Student Handbook

FUNDAMENTALS OF DRILLING & WORKOVER OPERATIONS

SAUDI ARABIAN DRILLING ACADEMY (SADA)
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Preface

The Fundamentals of Drilling and Workover Operations textbook has been published in 2018 to serve as a reference book for Saudi Arabian Drilling Academy (SADA) students.

This textbook has been designed for readers that have none or limited knowledge on the subject of Rig Drilling. The textbook covers a wide range of topics related to " Drilling & Workover Operations", beginning from the origin of hydrocarbons, rotary drilling, major rig types and systems to common operations, common practices in modern drilling and workover. The textbook is edited and intended to raise the knowledge of its readers on the subjects covered to the level of 'awareness.' Therefore, this book can be considered as a foundation for higher level of technical education on the fundamentals of drilling and wellsite operations. The manual is well structured to represent the order of operations normally being practiced on a real life rig drilling operation.

Relevant Saudi Aramco handbooks and manuals have extensively been used in the development of this textbook. The sections that have extensive use of Saudi Aramco materials have been cited and listed at the last page of the this textbook. It is also worth mentioning that it would not have been possible to come up with this reference book without the generous support received from Saudi Aramco and (SADA) stake holders.

SADA appreciates all stakeholders for their contribution to the program development.

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1. HYDROCARBONS

1.1 IMPORTANCE OF HYDROCARBONS IN OUR DAILY LIFE

A hydrocarbon is a molecule whose structure includes only hydrogen and carbon atoms.

Because they are the building blocks of everything that define modern society. They are actually too important to burn, even though we mainly use them as fuel. All modern medicine, material science (polymers, semi-conductors, LED, etc.) are synthetic products of hydrocarbons. When HC's are gone, those products are gone with them...

Examples of Hydrocarbons:

- Natural gas and fuels

  - Many of the natural fuel sources we use are hydrocarbons. Compounds like methane, butane, propane, and hexane are all hydrocarbons. Their chemical formulas consist of only carbon and hydrogen atoms, in a variety of ratios and chemical configurations.

- Plastics

  - Many of the plastics we use in everyday life and in industry are made from long chains of monomers, formed from petrochemicals. These petrochemicals are simply hydrocarbons of different chemical compositions.

- Paraffin
  - The wax that we use for a variety of industries, everything from candle making and food preservation to medical and industrial uses, contains hydrocarbons.
- Isopropyl alcohol
  - This common medical chemical is interesting in that it contains a hydrocarbon.
- Asphalt
  - the common substance that most people are familiar with is actually a hydrocarbon that has been heated to form the substance tar. It is then mixed with other key industrial ingredients to form the mixture that makes up the road's surface.

Over the past decade, global primary energy consumption has increased by 17%. For overall energy consumption, Hydrocarbons continued to maintain a dominant share. Oil led all sources with a third of global energy consumption.

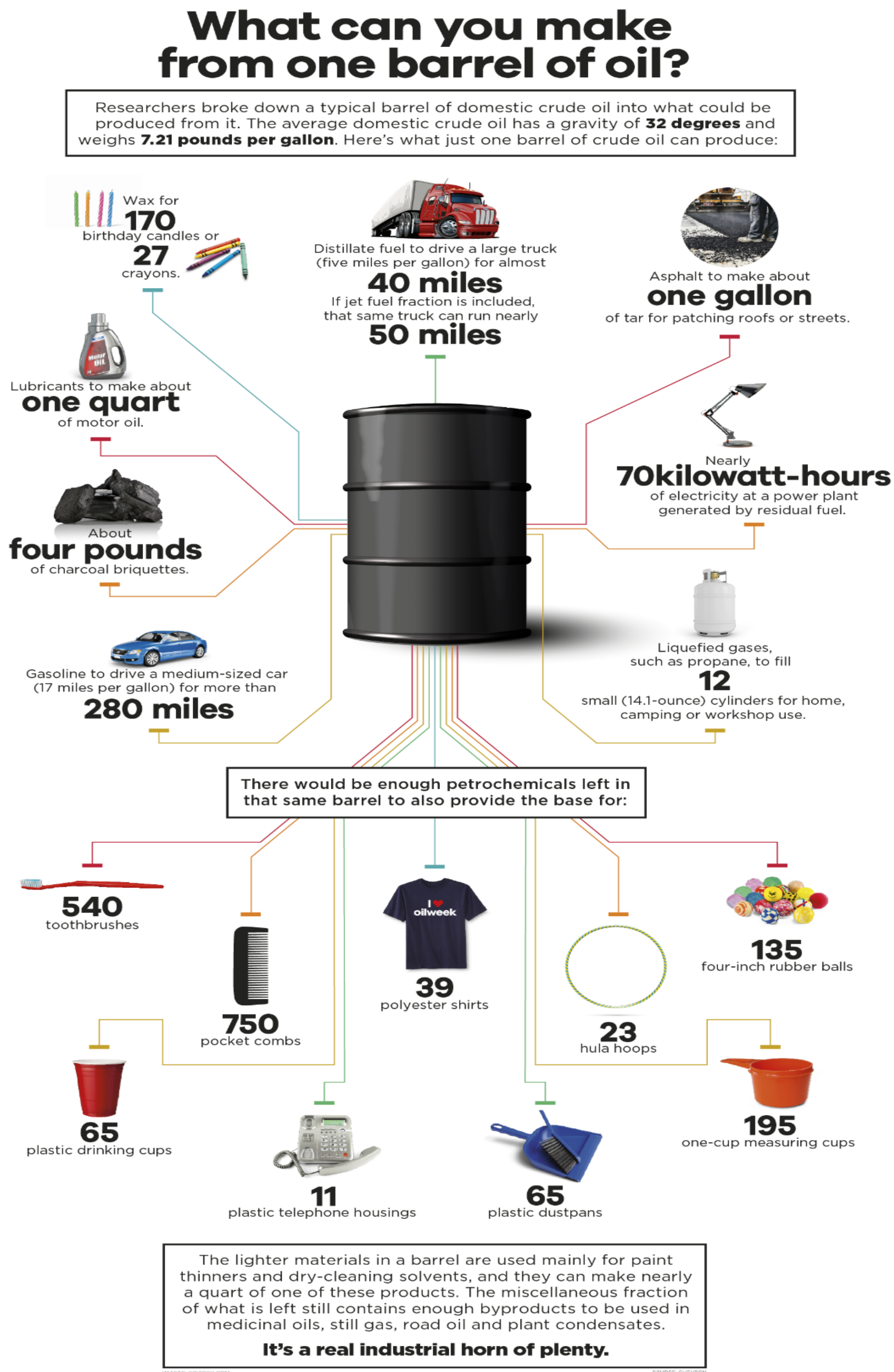


Figure 1 Importance of hydrocarbon in our daily life

1.2 ORIGIN OF OIL AND GAS

Hydrocarbons form by decomposition of living organisms under increasing temperature and pressure in millions of years.

Living organisms (plants, sea creatures, sea animals) will settle at the sea bottom once they die. They will be buried with further deposition exposing them to the rising temperature and pressure. As they decay with the help of earths radioactivity, they turn into hydrocarbons.

The first rock where hydrocarbons are formed called **the source rock**. Hydrocarbons will migrate up if they can find fractures in the source rock till they are trapped by a seal rock.

They then will accumulate under making oil and gas **conventional reservoirs**. Hydrocarbon reservoirs are limited. Once depleted it will take millions of years to generate them back.

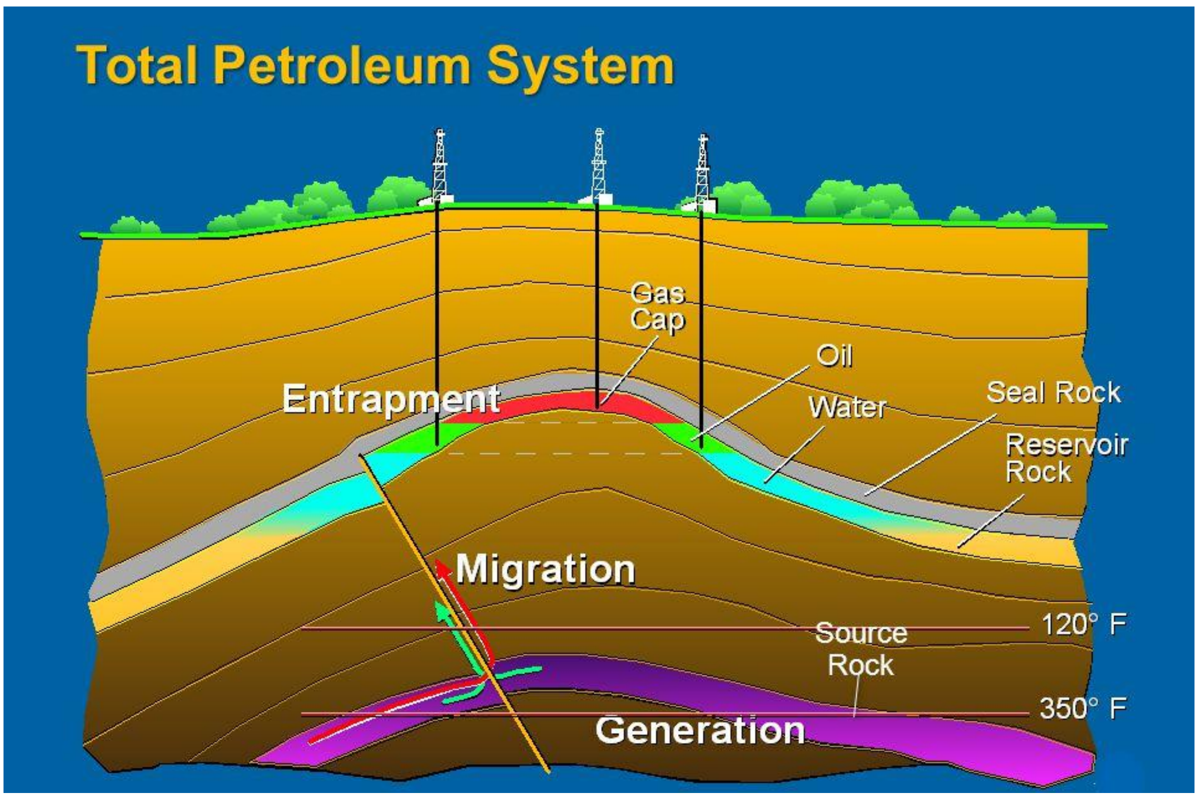


Figure 2 Total Petroleum system

1.3 IMPORTANCE OF HYDROCARBONS FOR SAUDI ARABIA

Saudi Arabia and the other Gulf countries have reserves of mostly conventional high-grade oil. Venezuela's huge reserve numbers come from the massive heavy oil deposits in the Orinoco Basin, while Canada's come from the oil sands. Extracting these heavier oil sources is more energy and carbon-intensive than the high-quality Gulf oil.

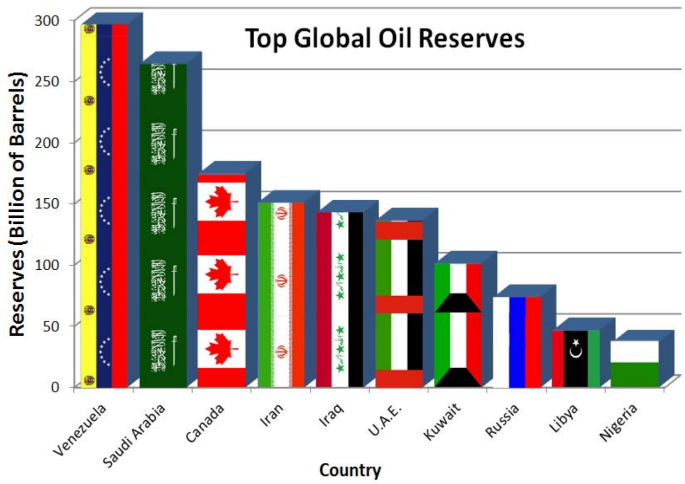


Figure 3 Top global oil reserves

Oil has largely transformed Saudi Arabia from an agricultural and basic-trade economy into a powerful oil-based one.

From ancient times to the 1930s, the inhabitants of what is now Saudi Arabia were Bedouin relying on livestock for survival or farmers and traders residing in a few towns, with some fishermen and, later, pearl divers, along the coast. Fueled by enormous revenues from oil exports, the economy boomed during the 1970s and 1980s. Unlike most developing countries, Saudi Arabia had an abundance of capital, and vast development projects sprang up, turning the once underdeveloped country into a modern state.

