water desalination is the removal of salt and other minerals from saline or salted water. Salt water is desalinated to produce fresh water for drinking or any other use that requires high quality fresh water.

Desalination is used on many ships and some rigs. The most common method to produce desalinized water is RO desalination.

RO desalination systems are almost the same as the systems that purify fresh water. The difference is that they process salt water instead of fresh water (figure 122).

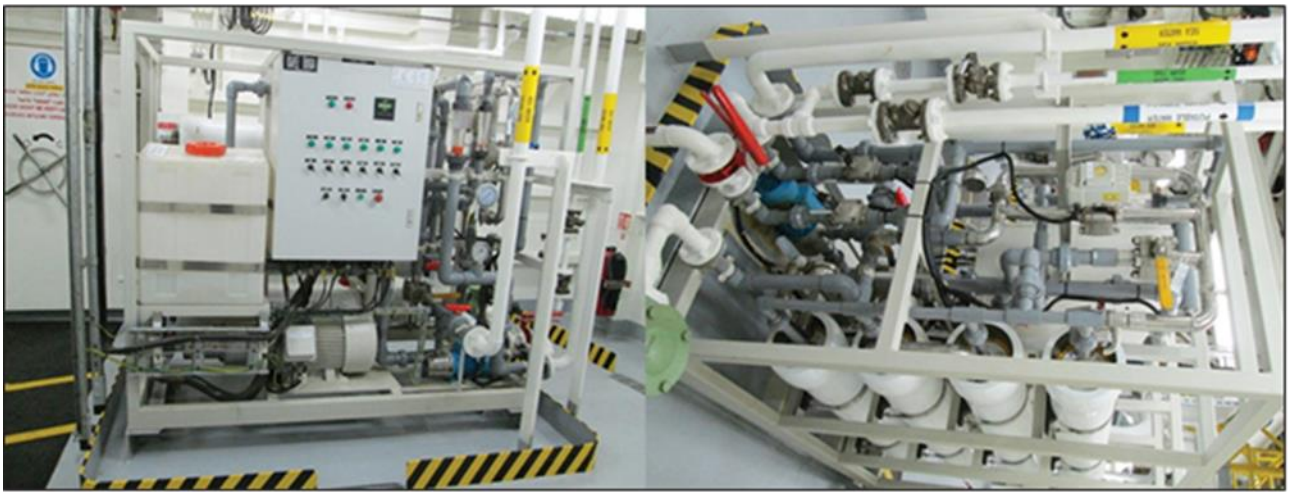


Figure 122
RO Desalination Plant

Waste Water Treatment

All offshore rigs must have waste water treatment equipment. This is to comply with international shipping laws to keep seas and oceans clean. All water releases from sea installations or vessels must be controlled. No waste water is dumped overboard into the sea before treatment.

Waste water and oily water are handled on the rig using:

- sewage treatment system
- oily water separator system

Sewage Treatment System

Waste water from the living quarters, washrooms, kitchen and clinic is directed to a sewage treatment system on the jackup rig (figure 123). This is done in order to decompose waste matter through bacterial action.

Figure 123
Sewage Treatment Plant

Oily Water Separator System

Water contaminated with oil is an unavoidable product of ships and drilling operations. Oily water separators (OWS) ensure that ships do not discharge oil when pumping out bilges. Oil may leak from any onboard machinery, or empty oil tanks could be filled with water as ballast/balance.

According to international law, water contaminated with oil must be collected and then fed to the oily water separator for treatment (figure 124).

Figure 124
Oily Water Separator Models

Oil Content Monitor

Monitoring and controlling are two main functions of an OWS unit and are performed by an oil content monitor (OCM).

The OCM (figure 125) continually checks and records the quantity of oil in the discharging water. It should never exceed 15 particles per million (ppm). The OCM activates an alarm if the oil content level goes above this value.

A signal to the control unit will activate or redirect the discharge based on the OCM's setting.

Figure 125
OCM on Oily Water Separator

SUMMARY

There are three types of offshore drilling rigs:

- jackup rigs
- semi- submersible rigs
- drill ship rigs

The auxiliary equipment that supports them includes:

- casing stabbing basket
- pedestal cranes
- helicopter deck
- anchoring equipment
- cantilever and drill floor skidding system
- RO plant

- desalination plant
- waste water treatment

EXERCISE D

Directions: Circle the correct answer to items 1 below.

1. What type of rig does Saudi Aramco use for shallow offshore drilling?

   a. Supply ships

   b. Jackup rigs

   c. Semi-submersible rigs

   d. Drill ships

2. On a jackup rig, the jacking system .

   a. moves the legs up or down

   b. use a rack and pinion system

   c. is controlled from driller's panel

   d. a and b

3. On a jackup rig, the conductor tensioner system is used to .

   a. compensate the weight of the Blowout Preventer (BOP)

   b. compensate weight of hull on the legs

   c. eliminate loads on the conductor from sea waves and currents

   d. a and c

4. Another name for the offshore stationary crane is the **pedestal crane**.

5. The **helideck** is the landing area for helicopters on an offshore rig.

6. The **cantilever system** moves the rig's substructure right or left to position it over the well.

7. What process removes salt from seawater to produce drinking water?

   Desalination

8. Which system uses electric motors to move the substructure forward and backward or left and right to position it over the well?

   Rack and Pinion Skidding System

9. Circle the rig or rigs that can be used to drill in deep water (300 ft. or more).

   a. Jackup rigs

   b. Semi-submersible

   c. Drill ship rigs

10. What system compensates for the constant change of sea height on offshore rig and keeps the conductor pipe straight as the sea level changes?

    Conductor Tensioning System

PART IV	OBJECTIVE 1.4

Identify the Procedures for Drilling Oil and Gas Wells

The purpose of drilling a well is to extract hydrocarbons. The drill bit on the rig makes a hole deep in the ground to reach a hydrocarbon reservoir. A hydrocarbon reservoir is oil and/or gas trapped in layers of rock formations deep underground.

The process and tasks involved in drilling a well include:

- rig up
- surface section
- intermediate section
- production section
- lay down the drilling string
- remove the BOP and install the wellhead
- rig down

Rig Up

Rig up means assembling the rig equipment at a new location.

A drilling rig is a group of individual machines and equipment put together to drill the well. Rig crews transport the rig in small sections to a new location. They use special equipment like cranes and large transport trucks.