The economy of Saudi Arabia is now centered on the country's enormous petroleum resources. (Although Saudi Arabia also has large natural-gas reserves, the gas sector has been less important to the country's economy, and Saudi Arabia is not a natural-gas exporter.) Since the 1970s, the country has been the world's largest crude-oil exporter, and it possesses the world's largest proven conventional crude-oil reserves (estimated to be about 20 percent of the world's total proven crude-oil reserves). Saudi Arabia's unique ability to bring on or cut large amounts of crude-oil production (and hence exports) means that no other country has as much voluntary influence on the world crude-oil market; Saudi Arabia is thus referred to as the world's 'swing producer'. Within the Organization of Oil Producing and Exporting Countries (OPEC), of which it was a founding member, Saudi Arabia is of paramount influence, as other members are significantly smaller producers and have less ability to manipulate production voluntarily.

Saudi Arabia possesses around 22 per cent of the world's proven petroleum reserves and ranks as the largest exporter of petroleum.

Saudi Arabia takes the second spot on this list of the top 10 oil-producing countries. Its output came in at 12,090,000 bpd in 2017.

USA	15,647,000 bbl/day
Saudi Arabia	12,090,000 bbl/day
Russia	11,210,000 bbl/day

The oil and gas sector accounts for about 50 per cent of gross domestic product, and about 85 per cent of export earnings. Apart from petroleum, the Kingdom's other natural resources include natural gas, iron ore, gold, and copper.

Organization of Petroleum Exporting Countries (OPEC) is a consortium of oil-exporting nations, decided to maintain the current production level at a meeting in November 2014. Saudi Arabia - the biggest oil producer with around 30 percent quota of the organization's total production blocked calls for a production decrease from poorer countries in the organization.

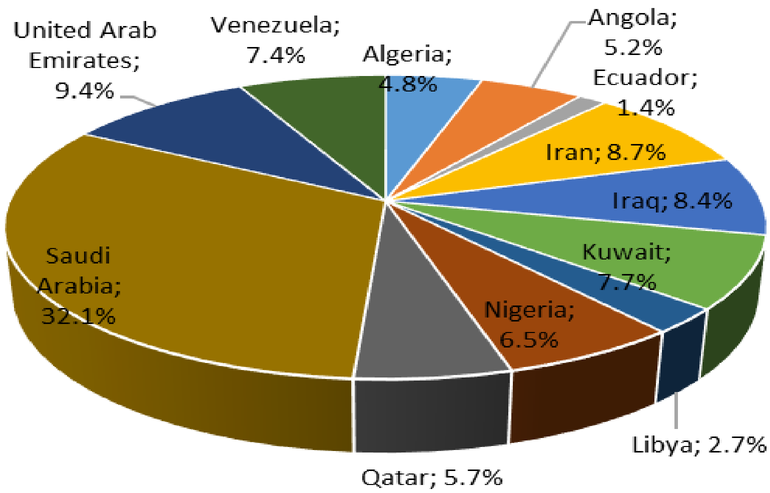


Figure 4 OPEC countries oil production percentages

2. HYDROCARBONS LIFE CYCLE

2.1 HOW TO EXPLORE AND EXTRACT HYDROCARBONS

The life of an oil and gas field can be sub divided into the following phases.

- Seismic phase
- Exploration phase
- Appraisal (Drilling) phase
- Development phase
- Maintenance/workover phase
- Abandonment

2.1.1 Seismic phase

Oil and gas explorers use seismic surveys to produce detailed images of the various rock types and their location beneath the Earth's surface and they use this information to determine the location and size of oil and gas reservoirs.

Seismic is in a way like a medical x-ray scan. As x-ray gives an idea about human inside, the seismic gives information about the earth crust.

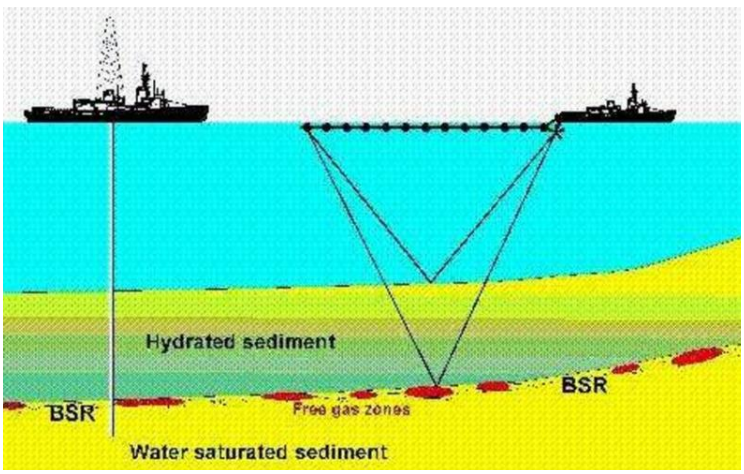


Figure 5 Seismic Operation

At this stage we are not sure if there is oil or not. The next phase is to drill an exploration well to find out if the structure has hydrocarbons in it.

2.1.2 Exploration phase

Exploration wells are drilled for data collection in new regions. Information is mainly represented by drilled rock, core samples, well tests and well logging data.

The length of the exploration phase will depend on the success of making discoveries. There may be single exploration well or many exploration wells drilled.

Once exploration drilling is completed, it is time to study all the findings. The hydrocarbon type and the approximate volume are being studied. Are the reservoir properties constant? That is what will be studied in the appraisal phase.

2.1.3 Appraisal phase (Drilling field boundaries wells)

If an economically attractive discovery is made, then the company enters the appraisal phase of the life of the field.

During this phase more seismic studies may be performed and more wells will be drilled to establish the extent of the reservoir. These appraisal wells will yield further information, on the basis of which future plans will be based.

2.1.4 Development phase (Drilling field wells)

Once the appraisal phase has been completed and the reservoir is decided to be developed. The next step is to identify how many producing wells and injection wells are need to be drilled. The moment the producers are drilled and completed, the reservoir is considered a producing reservoir. So, you will need surface facilities ready to separate gas, oil and water phases from the production.

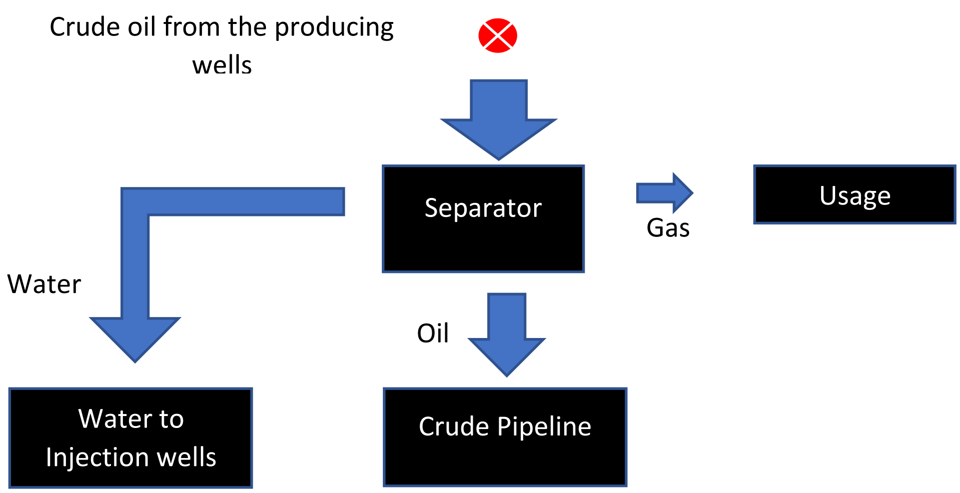


Figure 6 Surface Facilities

2.1.5 Maintenance phase (work over)

The well will not keep its initial production constant for various reasons. Therefore, some maintenance may be needed to regain the production as much as possible.

2.1.6 Abandonment phase

Once the well completes its economic life which is called a depleted well, it is time to initiate the abandonment phase. There are a number of proper procedures to be followed before leaving the depleted producers.

2.2 Companies work in drilling industry

2.2.1 Operator company

The company that serves as the overall manager and decision-maker of a drilling project. Generally, but not always, the operator will have the largest financial stake in the project. At the successful completion of logging the target zones, the decision to complete or plug and abandon generally has partner input and potential override clauses. As far as the drilling contractor and service companies are concerned, the designated operator is paying for the entire operation, and the operator is responsible for recouping some of that expense from the partners.

2.2.2 Drilling contractor company

The company that owns and operates a drilling rig. The drilling contractor usually charges a fixed daily rate for its hardware (the rig) and software (the people), plus certain extraordinary expenses.

2.2.3 Service company

The company which provide services to the petroleum exploration and production industry but do not typically produce petroleum themselves

2.2.4 Inspection company

The company which provide inspection service to the companies work in oil and gas field.

2.2.5 Catering company

The company which provide catering service to the companies work in oil and gas field.

2.2.6 Transportation company

The company which provide transportation service to the companies work in oil and gas field.

2.2.7 Training company

The company which provide Training service to the companies work in oil and gas field.

2.2.8 Companies Contributering in SADA

2.3 SUMMARY

Hydrocarbon products are everywhere in our daily life. Oil and Gas are two important natural energy resources made up of hydrocarbons. The Kingdom of Saudi Arabia is a major producer of Oil and Gas in the world. It ranks the 3rd in the world and the first among the OPEC countries in terms of daily production. They are the two important natural resources which helps immensely in the development of the country.

The process of extracting oil and gas from beneath the earth has some major phases. Included in these phases are exploration phase, appraisal phase, development phase, workover phase and abandonment phase.

3. ROTARY DRILLING PROCESS

3.1 ROTARY DRILLING OVERVIEW

The concept of rotary drilling has evolved and grown over time. Leonardo da Vinci created a design for a rotary drill in the early 1500s; it closely resembled the rotary drilling method employed today. Even though rotary drilling has had an early beginning, its use did not gain popularity until the late 1800s to early 1900s. Though there were many patents for rotary drills as early as the 1830s, the first one was invented by Englishman Robert Beart in 1845.

Rotary drilling was first used for drilling oil wells in 1901 when Captain Anthony Lucas and Patillo Higgins applied it to their Spindletop well in Texas. By 1925, the rotary drilling method was improved with the use of a diesel engine.

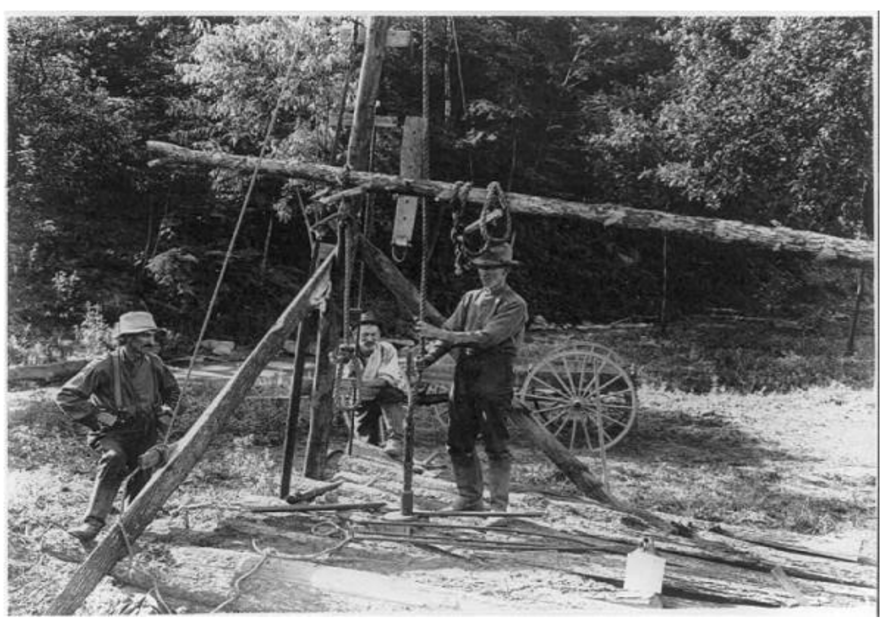


Figure 7 Historical pictures for rotary drilling

Rotary drilling is characterized as a method of drilling that employs a sharp, rotational drill bit to bite its way through the earth's crust. It is used in the construction, mining, and oil industries for its ability to cut through even the most challenging and hardest formations.

A bit is mounted on the lower end of drill pipe and is rotated against the bottom of the hole. A drilling mud is circulated down the hole, ordinarily through the drill pipe, and back up to the surface through the annulus between the drill pipe and the borehole wall.

The drilling mud serves several purposes. It supplies a fluid medium for carrying the cuttings from the hole to the surface, exerts a hydrostatic pressure against the borehole wall which opposes flow of subsurface fluids into the borehole during the drilling operation, cools the bit, and in some instances forms a filter cake of low permeability on the borehole wall to prevent flow of the fluids from the borehole into the formations penetrated thereby.

Frequently extreme pressure lubricating additives are incorporated in the drilling mud, and in such instances the drilling mud lubricates the bearings of the drill bit.

The rotary drilling rig consists of a prime mover, hoisting equipment, rotating equipment and circulation equipment, all of which perform tasks crucial to drilling a well or hole. With the help of pneumatics, hydraulics or an electric motor, high torque and rotation are transmitted from the prime mover to the drill, which sits on a mast above the hole.

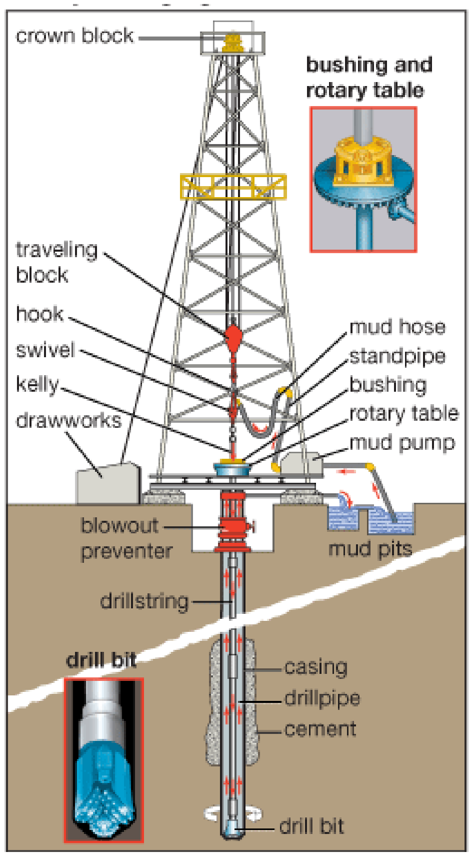
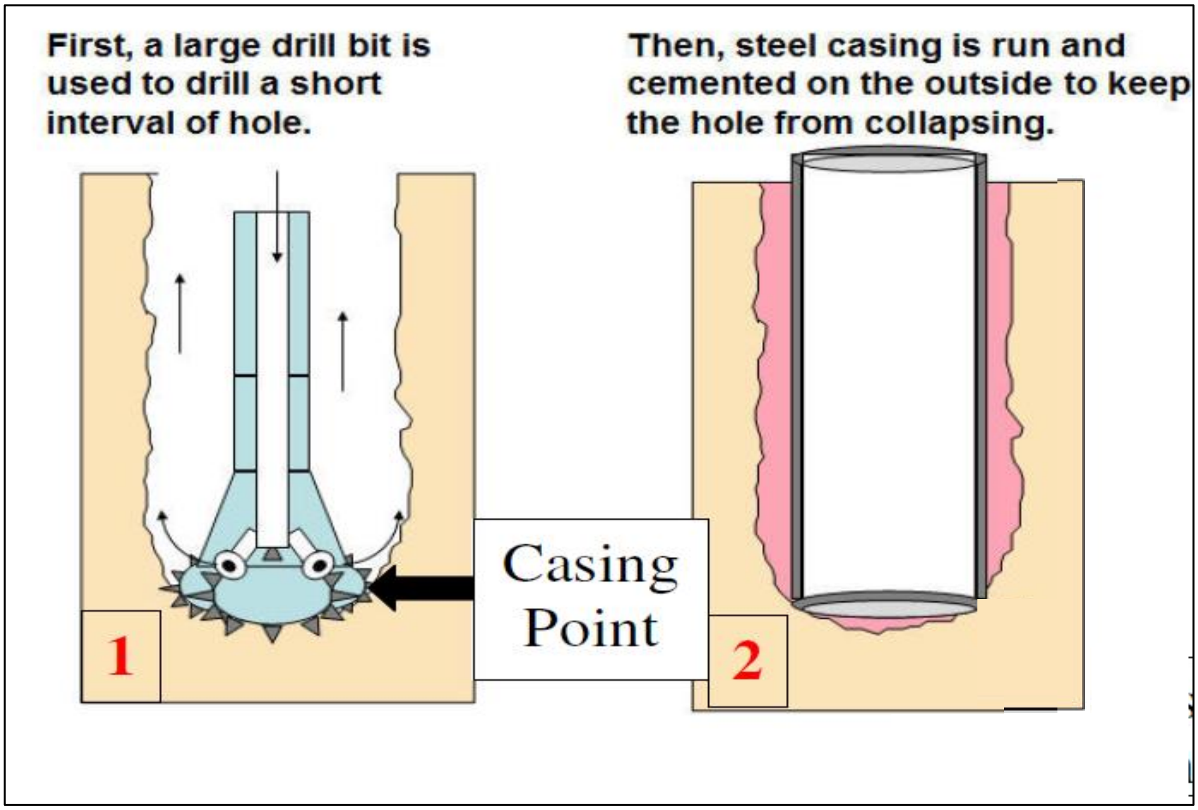
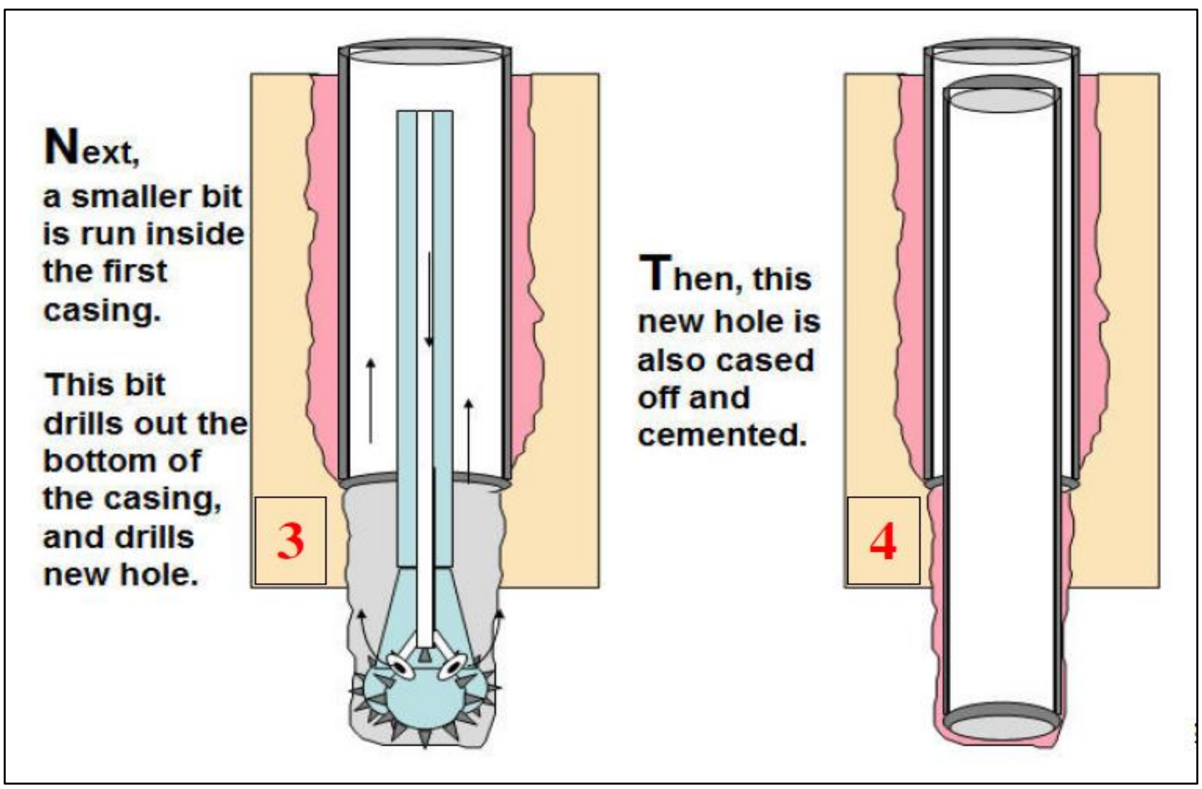
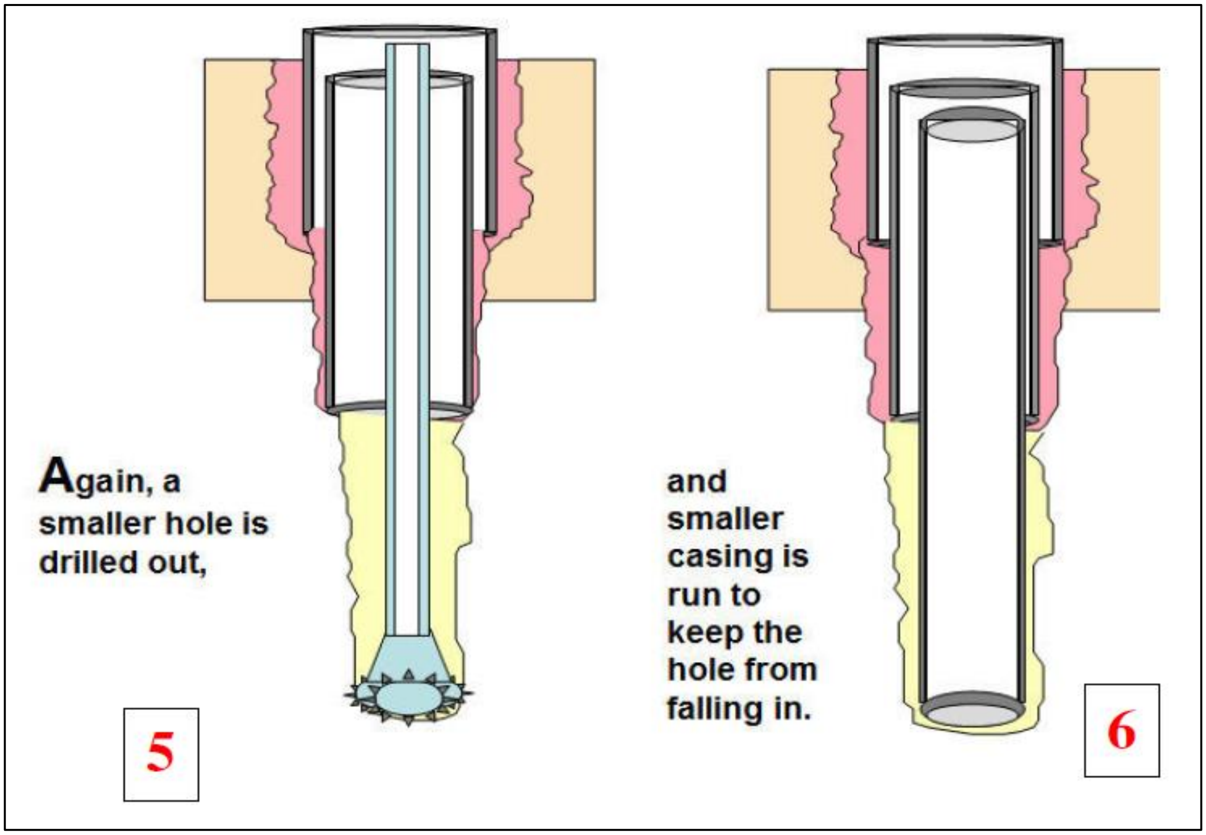