When the drilling rig reaches the new well location, workers assemble the sections together in the proper order. Cranes lift the sections into position. Crane operators line up equipment for assembly (figure 126).

Figure 126
Rigging Up the Substructure

When the substructure of the rig is ready, workers lift the derrick into its standing position. The derrick is raised by hydraulic equipment, or the drawworks and raising lines (figure 127). When the derrick is standing and secured, the rig assembly continues until all the equipment is ready to drill the well.

Figure 127
Raising the Derrick

Surface Section

The surface section is the first section of the hole to be drilled. This large diameter hole is drilled to a set depth. The end depth of the surface hole depends on the rock formations being drilled. Once the surface section is drilled, the hole is cased.

The surface section involves the following activities:

- installing the conductor pipe
- BHA makeup
- spudding the well
- drilling the surface hole
- running and cementing the surface casing
- installing the BOP

Installing the Conductor Pipe

A conductor pipe (figure 128) is a large diameter pipe driven into the ground before the drilling rig arrives on site. The conductor pipe is driven into the ground to a depth of 60 ft. to 150 ft. It is cemented into the formation to prevent the drilling fluid from flowing around the outside of the conductor pipe.

The conductor stops the loose soil around the surface of the hole from falling in, or being washed away by the drilling fluid. It also stops water in the formation from entering the hole and contaminating the drilling fluid.

Figure 128
Conductor Pipe

BHA Make Up

The Bottom Hole Assembly (BHA) is built/assembled after the rig is completely rigged up. The BHA is made up of drill collars and other tools. Drill collars add weight to the drill string, so that the bit drills the rock formation. Tools in the BHA help keep the hole straight. The bit connects to the BHA to drill the formation rocks to make the well. The BHA can be 300 ft. to 1000 ft. long.

The components of the BHA are the heaviest and hardest to handle. They have the largest diameter among the drill string tools. They require the greatest amount of torque to tighten them. As the BHA drills deeper into the formation, drill pipes are added to the drillstring (figure 129).

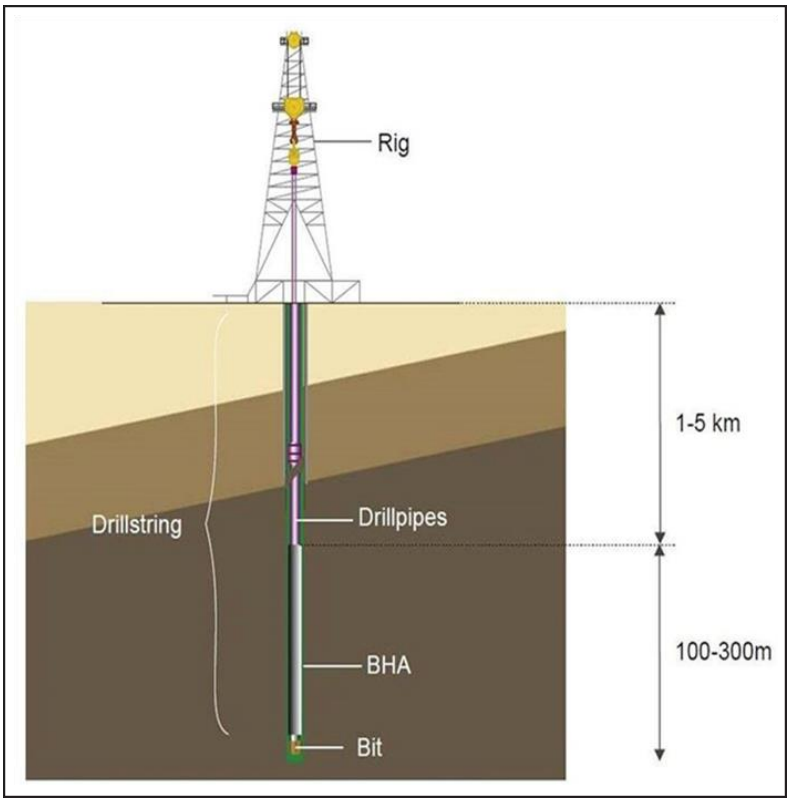


Figure 130
Bottom Hole Assembly in Drill String

Spudding the Well

"Spudding the well" is when the bit first touches the ground and begins drilling. This is the official start of the new well. The time and date are recorded, and used to measure how long it takes the crew to drill the well.

Drilling the Surface Hole

In most wells the surface hole is spudded in with water or water based mud. The end depth of the surface hole is determined by the type of formation that comes out of the hole as the rig drills deeper.

While drilling, the crew on the rig floor makes pipe connections. They also perform the following two important tasks while drilling the surface hole:

- wellbore survey
- prepare casing

Wellbore Survey

The drilled hole may not be vertical. The bit may start drilling away from a straight vertical line. This can happen due to the force of rotation on the bit or BHA. A wellbore survey measures if the hole is vertical.

The survey barrel is inserted into the drill pipe and lowered into the drill string. When the survey barrel is just above the bit, it takes a survey. The survey barrel is then removed from the drill string to read the survey.

Measurement devices range from simple pendulum-like devices to complex Measurement While Drilling (MWD) electronic devices.

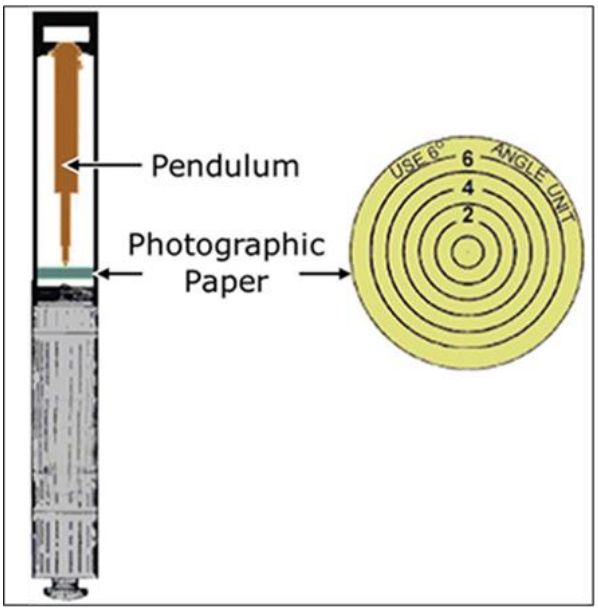


Figure 131
Survey Tool

In simple pendulum measurements, the position of a freely hanging pendulum relative to a measurement grid (attached to the housing of the tool and assumed to represent the path of the wellbore) is captured on photographic film (figure 131).