Figure 8 Rotary drilling rig

3.2 OIL AND GAS WELLS DRILLING SEQUENCES






Again, a smaller hole is drilled out,
and smaller casing is run to keep the hole from falling in.
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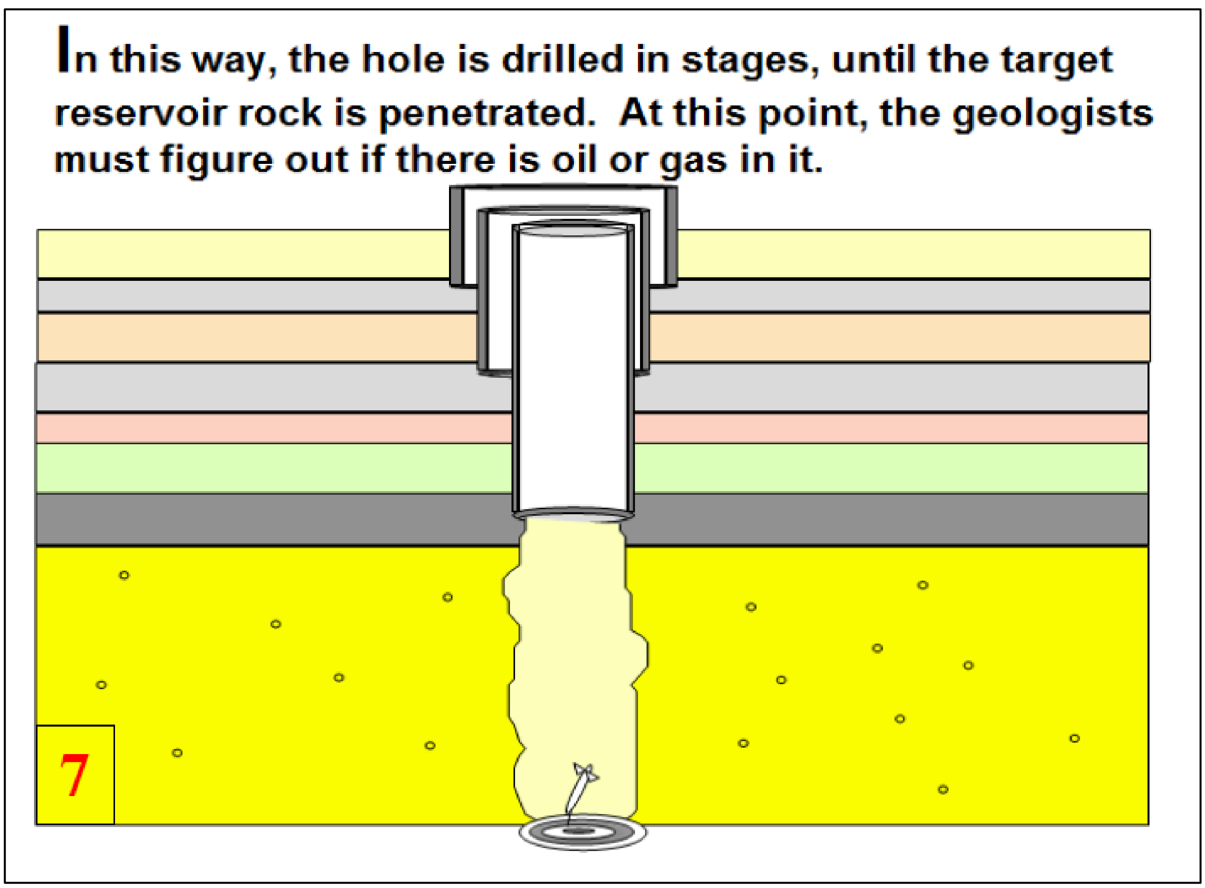
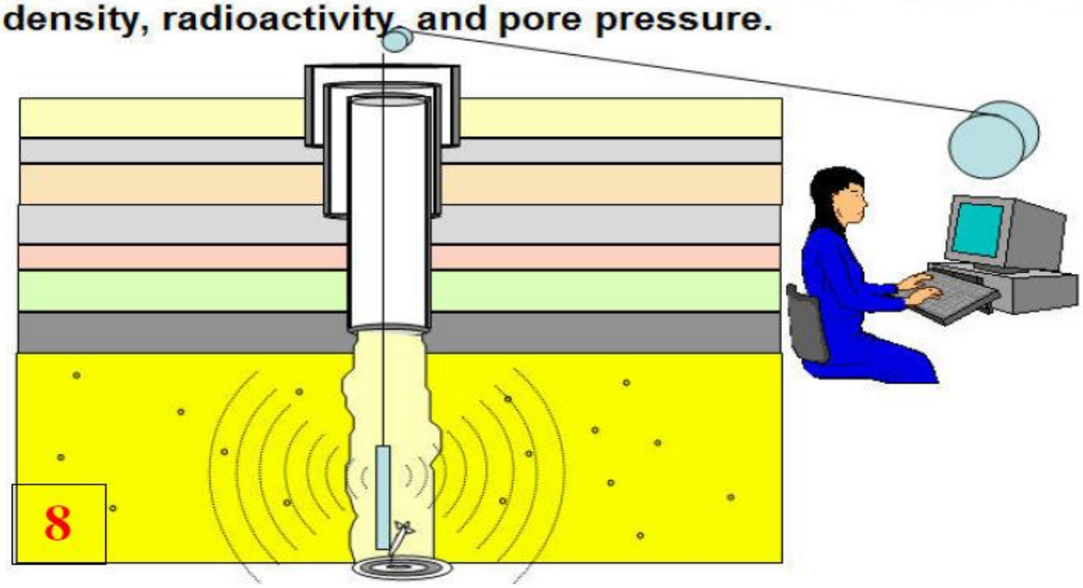
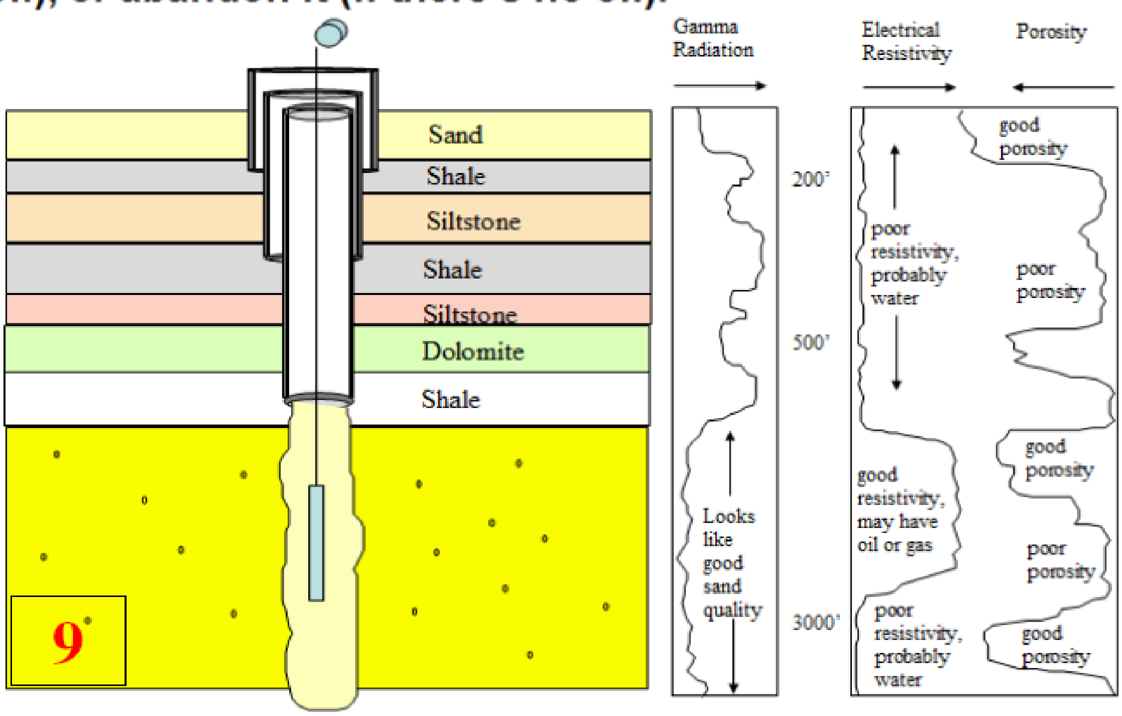

In this way, the hole is drilled in stages, until the target reservoir rock is penetrated. At this point, the geologists must figure out if there is oil or gas in it.
7

How do Geologists tell if the reservoir has oil or gas?

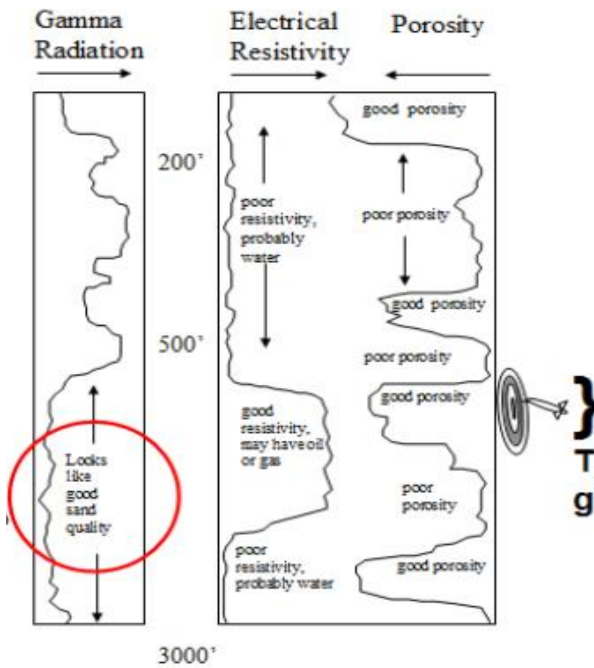
They do this by running logs across the zone. Logs are tools run on electric cable ("wireline") which record the physical properties in the rock such as resistivity, porosity, density, radioactivity, and pore pressure.



Here's an example of what a log looks like. Geologists look at logs to decide whether or not to complete a well (if there is oil), or abandon it (if there's no oil).



Can you tell where the geologist would complete this well?

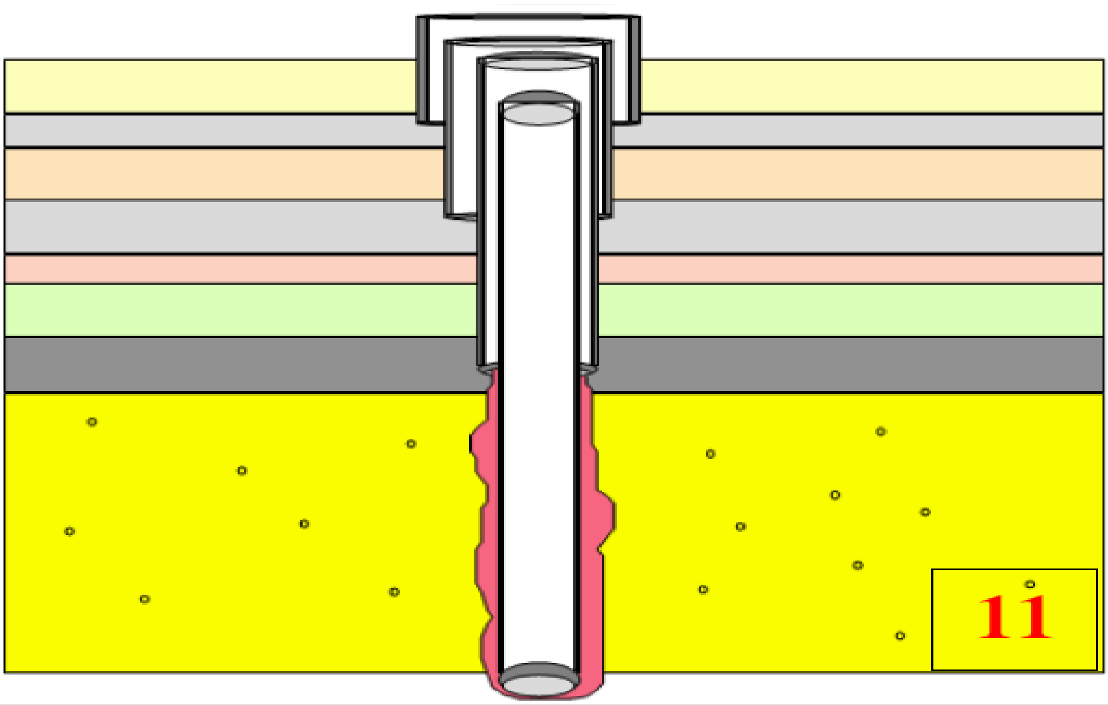


Right here!

This shows a clean sand, with good porosity and resistivity.

10

If the well looks good on the logs, we run a final string of casing across the production zone, and cement it in place.