The film is developed and examined when the tool is removed from the wellbore, either on wireline or the next time pipe is tripped out of the hole.

MWD is now standard practice in offshore directional wells, where the tool cost is offset by rig time and wellbore stability considerations if other tools are used. The measurements are made downhole, stored in solid-state memory for some time and later transmitted to the surface (figure 132).

Data transmission methods usually involve digitally encoding data and transmitting to the surface as pressure pulses in the mud system.

Some MWD tools have the ability to store the measurements for later retrieval with wireline or when the tool is tripped out of the hole if the data transmission link fails.

Figure 132
MWD Device

Prepare Casing

A casing is a large diameter pipe that is inserted into the hole. The casing is run (lowered in the hole) as soon as the surface hole has been drilled.

Before running the casing, the first job is to drift the casing to check that the internal diameter of the casing meets the specified tolerance.

A tool called a drift rabbit (figure 133) is run through the length of the casing to check the internal diameter. The casing must be in good condition for tools and equipment to be able to pass through it later on.

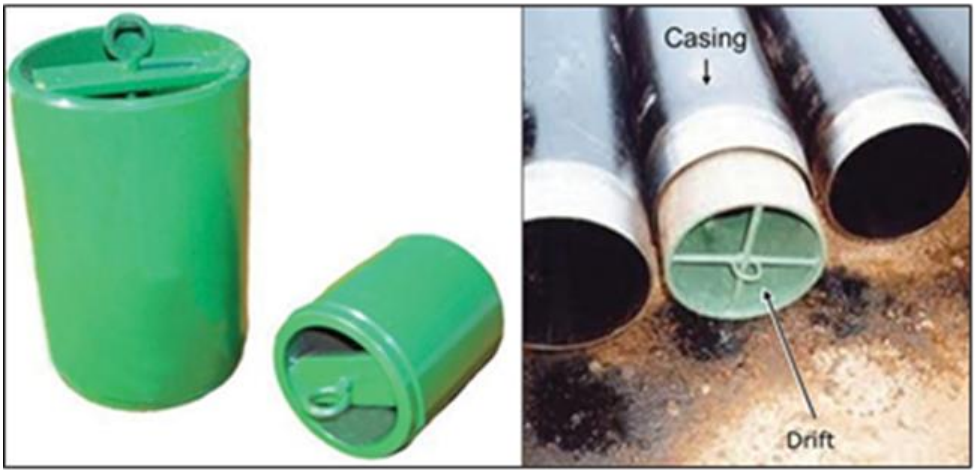


Figure 133
Casing Drift (Rabbit)

The drift is inserted at one end of the casing and a rope is used to pull it all the way through to the other end. The rabbit will pass through the casing if there are no obstructions, damage or distortion in the casing. The crew will also clean and inspect the casing threads for damage (figure 134).

Figure 134
Casing Cleaning/Inspection

Run and Cement Surface Casing

Workers cement the casing in place to prevent the hole from falling in. Casing stops fluids in the formation from getting into the hole and stops drilling fluid from leaking into the formation.

The length of time before a drilled hole is cased can affect the condition of the well. The longer a hole is left open, the more difficult it may become to run casing. It is important to prepare in advance to case the hole as soon as it is drilled.

Casing is run after every drilled section of the well. The first string of casing after the conductor is called surface casing. The surface casing is run in the hole as soon as the surface hole is drilled.

Every casing section is smaller in diameter as the well is drilled deeper (figure 135). Each casing section runs from the depth that the section is drilled to, all the way to the wellhead.

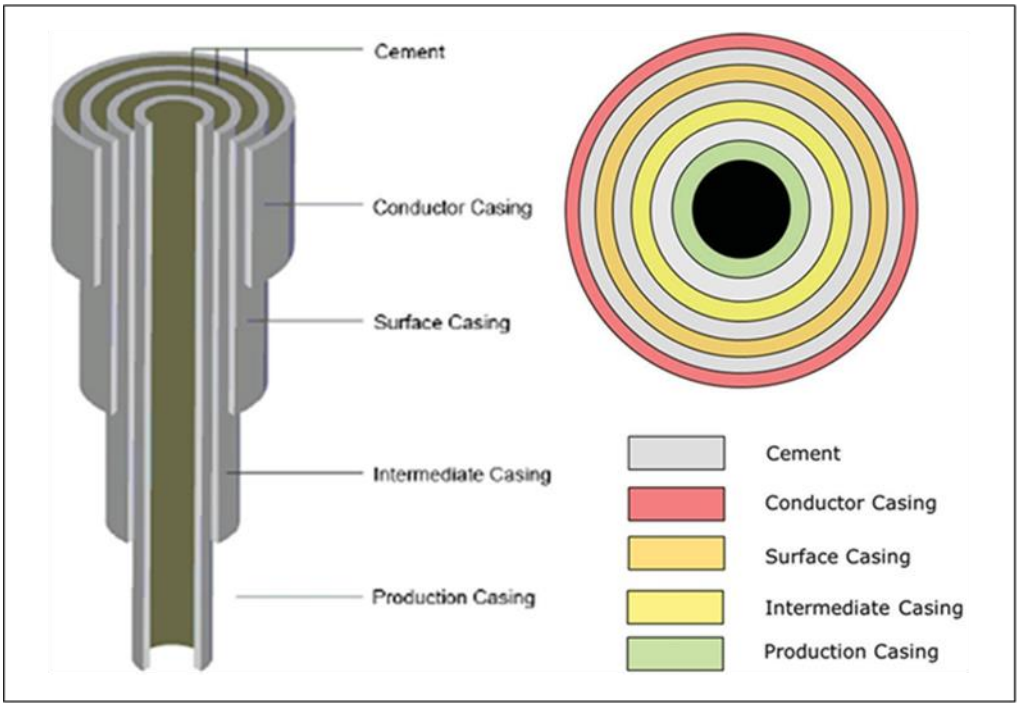


Figure 133
Casing Sections

Install the Blowout Preventer

A blowout happens when high pressure fluids from the formation reach the surface. When the hole gets deeper, there is a danger of drilling into formations that contain high pressure fluids. The blowout preventer (BOP) is usually installed after the surface section has been drilled and cased (figure 136).

The BOP is a set of seals that close off the top of the hole. The seals are used to prevent high pressure fluids from exiting the casing at surface. The seals can close around the pipe or kelly while drilling the well.

The BOP components are powered by hydraulic oil for closing and opening the parts that seal off the well. There are valves attached to the sides of the BOP. The valves allow the driller to bleed off the high pressure while the well is sealed.

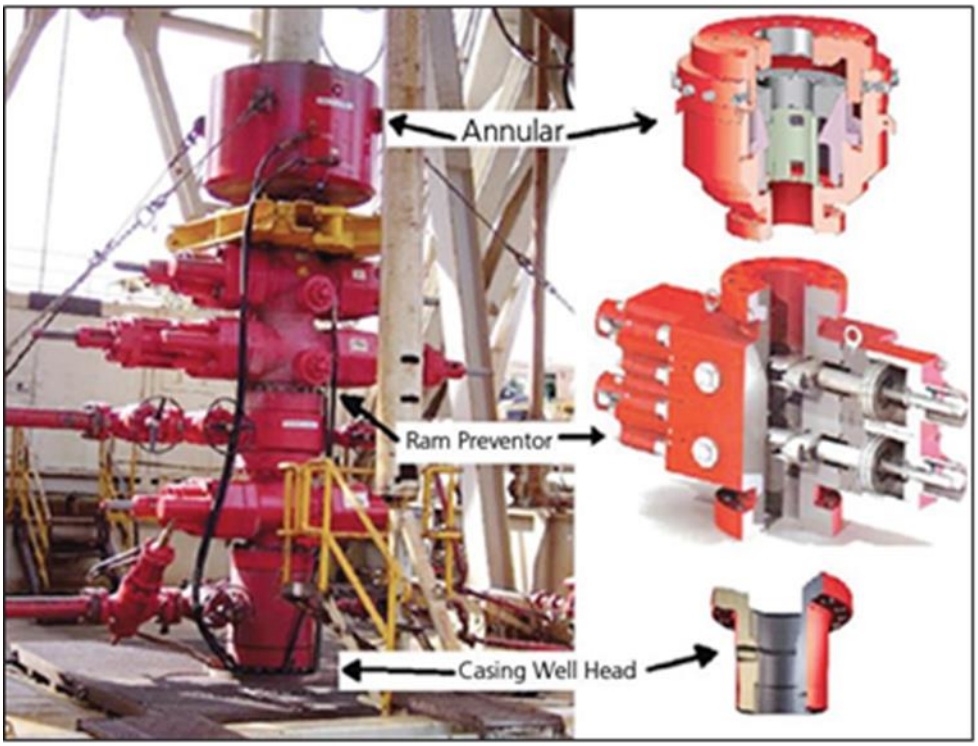


Figure 136
Blowout Preventer and Casing Wellhead

Intermediate Section

After the surface casing is cemented into the ground, and the BOP installed, the next section of the hole will be drilled. This section of the well is called the intermediate hole, or intermediate section. As with every section, the intermediate section is drilled, and then immediately cased.

Drill Intermediate Hole

This section is often the longest section of a well. There may be more than one intermediate section of the hole. The intermediate hole section runs from the surface casing shoe to the hydrocarbon reservoir.

Part of the crew's job at this stage is to collect samples of drilled cuttings from the shakers to send to the geologist. The geologist examines the samples then determines the best place to stop drilling to run casing.

Install Intermediate Casing

The intermediate casing seals off the high pressures in the reservoir formation from the weaker formations in the intermediate section. This casing is stronger than the surface casing. It has to withstand higher pressure. It also uses a different type of thread that seals better against gas.

The intermediate casing also seals off any fragile or unstable formations that may cause problems when drilling further. If an unstable formation is drilled through, the hole may have to be cased. This allows the hole to be drilled deeper without the unstable formation causing problems. This also means that more than one intermediate section has to be drilled.

When small pieces of the formation come loose and fall into the hole, it is known as sloughing (pronounced "sluffing").

Figure 137 shows an example of an unstable formation. In this example, the hole needs to be cased to avoid the sloughing shale from falling into the hole. Pieces of the formation falling into the hole make drilling difficult, and may cause the drill string to get stuck.