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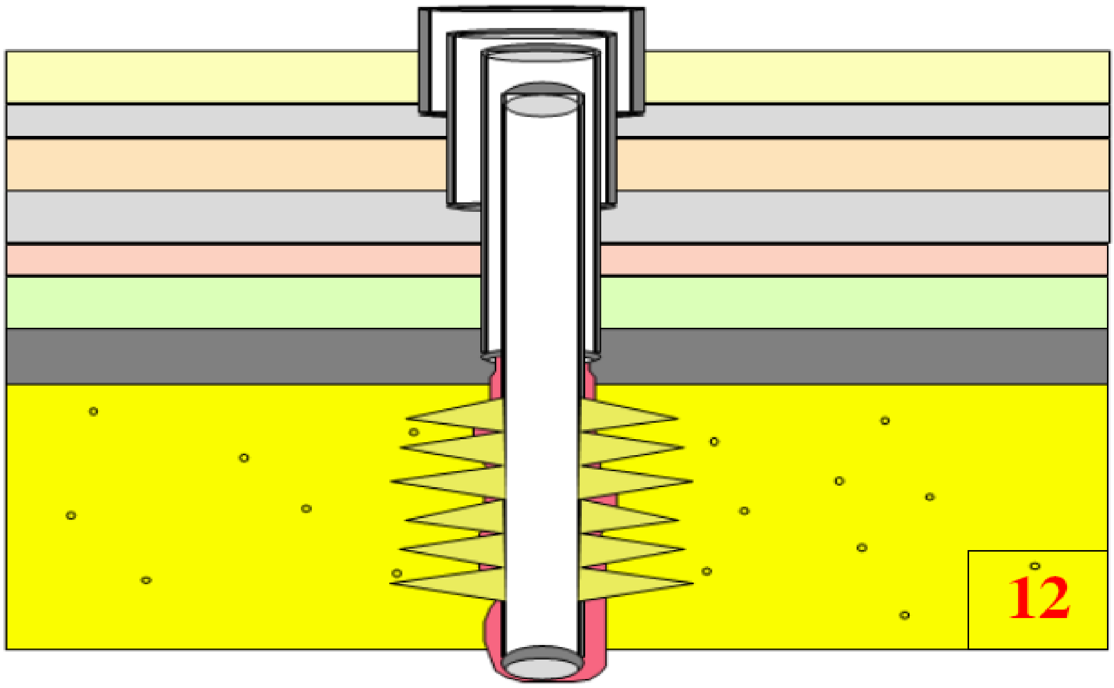
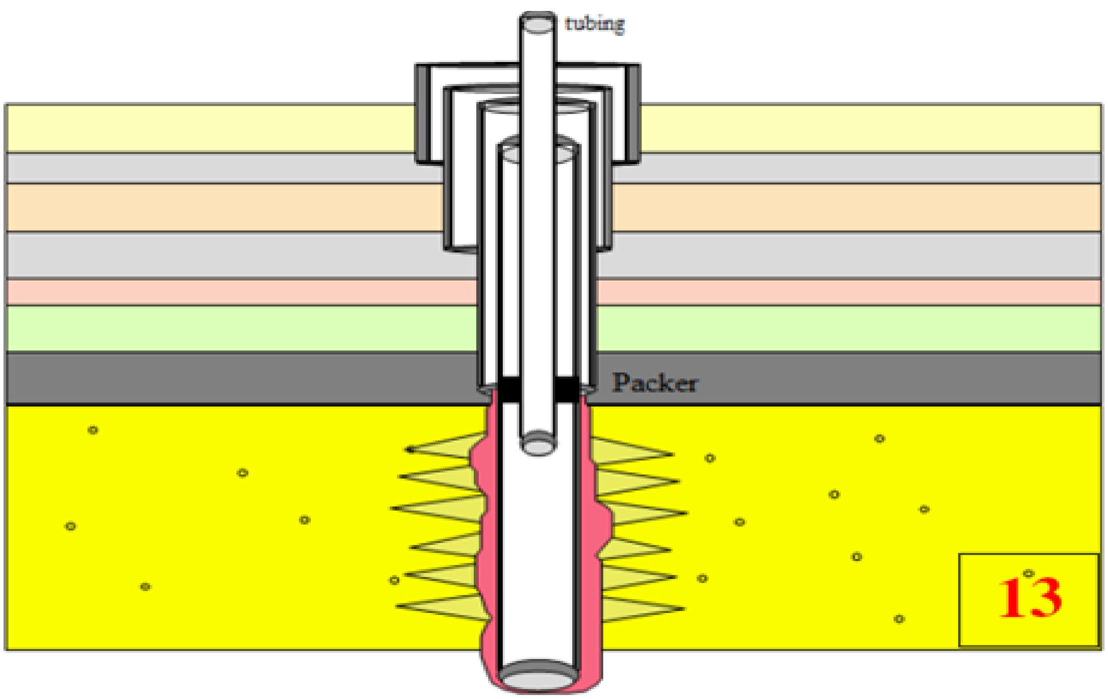
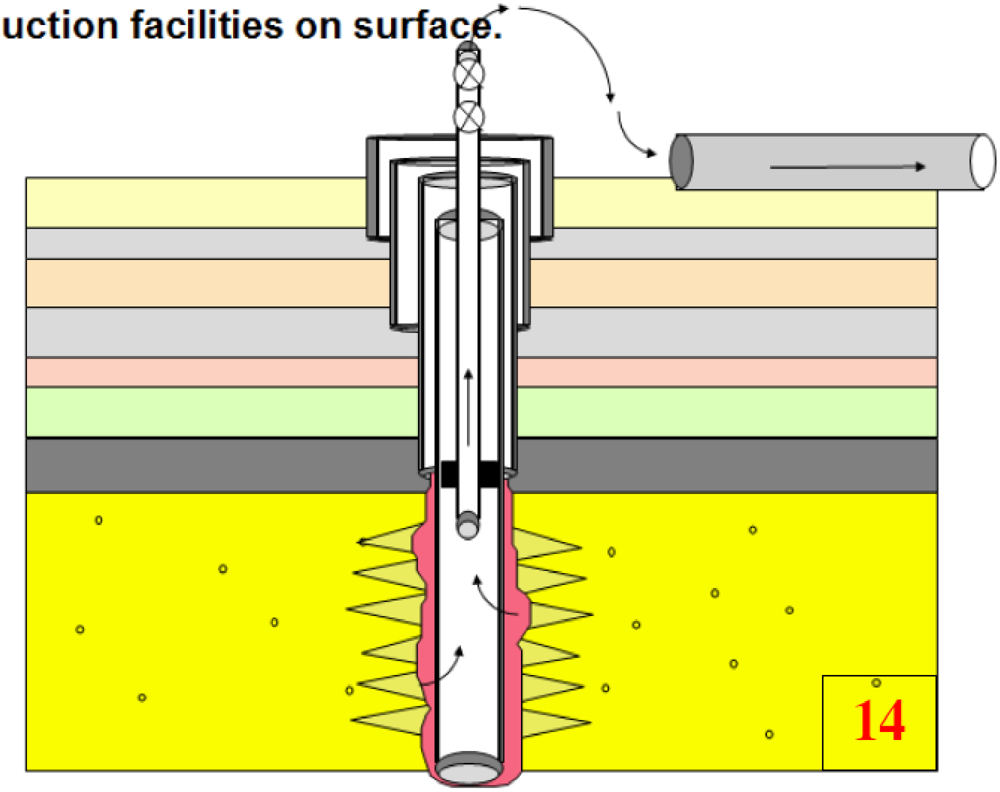
Then, we run perforating guns in the hole and perforate (shoot holes) in the casing across the productive zone.



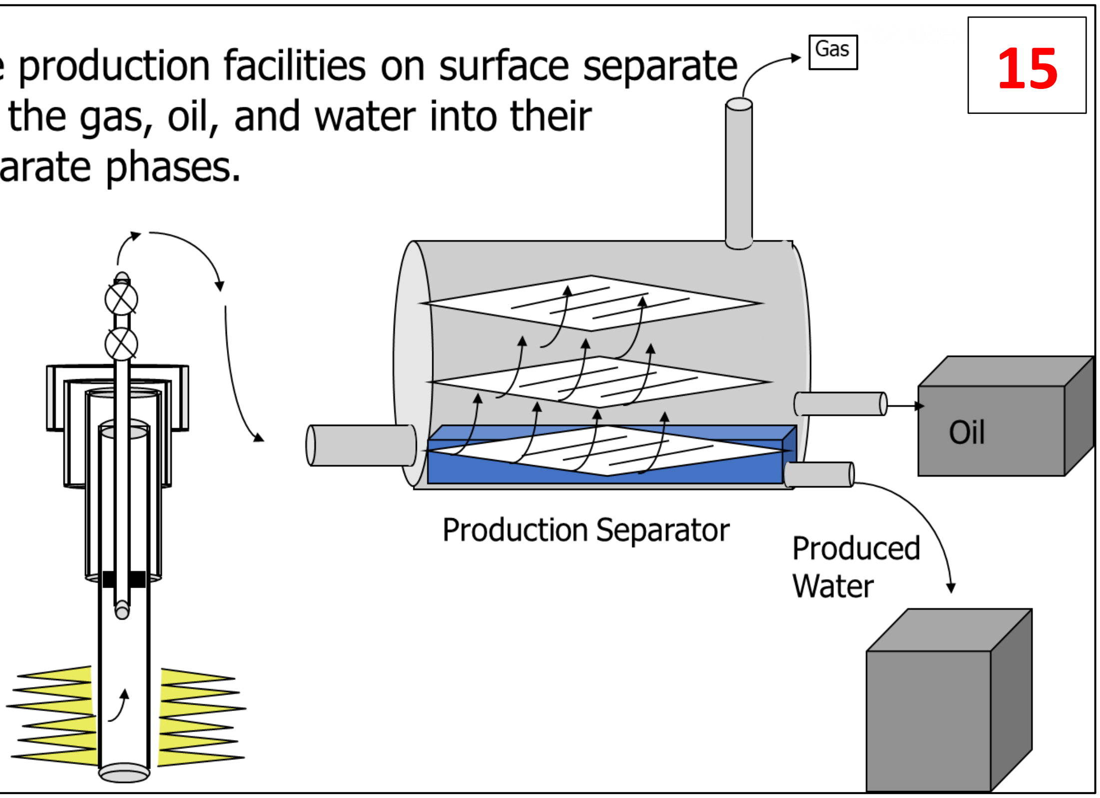
Production tubing is run, with a packer to isolate the produced zone from the casing above.

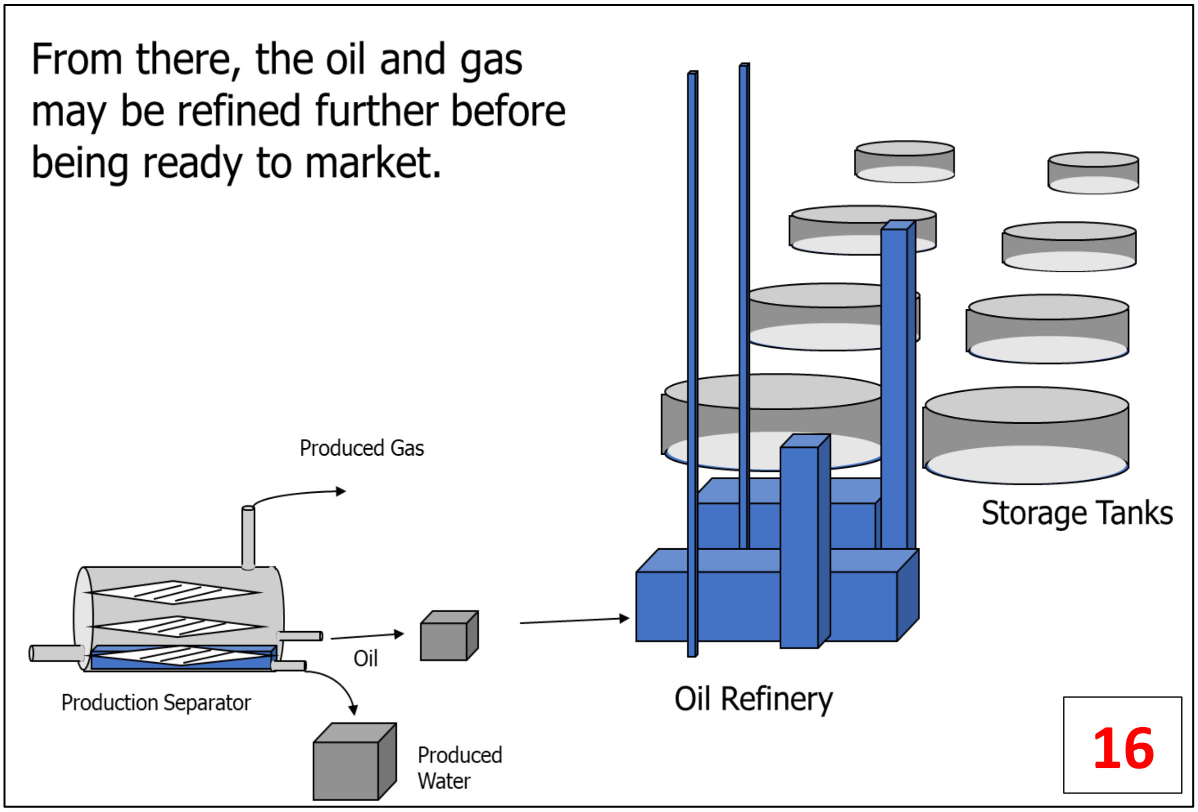


Finally, the well is produced into a pipeline, which takes it to production facilities on surface.



The production facilities on surface separate out the gas, oil, and water into their separate phases.