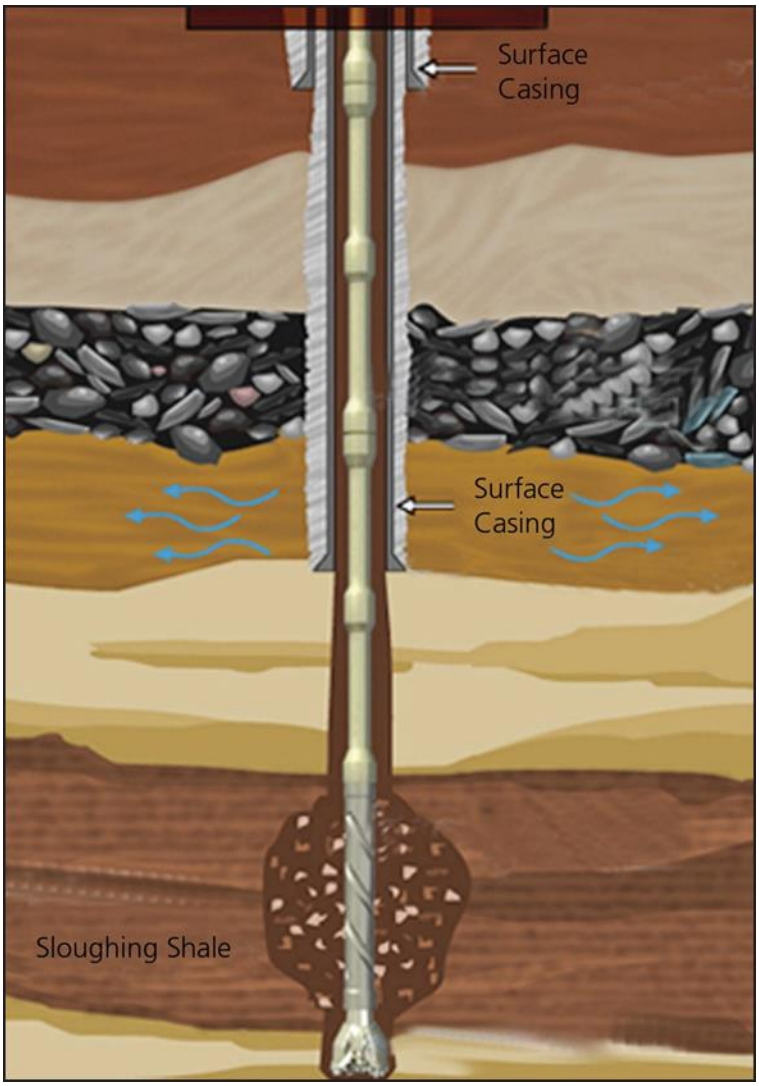


Figure 137
Sloughing (Unstable) Formation

The intermediate casing must be cemented into a strong formation; if the formation is not strong enough, it can crack under pressure which may allow gas or oil to flow around the cement and come to the surface outside of the cement and casing. This is dangerous and can cause loss of the rig.

Intermediate casing (figure 139) runs from the drilled depth, all the way to the well head at the surface.

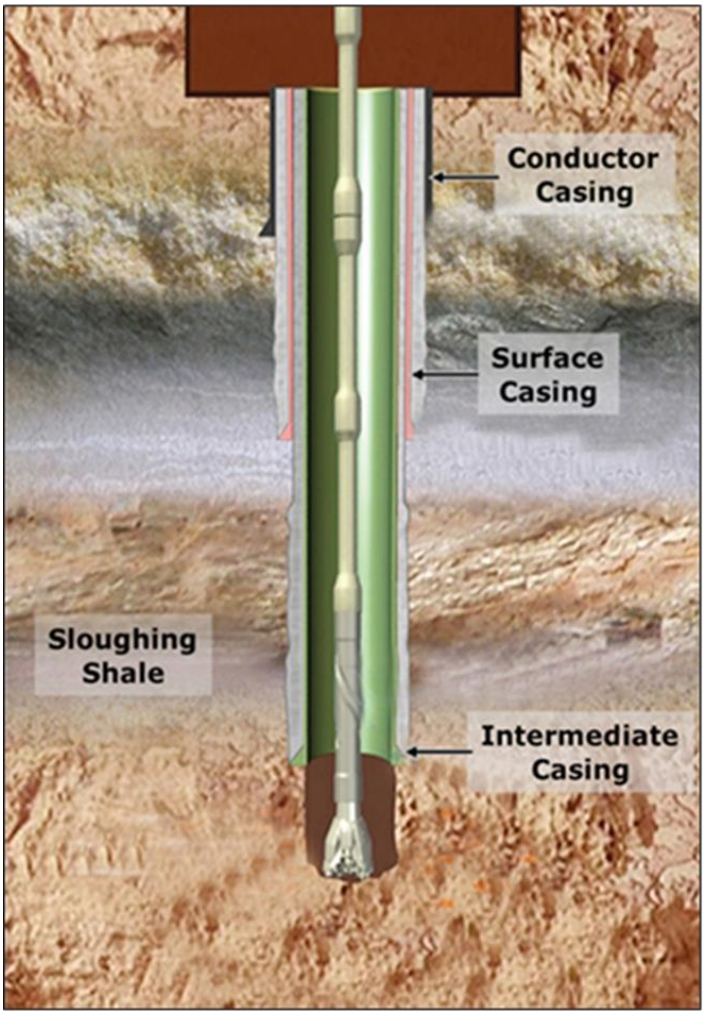


Figure 139
Intermediate Casing

Production Section

The production section of the well is the last drilled section of the well. Here the rig drills into the formation that holds the hydrocarbon reservoir. After this section of the hole is drilled, the production casing is run.

Drill Production Hole

The production hole can have the highest pressure. The formation drilled is called the hydrocarbon bearing zone. The rig must be prepared for any unexpected pressure or gas on the surface.

Run Production Casing

Production casing is the casing that is set in the target reservoir. A reservoir contains the natural resources that are the purpose for drilling the well. Production casing may have components, such as pumps or screens, which assist in getting the oil or gas to surface.

The production casing is also run to the surface. The wellhead and completion tools are installed at the end of the well.

Lay Down Drilling String

When the drilling is done and the production casing is in the hole, the drill string is put back onto the pipe rack. All equipment is stored in preparation for moving to the next well site.

Remove the BOP and Install the Wellhead

At the end of the well, the BOP is removed. This is called “nipple down” the BOP. The BOP is cleaned thoroughly and removed from under the rig.

When the BOP has been removed the wellhead (also called Production Tree or Christmas Tree) is installed (figure 140). The wellhead is a series of valves that is attached to the top of the casing. This valve assembly is used to close off the well.

After the drilling rig has moved off the location, a pipeline is attached to the wellhead. The pipeline transfers the hydrocarbons from the well to a processing facility.

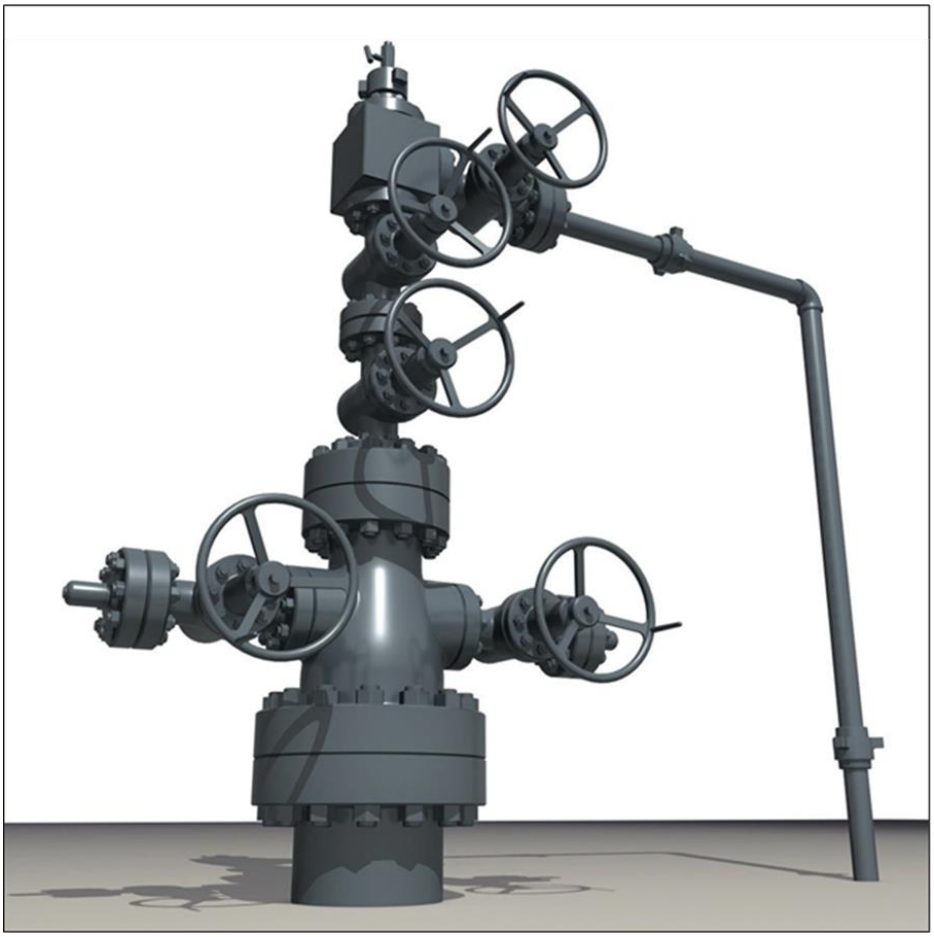


Figure 140
Wellhead/Production Tree/Christmas Tree

Tripping In and Out of a Well

A required part of the drilling process is to pull the drill string out of the hole regularly.

Pulling (the drill string) Out of the Hole (POH) is also known as “trip out”.

Running the drilling assembly back down to the bottom of the hole, or Run In Hole (RIH) is known as “trip in”.

A “round trip” operation of pulling the drill string out, and returning it to the wellbore is called "tripping".

Reasons for Pulling Out of Hole (POH)

Pulling out of hole, or a trip out is necessary for a number of reasons that include:

- reaching the Target Depth (TD) of the hole
- running casing
- replacing a worn or damaged bit
- equipment failure

Reaching TD

When the hole has been drilled to the target depth, then the drill string is tripped out. The casing can then be run into the hole.

Running Casing

Once the hole reaches a predetermined depth, the drill string is pulled out of hole in preparation to run casing. Casing is a steel pipe placed in the well to prevent the wall of the hole from caving in. Casing also prevents fluids from entering the wellbore.

Replacing a Worn/Damaged Bit

Drilling uses weight and rotation to make a hole in the rock formation which creates a lot of friction and heat between the bit and the formation. The heat and friction causes the bit to wear out over time. When the bit is worn or damaged (figure 141) it will not cut the rock as well as a new bit.

Bit damage can also be caused by objects accidently dropped in the well. This is one reason to keep tools and other equipment away from the rotary table.

Figure 141
Damaged

Equipment Failure

Equipment failure could be at surface or downhole. An example of surface equipment failure is the mud pumps. If the mud pumps cannot circulate drilling fluid, drilling cannot continue. It may be necessary to pull the drill string out of the hole until the bit is inside casing. This makes it less likely that the drill string will get stuck while the equipment is repaired.

Any part of the drill string could cause a downhole failure. Drill pipe can separate, or other tools can develop problems that require them to be replaced.

Tripping Procedure

Tripping pipe is a normal operation on the drilling rig. The pipe is either pulled out of, or run into the hole. The pipe is pulled out in single, double, or triple drill pipe stands and stood on the rig floor (figure 142). Before the drill string is pulled out, the driller will usually circulate for long enough to clean the hole.

Figure 142
Stands of Pipe on the Rig Floor and Derrick

Pulling Out of the Hole (POH)

To pull drill pipe out of the hole, the crew latches the elevators onto the top shoulder of the stand of drill pipe (figure 143). The driller then raises the traveling block to pull the pipe out.

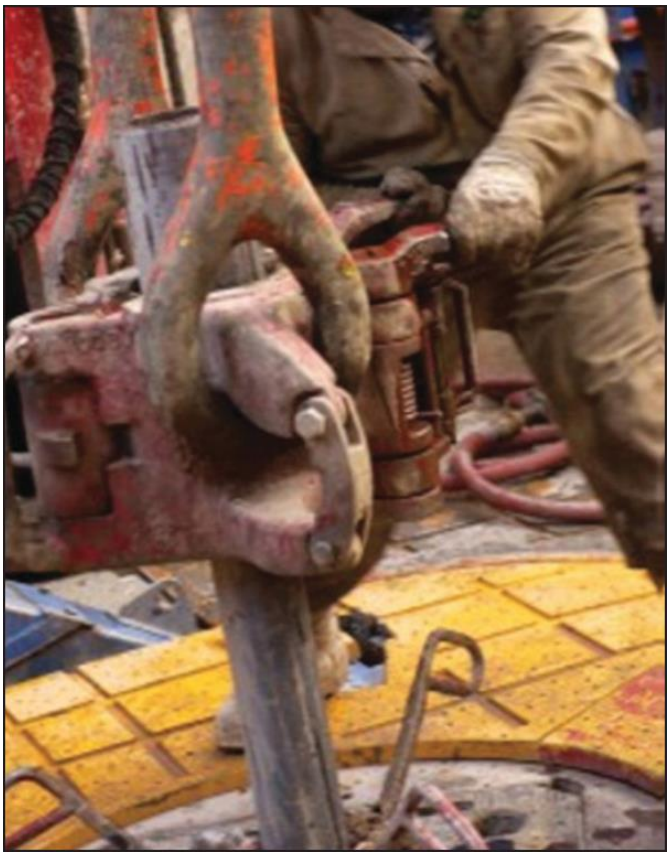


Figure 143
Elevators Holding Drill Pipe for Pulling Out of Hole

The crew pulls the slips out of the rotary table as soon as the driller starts to hoist the pipe. As soon as the stand is out of the well, the driller stops pulling. The crew then inserts the slips back into the rotary table.

The slips have to be installed so the connection between the pipes is not too high above the rotary table. If the connection is too high, the pipe will bend when the driller uses the rig tongs to break the connection.