From there, the oil and gas may be refined further before being ready to market.
Produced Gas
Oil
Production Separator
Produced
Water
Oil Refinery
Storage Tanks
16

3.3 Exercise

1. Re arrange the operations sequence
    a. Start cementing job ( )
    b. Run the casing ( )
    c. Drilling the hole ( )
    d. Complete the well ( )

---

2. Re arrange the operations sequence

    a. Running 13 3/8'' casing ( )
    b. Drilling 8 ½ '' hole. ( )
    c. Start cementing 13 3/8'' casing. ( )
    d. Drilling 17 ½'' hole. ( )
    e. Start cementing 9 5/8'' casing. ( )
    f. Drilling 12 ¼ '' hole. ( )
    g. Running 9 5/8'' casing. ( )
    h. Start cementing 9 5/8'' casing. ( )
    i. Running 7'' casing. ( )

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3. What does the rotary drilling rig consists of?

    a. ……………………………………………..
    b. ……………………………………………..
    c. ……………………………………………..
    d. ……………………………………………..

---

4. …………………………………………… serves several purposes. It supplies a fluid medium for carrying the cuttings from the hole to the surface.
    a. Drilling fluid
    b. Drill bit
    c. Drill string

---

5. ……………………. has the ability to cut through even the most challenging and hardest formations.
    a. Drill string
    b. Drilling fluid
    c. Drill bit

4. DRILLING RIGS & TYPES

A drilling rig is a machine that creates holes in the earth subsurface. Drilling rigs can be massive structures housing equipment used to drill water wells, oil wells, or natural gas extraction wells. Drilling rigs can be mobile equipment mounted on trucks or trailers, or more permanent land or marine-based structures (such as oil platforms, commonly called 'offshore oil rigs'). The term "rig" therefore generally refers to the complex equipment that is used to penetrate the surface of the Earth's crust.

Small to medium-sized drilling rigs are mobile and used for drilling and workover. Larger rigs are capable of drilling through thousands of ft. of the Earth's crust so they are used for deep drilling.

4.1 ONSHORE DRILLING RIGS

Onshore drilling refers to drilling deep holes under the earth's surface whereas offshore drilling relates to drilling underneath the seabed.

The equipment used in both offshore and onshore drilling rigs are almost the same. However, there are some key differences between offshore and onshore drilling. Onshore drilling rigs come in different sizes and strengths. They are generally classified by their maximum drilling depth and their mobility.

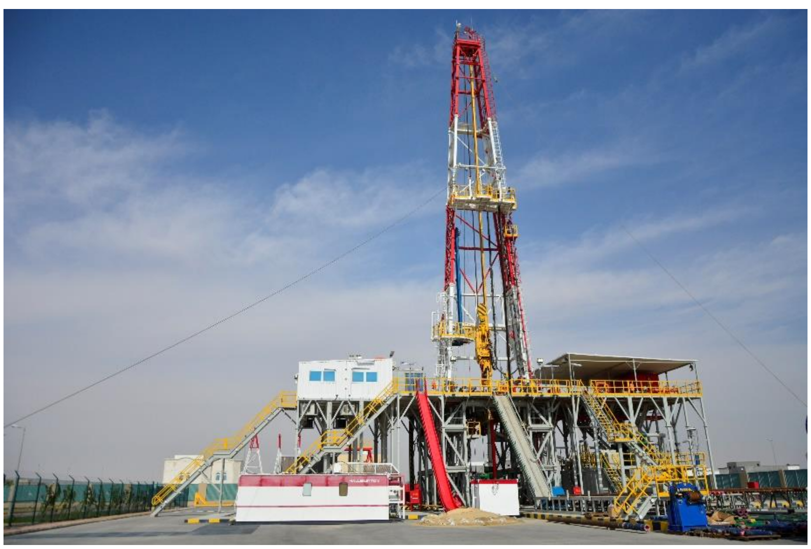


Figure 9 On-shore drilling rig

Figure 10 workover rig

4.2 OFFSHORE DRILLING RIGS

An offshore drilling rig used when drilling has to be performed below sea. The selection process of an offshore rig is heavily depends on the sea water depth.

Offshore drilling rigs are also called Mobile Offshore Drilling Units or MODUs. Figure 11 shows three different types of offshore rigs. They can be towed or propelled into place.

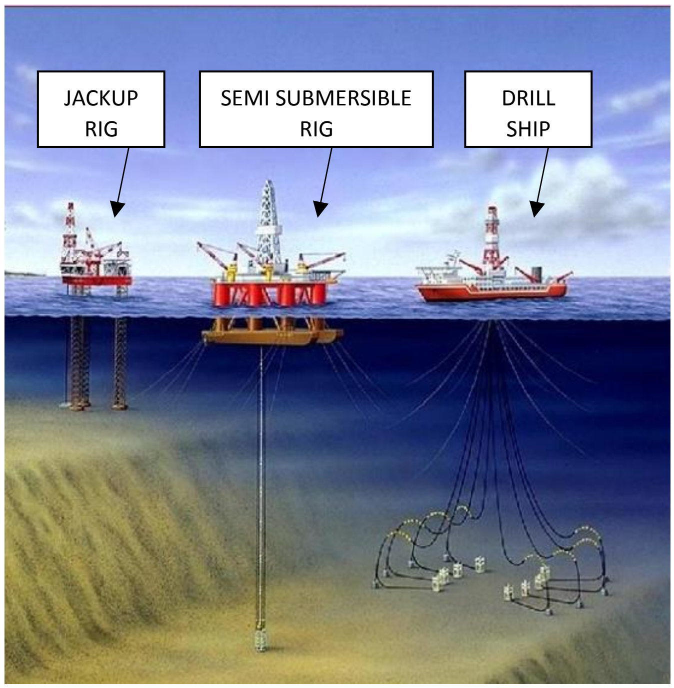


Figure 11 Types of offshore rigs

4.2.1 Jack-up Rigs

The jack-up rig is the most common rig in the offshore drilling industry today. Jack-up rigs can only operate in water that is less than 300 - 400 feet (100 - 121 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 jack-up rigs are the most common for drilling as they are stable while elevated. Four-legged rigs are more stable while floating.

Figure 12 Jack-up drilling rig

4.2.2 Semi-Submersible Rigs

Figure 13 shows a semi-submersible rig, which is used for drilling in deep water.

Figure 13 Semi-submersible Drilling Rig

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.

4.2.3 Drill Ship

A drill ship is a built or remodeled ship that accommodates a complete drilling rig. Once on location, the ship uses its propellers to keep the drilling rig over the well. Drill ships are used for deep water drilling at depths up to 12,000 feet (Figure 14).

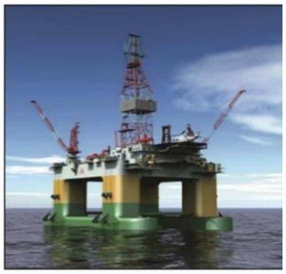
Figure 14 Drill Ship

4.3 Exercise

1. What's the name of this equipment?
    a. Semi-submersible rig
    b. Drill ship
    c. Jack up
    d. Land rig

---

2. What's the name of this equipment?
    a. Semi-submersible rig
    b. Drill ship
    c. Jack up
    d. Land rig



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3. What's the name of this equipment?
    a. Semi-submersible rig
    b. Drill ship
    c. Jack up
    d. Land rig

---

4. What's the name of this equipment?
    a. Semi-submersible rig
    b. Drill ship
    c. Jack up
    d. Land rig

5. …………………………can only operate in water that is less than 300 - 400 feet (100 - 121 meters) deep.
    a. Semi-submersible rig
    b. Jack up
    c. Drill ship
    d. Land rig

6. ………………………… expensive drilling rigs used for water depths of over 300 feet.
    a. Jack up
    b. Drill ship
    c. Semi-submersible rig
    d. Land rig

7. …………………………… are used for deep water drilling at depths up to 12,000 feet.
    a. Jack up
    b. Drill ship
    c. Land rig
    d. Semi-submersible rig

8. …………………………… drilling rig used when drilling has to be performed below sea.
    a. On-shore rig
    b. Land rig
    c. Off-shore rig
    d. Super rig

9. ………………………… drilling deep holes under the earth's.
    a. Drill ship
    b. Land rig
    c. Off-shore rig
    d. Semi-submersible rig

5. MAJOR RIG SYSTEMS

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

- Power system
- Hoisting system
- Circulating system
- Rotating system
- Well control system [3].

The accessories is including the handling equipment and tools.

5.1 POWER SYSTEM

The power needed to operate the rig comes from diesel engines. The power is transferred from the engines to the rig equipment through either a mechanical or an electrical drive.

On a mechanical rig, the drive power is transferred from the engines to the rig equipment by a driveshaft, belt, chain, or gears. Most of the rig area has large diesel engines and large drive assemblies. The engines need to be close to the equipment they are powering. Also, there are fuel lines that provide fuel to all the engines.

The electricity produced by the generators is directed to the SCR or VFD system. These transforms, regulate, and distribute the electricity so that it can power the rig equipment. **Electrical rigs have replaced mechanical rigs as they are easier to rig up and maintain than mechanical rigs.**

The power system consists of:

- Diesel engines
- Generators
- SCR room
- VFD room
- Cabling
- Diesel tanks

NOTE: DC motors are driven by Silicon Control Rectifiers (SCR), and a Variable Frequency Drive (VFD) is used to drive AC motors.

5.1.1 Diesel Engines

The diesel engines on a rig can either supply mechanical power to a machine part or drive the generator. The size and number of diesel engines on a rig depends on the size of the rig. Figure 15 shows some examples of diesel engines.

Figure 15 Diesel Engines

5.1.2 Generators

A generator converts mechanical energy into electrical energy. The generator is attached to the driveshaft of a diesel engine to form a generator set. It converts the rotation of the driveshaft into electricity. Figure 16 shows a generator set.

On a mechanical rig, the generators are smaller as they do not provide all the power to operate the mechanical equipment. Generators on electrical rigs are larger because they provide all the power for the rig and its components.

Figure 16 Generators

5.1.3 SCR Room

Generators produce ac electricity. The SCR room is where the generator output is converted from ac to dc electricity. The dc motors drive the draw-works, rotary table, top drive, and the mud pumps. The driller can control this equipment by varying the supply voltage to the appropriate motor.

CAUTION: The SCR room is a HIGH VOLTAGE area that contains the electric circuit breakers. The SCR room must be kept completely dry from mud, fluids, or water.

5.1.4 VFD Room

The VFD room performs a similar function as an SCR, but for ac motors. It converts the generator output to an electrical 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 dc motors. It is cheaper to operate, smaller, and allows more control of the power sent to the equipment. Figure 17 shows the SCR and VFD room.

Figure 17 VFD Room

5.1.5 Cabling

Cables carry the electricity from the SCR/VFD room to the motors or other equipment. Cables provide electricity as well as communications and are easily damaged if mishandled.

Figure 18 shows an example of a cable connector and a socket. These have special covers on them to prevent fire or explosion and must be installed correctly. The cables connect to a board [4].

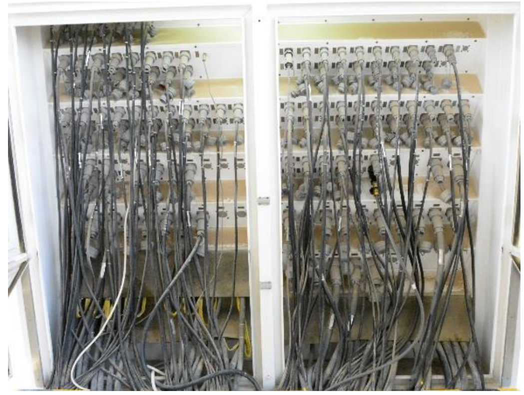


Figure 18 Cabling

CAUTION: All cables should be routed in such a way that they do not create a trip hazard or obstruct a walking area.

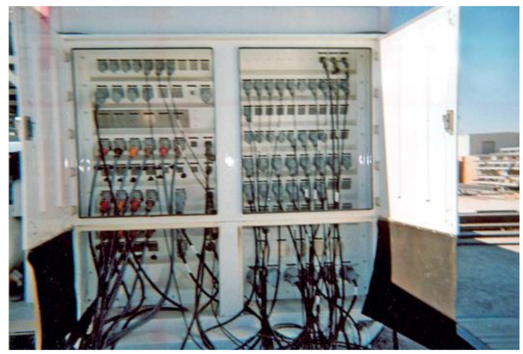


Figure 19 Electrical Cable Plug Board

5.1.6 Diesel tanks

Tanks are designed to deposit & save fuels conveniently. The tank is designed with a water draw at the very bottom of the tank, so that any water formed can be drawn off. The tanks also usually have floating suction that pulls fuel off the top and does not pull any water off the bottom or disturb any water that could be on the bottom.

Figure 20 Diesel tanks

5.1.7 Exercise

10. What’s the name of this equipment?
    a. VFD Room
    b. Diesel Engine
    c. Generator
    d. Kelly bushing

---

11. What’s the name of this equipment?
    a. VFD Room
    b. Diesel Engine
    c. Cabling
    d. Kelly bushing

---

12. What’s the name of this equipment?
    a. VFD Room
    b. Diesel Engine
    c. Generator
    d. Kelly bushing

---

13. What’s the name of this equipment?
    a. VFD Room
    b. Diesel Engine
    c. Generator
    d. Kelly bushing

---

14. What’s the name of this equipment?
    a. VFD Room
    b. Diesel Engine
    c. Generator
    d. Cabling

15. …………………………converts mechanical energy into electrical energy.
    a. VFD Room
    b. Diesel Engine
    c. Generator
    d. Cabling

---

16. …………………………is where the generator output is converted from ac to dc electricity.
    a. VFD Room
    b. Diesel Engine
    c. SCR Room
    d. Cabling

---

17. …………………………supply mechanical power to a machine part.
    a. VFD Room
    b. Diesel Engine
    c. Generator
    d. Cabling

---

18. ………………………is designed to deposit & save fuels conveniently.
    a. Water tank
    b. Mud tank
    c. VFD Room
    d. Diesel tank

---

19. ………………… carry the electricity from the SCR/VFD room to the motors or other equipment.
    a. VFD Room
    b. Cables
    c. SCR Room
    d. Cabling

20. …………………………It converts the generator output to an electrical ac supply that can be adjusted to control the motors.
    a. VFD Room
    b. Cables
    c. SCR Room
    d. Cabling

5.2 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 below. It includes:

- Derrick
- Monkey board
- Crown block
- Traveling block
- Hook
- Draw works
- Drill line
- Dead line anchor
- Top drive

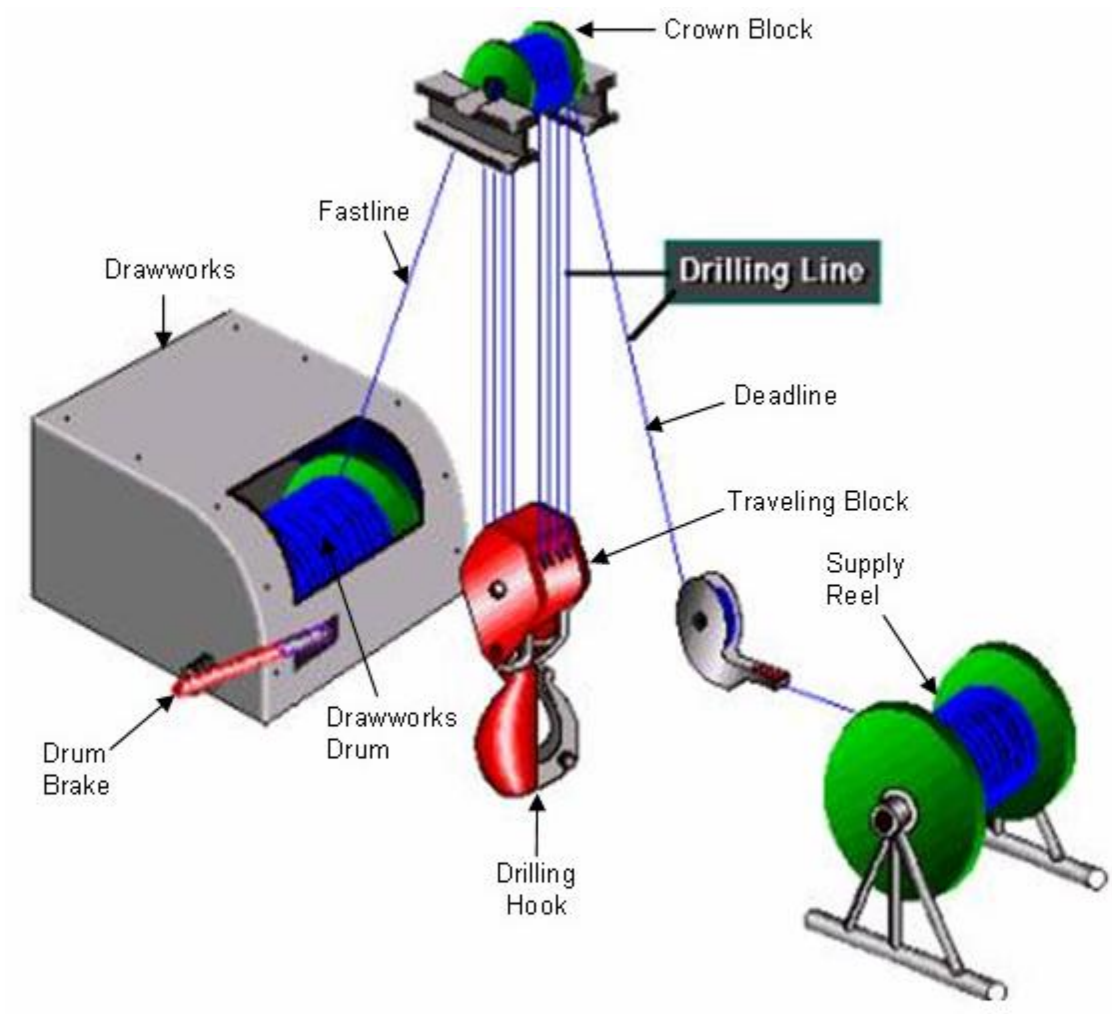


Figure 21 Hoisting Systems

5.2.1 Derrick

The derrick is installed on the rig floor, over the rotary table on top of the substructure. The traveling block, swivel, and kelly (or top drive) are supported from the top of the derrick.

The derrick is what the hoisting system hangs from. It allows the top drive or kelly to be raised to add pipe and lowered as the bit drills the hole [5].

5.2.2 Monkey Board and Stabbing Board

These are two different boards located on the derrick. The derrickman works on these platforms when tripping pipes in and out. The monkey board is used for running drill strings and the stabbing board is used for running casing strings.

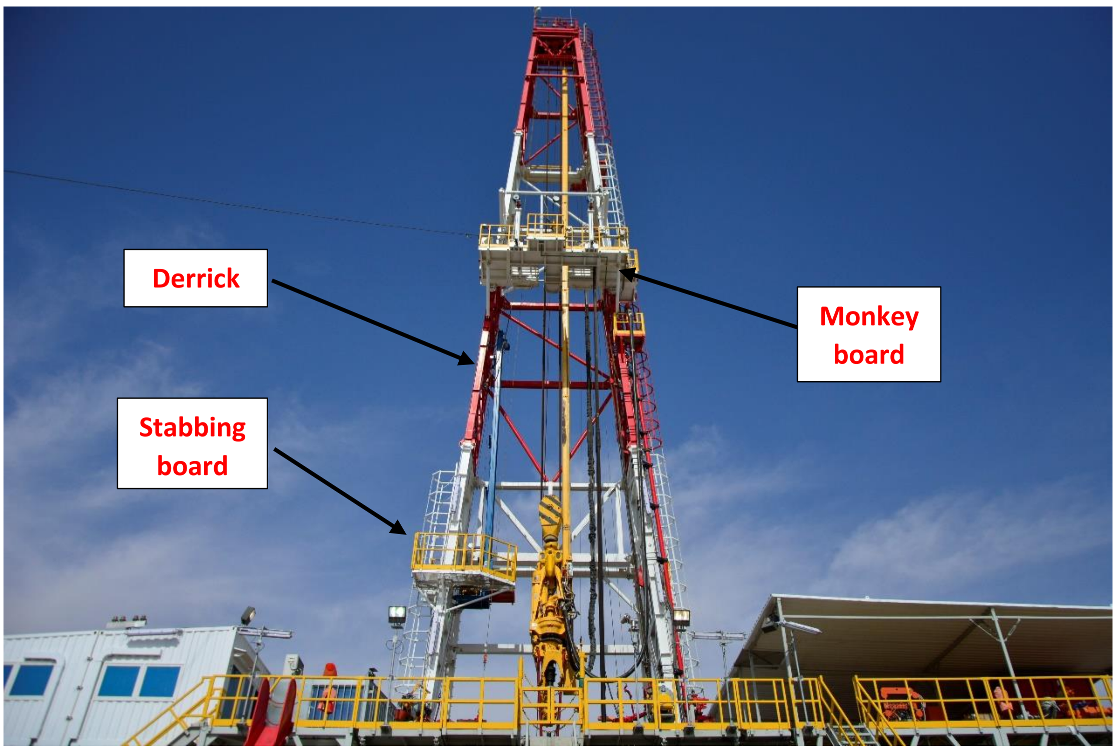


Figure 22 Derrick, Monkey and stabbing board

5.2.3 Crown Block

The crown block and traveling block work together as in a pulley system. The crown block is attached to the top of the derrick and has sheaves that rotate. The sheaves have grooves that allow the drill line to move through the crown block and spool onto the drawworks drum. The sheaves on the crown block are the top of the working path for the drill line. Figure 23 shows the crown block.

Figure 23 Crown Block

5.2.4 Traveling Block

The traveling block is shown in (Figure 24). It also contains sheaves like those on the crown block. The sheaves allow the drill line to move through the traveling block as the drawworks rotate. As the drawworks feed out the drill line, the traveling block lowers. The traveling block is raised if the drawworks rotate in the other direction to pull in the drill line. The traveling block is the lower part of the working path of the drill line.

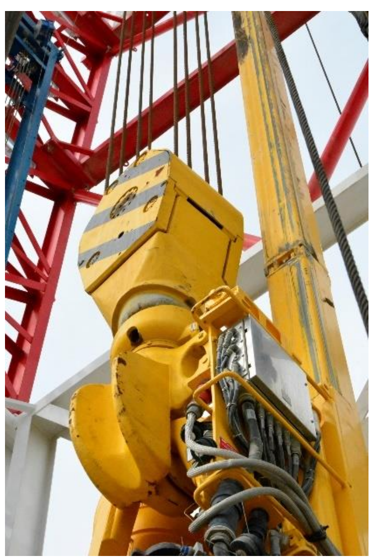


Figure 24 Traveling block & Hook

5.2.5 Hook

As shown in Figure 25, the hook is below the traveling block. The hook can be part of, or separate from, the traveling block. The swivel (or top drive) hangs from the hook when drilling. During tripping operations, the kelly is put away and equipment used to handle drill pipe is attached to the hook [6].

Tripping is called when the drill string is being lowered into the hole before drilling starts (tripping in) or pulled out of the hole (tripping out). A 'round trip' is when the drill string is pulled out of the hole, for example to change the bit, and then run back down to the bottom of the hole.

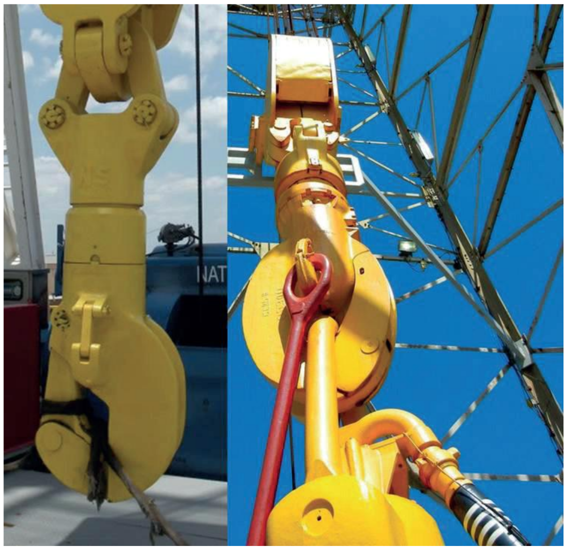


Figure 25 Hook

5.2.6 Drawworks

The drawworks is shown in Figure 26. This is the machine that reels in or out the drill line. The drawworks is installed on the rig floor. It has a rotating section called the drum or spool. The drill line is anchored to the drum so that as the drum rotates, the drill line is reeled in, or reeled out. This action raises and lowers the traveling block, as the line is fed through the sheaves on the crown block and traveling block.

Figure 26 Drawworks

5.2.7 Drill Line

The drill line is a wire rope that suspends the weight of the drill string and traveling block assembly. One end of the drill line is attached to the drum on the drawworks, and the other is attached to a deadline anchor at the bottom of the derrick.

a spool of new drill line is located after the deadline anchor. New drill line is fed through the hoisting system to replace the old drill line when it becomes worn.