The crew installs two tongs onto the pipe and “make the tongs bite”. This means that they swing the tongs around the pipe until the jaw closes and grips the pipe. The safety lines attached to the tongs must be tight.

The driller will then use the drawworks cathead to pull on one of the tongs' lines. This tong will loosen, or "break out", the drill pipe connection.

When breaking out a connection (figure 144), the breakout tong will hold onto the top pipe of the connection. The makeup tong will hold the drill pipe below the connection.

Figure 144
Breaking a Connection

The driller pulls on the breakout tong line. As the breakout tong tightens, the line on the makeup tong also tightens. The driller continues to pull the breakout line until the connection loosens. The tong may need to be pushed back around the pipe to try again.

After the connection is broken out, the crew installs the pipe spinner (figure 145) onto the pipe.

Closing the jaws of the pipe spinner on the pipe squeezes the rollers or a chain onto the pipe. The spinner then rotates the chain or rollers to loosen the pipe until it is completely disconnected from the pipe in the rotary table.

Figure 145
Pipe Spinner

A mud can, or bucket, is inserted over the connection (figure 146). The driller picks up on the traveling block enough to pull the pin of the stand out of the box in the rotary table. The mud can directs mud that was trapped in the pipe to drains leading to the mud tanks.

Figure 146
Mud Can/Bucket Installed on Pipe

As soon as the mud has drained, the crew removes the mud can. The driller begins to lower the stand.

The crew pushes the bottom of the stand to its standing spot on the rig floor. As soon as the pin contacts the floor, the derrickman on the monkey board (figure147) pulls the pipe into the fingerboard.

The stand is held in place by a small rope to prevent it from coming out of the fingers.

Figure 147
Derrick Man on Monkey Board

After the stand is racked, the driller lowers the block and elevators. When they are low enough, the crew latches them onto the next stand in the rotary table. Then the process repeats until all the drill string is out of the ground.

Running in Hole (RIH)

Running into the hole is the opposite of pulling the pipes out of the hole. The BHA is assembled first and run into the hole. Then the stands of pipe in the derrick are connected.

To pick up a stand of pipe, the driller runs the block up to the derrick man. The derrick man throws a drill pipe into the elevators, while grabbing the handles and closing the elevators (figure 148).

Figure 148
Derrickman Throwing a Pipe Into the Elevators

The driller continues to raise the traveling block until the pin is at chest height. The crew then guides the bottom of the pipe to the rotary table. When the pipe is lined up, the driller lowers the traveling block. As the pipe lowers, the crew guides the pin of the stand into the box of the pipe in the rotary table. This is called stabbing pipe (figure 149).

Figure 149
Stabbing Pipe

The crew installs the pipe spinner onto the stand. They close the spinner and then spin the stand into the connection. They remove the pipe spinner when it has spun the stand in as far as it can. The crew installs the make-up tong onto the pipe above the connection. The breakout tong goes onto the lower pipe. The driller torques the connection by pulling on the make-up tong line.

The driller picks up on the drilling string. This allows the crew to pull the slips out of the rotary table. The slips should be pulled far enough so they do not fall onto the rotary table while the driller lowers the pipe into the hole.

The driller lowers the pipe until the elevators are close to the rig floor. The crew sets (install) the slips into the rotary table (figure 150), when the weight of the drill string is set into the slips the elevators are opened.

One rig man looks up at the derrickman to line up the elevators. After opening and lining up the elevators, the driller raises the elevators to the derrickman to throw a pipe into it and repeat the process. When all of the pipes in the derrick are run into the hole, the kelly is installed again to continue drilling.

Figure 150
Setting the Slips

SUMMARY

You now know the purpose and sequence of procedures for drilling a well.

You learned that the first section drilled is the surface hole. Surface casing is installed when the drilling is done for that section. You also learned that time is critical and to install the casing as soon as drilling stops.

You now know that the BOP is installed to close off the well and keep gas or oil from escaping the well in an emergency.

You learned that the production casing is the string of casing that is set into the oil/gas reservoir and transports the oil or gas to the production tubing.

You have now learned the purpose and main procedure for tripping pipe.

You know that there are a number of reasons for tripping pipe. Reaching TD, hole cleaning, replacing the bit, and equipment failure are examples of why a trip might be required.

EXERCISE E

Directions: Circle the correct answer to items 1- 10 below.

1. What equipment is installed on the top of the well when the BOP is removed?

   a. Wellhead

   b. Conductor pipe

   c. Top Hole Assembly (THA)

   d. Surface casing

2. What is the last section of a well called?

   a. Intermediate section

   b. Intermediate casing

   c. Production section

   d. Conductor casing

3. Why is a wellbore survey carried out?

   a. To ensure the horizontal direction of the drill string is correct

   b. To check that the drill string is not drifting away from the vertical

   c. To identify areas of sloughing shale before drilling starts

   d. To calculate the diameter of the conductor pipe

4. What is the purpose of a drift?

   a. To stop drilling fluid causing the drill string to drift in the wrong direction

   b. To install the intermediate casing correctly

   c. To make sure that the drill string is not drifting away from the vertical

   d. To check internal diameter of the casing meets the specified tolerance

5. What is the first part of the well to be drilled?

   a. Initial section

   b. Surface section

   c. Production section

   d. Intermediate section

6. What is latched to the top of the stand of drill pipe to pull it out of the hole?

   a. The elevator

   b. The slips

   c. The kelly

   d. The break-out tong

7. Why should a rig man look up to the derrickman when the elevator is opened?

a. To make sure the elevator has opened

b. To line up the elevator

c. To install the kelly

d. To line up the elevator and the slips

8. Where does the production casing run to?

a. To the bottom of the intermediate casing only

b. To the bottom of the surface only

c. To the bottom of the conductor pipe only

d. All the way to the surface

9. When must the BOP be functionally and pressure tested?

a. After installation and during operations

b. Before installation and removal only

c. Before installation only

d. During operations only

10. Which drilled hole has the highest pressure?

a. Surface hole

b. Intermediate hole

c. Production hole

d. Conductor pipe

Agitate

To move or stir up a liquid or gas.

Anchor

To connect something to a solid base or hold something firmly in place.

Assemble

To connect or put together the parts of something.

Baffle

A device that slows the flow of a liquid or gas.

Clamp

To hold something tight or press things tightly together with a device. A device used to hold things or press them tightly together.

Compartment

An enclosed space or area that is usually part of something larger and is often used to hold a specific thing.

Console

A flat surface that has the controls for a machine.

Conventional

Standard, usual or traditional.

Crane

A machine with a long arm that lifts and moves heavy objects.

Diameter

The distance through the center of something circular from one side to the other.

Dismantle

To take something apart, such as a machine or structure, so that it is in separate pieces.

Drum

A machine or part of a machine that is shaped like a cylinder.

Evacuate

To leave, or be removed from, a dangerous place in an emergency.

Grip

To hold tightly, or a part for holding something.

Groove

A long, narrow cut or channel in a surface.

Hinge

A movable joint of metal or plastic used to fasten two parts together and allow one of them to move, such as the top on a box.

Integrated

Having different parts working together as one whole or unit.

Interface

A device that allows communication with equipment and between equipment parts.

Intermediate

Something that happens in the middle of a process or series.

Jaws

Two parts of a machine or tool that open and close to hold or crush something.

Latch

A device for holding a door, gate, or hatch closed; a latch is a movable bar that drops into a hole or opening.

Lever

A handle that operates or adjusts something on a machine, vehicle, device, etc.

Parameter

A value or limit that controls how something should be done.

Pinch

To press against, or squeeze a part of the body in a painful way.

Piston

A metal cylinder that slides up and down inside a tubular housing, receiving pressure from or exerting pressure on a fluid.

Pit

A hole in the ground usually made by digging.

Pulley

A device that uses a rope or chain to lift or move heavy weights.

Rack

A frame or stand that has shelves, hooks, slots, etc., in which or on which you place things.

Ramp

A surface with a slope that joins two surfaces that are at different levels or heights.

Reel

A device shaped like a cylinder that has a string, cord, or wire, wrapped around it. As a verb, reel in means pull in, and reel out means let out.

Sheave

A wheel with a groove for a rope to run on, as in a pulley block.

Spool

A round object that is made to have something such as thread, wire, or tape wrapped around it.

Spudding

To start the well drilling process by penetrating rock and other sedimentary material with the drill bit.

Thread

The raised line that curves around a screw or around the inside of the lid of a container.

Tubular

In the shape of a tube, or made of a tube or tubes.

Winch

A machine that has wire rope or chain used for pulling or lifting heavy things.

FINAL TEST ANSWER KEY

Circle the most correct answer. Minimum passing score 70% (14 out of 20 questions correct).

Objective 1.1

1. Who gives instructions and assigns tasks to a Rig man?

   a. Driller

   b. Assistant Driller

   c. Mud Engineer

   d. Rig Foreman

2. Who is responsible for the well and all operations?

   a. Driller

   b. Assistant Driller

   c. Mud Engineer

   d. Rig Foreman

3. Who assists in drilling operations and performs maintenance?

   a. Driller

   b. Assistant Driller

   c. Mechanic

   d. Rig man

4. Who must be trained and certified to maintain hydraulic equipment?

a. Driller

b. Assistant Driller

c. Mechanic

d. Rig man

5. Who operates the main drilling equipment?

a. Driller

b. Assistant Driller

c. Electrician

d. Rig man

Objective1.2

6. What is mandatory to wear when travelling to a rig by boat or helicopter?

a. Hard hat

b. Safety Boots

c. Life Jacket

d. Safety glasses

7. What is the height above which you must wear a safety harness?

   a. 2 meters or 6 feet

   b. 1.8 meters or 6 feet

   c. 1 meter or 3 feet

   d. 5 meters or 15 feet

8. What is a man down emergency situation?

   a. A person who is only injured

   b. A person who is only unconscious

   c. A person who is injured or unconscious

   d. A person who is injured, unconscious or missing

9. What is used to pull people away from an electrical hazard?

   a. Drilling Line

   b. Boat Hook

   c. Insulated Hook

   d. Electrical Hook

10. Which gas on the rig is both toxic and flammable and must be detected with a gas detector?

    a. Carbon Monoxide

    b. Hydrogen Sulfide

    c. Oxygen

    d. None of the above

Objective 1.3

11. What part of a drilling rig supports the crown block?

    a. Derrick

    b. Draw works

    c. Dead line anchor

    d. Hook

12. Where is the highest noise area of a drilling rig?

    a. Catwalk

    b. Mud tanks

    c. Rig floor

    d. Generator area

13. Which system is used to turn the drill string in the well?

    a. Circulating system

    b. Rotating system

    c. Well control system

    d. Hoisting system

14. On a jackup rig, the jacking system .

    a. moves the legs up or down

    b. use a rack and pinion system

    c. is controlled from driller's panel

    d. a and b

15. On a jackup rig, the conductor tensioner system is used to .

    a. compensate the weight of the Blowout Preventer (BOP)

    b. compensate weight of hull on the legs

    c. eliminate loads on the conductor from sea waves and currents

    d. a and c

Objective 1.4

16. What is the purpose of a drift?

    a. To stop drilling fluid causing the drill string to drift in the wrong direction

    b. To install the intermediate casing correctly

    c. To make sure that the drill string is not drifting away from the vertical

    d. To check internal diameter of the casing meets the specified tolerance

17. What is the first part of the well to be drilled?

    a. Initial section

    b. Surface section

    c. Production section

    d. Intermediate section

18. What is latched to the top of the stand of drill pipe to pull it out of the hole?

    a. The elevator

    b. The slips

    c. The kelly

    d. The break-out tong

19. Why should a rig man look up to the derrickman when the elevator is opened?

    a. To make sure the elevator has opened

    b. To line up the elevator

    c. To install the kelly

    d. To line up the elevator and the slips

20. Where does the production casing run to?

    a. To the bottom of the intermediate casing only

    b. To the bottom of the surface only

    c. To the bottom of the conductor pipe only

    d. All the way to the surface

Name: _____ ID #:_____Date:_____

Circle the most correct answer. Minimum passing score 70% (14 out of 20 questions correct).

Objective 1.1

1. Who gives instructions and assigns tasks to a Rig man?

   a. Driller

   b. Assistant Driller

   c. Mud Engineer

   d. Rig Foreman

2. Who is responsible for the well and all operations?

   a. Driller

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