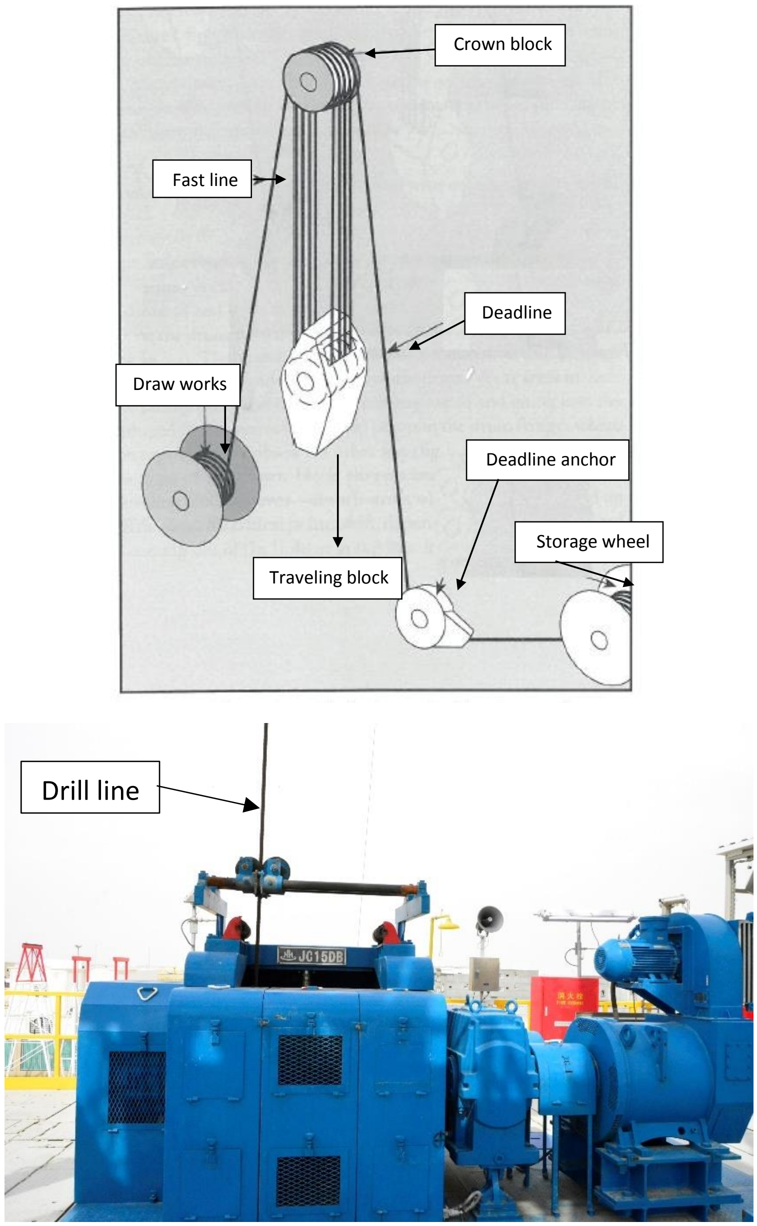


Figure 27 Drill Line

5.2.8 Deadline Anchor

The deadline anchor 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 sensor can be installed in the deadline anchor to measure the weight hanging from the hoisting system [7].

Figure 28 Deadline Anchor

5.2.9 The Top Drive

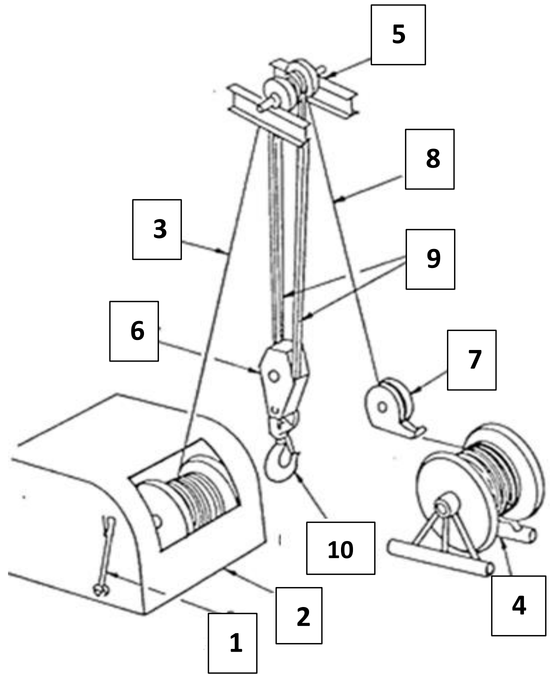
On some rigs, a top drive is used instead of the kelly bar, swivel, and rotary table. It also provides mud flow and rotation to the drill string

The main difference is that the top drive rotates the drill string, not the rotary table. The top drive is also carried by the hoisting system [8].

Figure 29 The Top Drive

5.2.10 Exercise

1. Pick the number for the following equipment.



a- Travelling block ....

b- Storage reel ....

c- Crown block ....

d- Hook ....

e- Fast line ....

f- Drum brake ....

g- Dead line ....

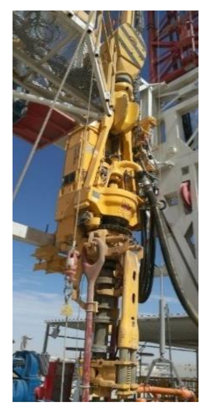
h- Draw work ....

i- Dead line anchor ....

j- Drilling line ....

---

2. What's the name of this equipment?
   A. Dead line anchor
   B. Top drive system
   C. Draw work
   D. Crown block



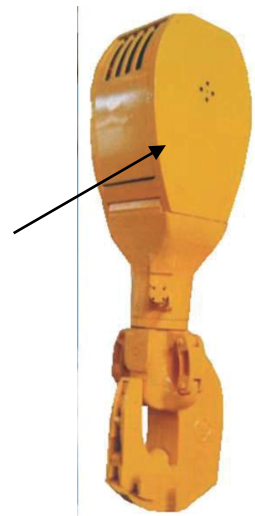
---

3. What's the name of this equipment?
   A. MAST
   B. Monkey board
   C. Draw work
   D. Crown block

4. What's the name of this equipment?
    A. MAST
    B. Monkey board
    C. Draw work
    D. Crown block

---

5. What's the name of this equipment?
    A. Monkey board
    B. MAST
    C. Hook
    D. Travelling block



---

6. What's the name of this equipment?
    A. Travelling block
    B. Monkey board
    C. MAST
    D. Hook

7. What's the name of this equipment?
    A. Travelling block
    B. Monkey board
    C. Dead line anchor
    D. Hook

8. What's the name of this equipment?
    A. Travelling block
    B. Monkey board
    C. Dead line anchor
    D. Hook

9. What's the name of this equipment?
    a. Drilling line
    b. Hook
    c. Monkey board
    d. Dead line anchor

10. ………………………………… is a board that Used while running and pulling drill strings.
    a. Travelling block
    b. Monkey board
    c. Dead line anchor
    d. Hook

---

11. ………………………. secures the wire rope with a set of clamps.
    a. Travelling block
    b. Crown block
    c. The deadline anchor
    d. Monkey board

---

12. ………………………. is a wire rope that suspends the weight of the drill string and traveling block assembly.
    a. Drilling rig
    b. Monkey board
    c. Hook
    d. Drilling line

---

13. …………………… Is attached to the top of the derrick and has sheaves that rotate.
    a. Crown block.
    b. Drilling rig
    c. Monkey board
    d. Hook

---

14. …………………… below the traveling block. The hook can be part of, or separate from, the traveling block.
    a. Derrick
    b. Hook
    c. Drilling rig
    d. Monkey board

---

15. ………………… the machine that reels in or out the drill line, it used to POOH and RIH the drill string.
    a. Derrick
    b. Hook
    c. Monkey board
    d. Draw work

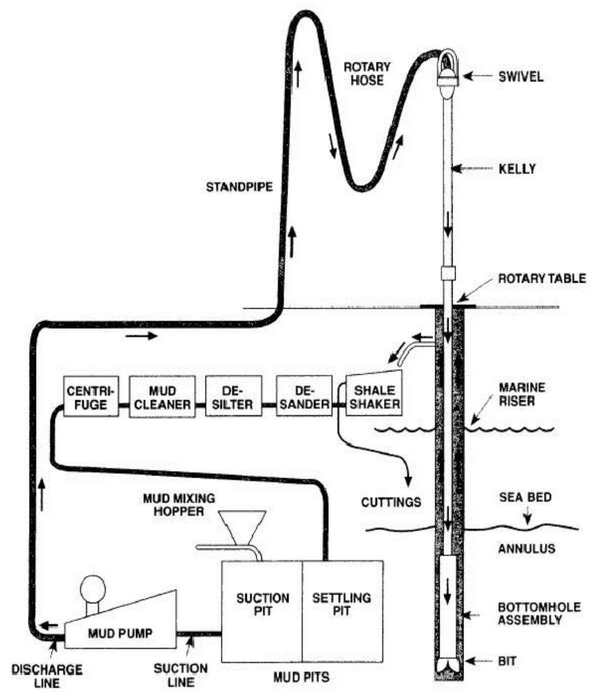
---

16. ………………… the machine that reels in or out the drill line, it used to POOH and RIH the drill string.
    a. Derrick
    b. Hook
    c. Monkey board
    d. Draw work

5.3 CIRCULATING SYSTEM

The circulating system is shown in (Figure 30). This system 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. The circulating system includes:

- Water Pit
- Mud Mixing Equipment
- Mud Tanks
- Mud Pumps
- Piping and Hoses
- Standpipe
- Rotary Hose
- Swivel
- Drill String
- Drill Bit
- Mud Return Line
- Solids Control Equipment
- Reserve pit



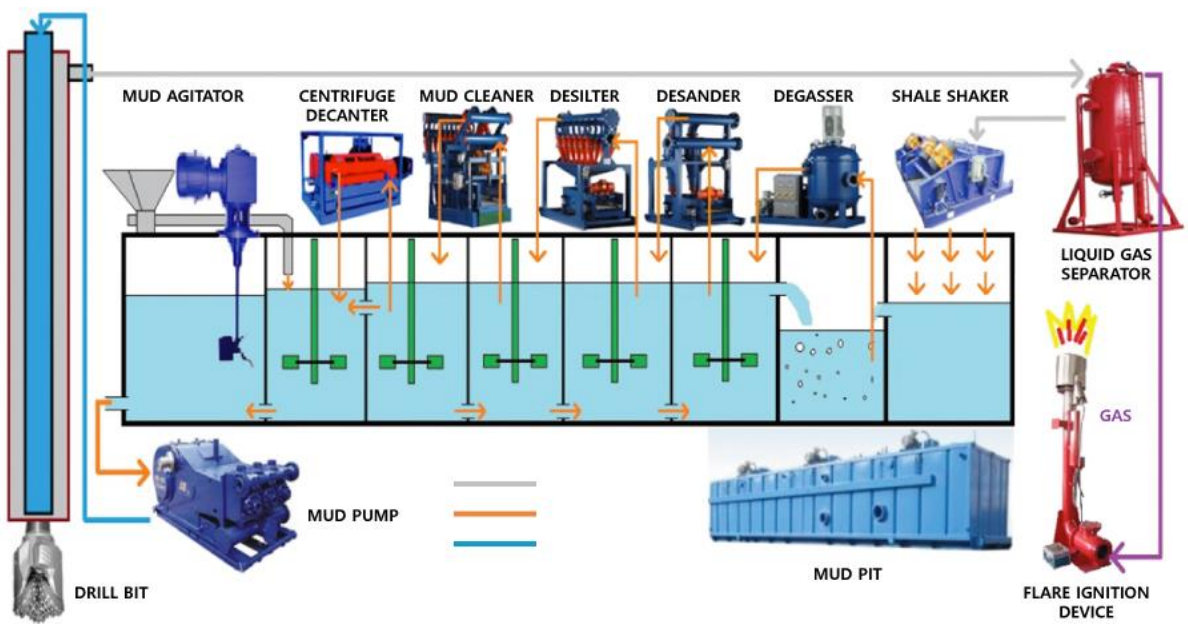


Figure 30 Circulating System

5.3.1 Water pit

Tank which used to store the water required to be mixed with other material to form the drilling fluids which is essential for the drilling operations

5.3.2 Mud Mixing Equipment

5.3.2.1 Mixing Hopper

The device used to facilitate the addition of drilling fluid additives to the whole mud system.

Figure 31 Hopper

5.3.2.2 Mixing Pump

A type of pump commonly used in the handling and mixing of oilfield fluids.

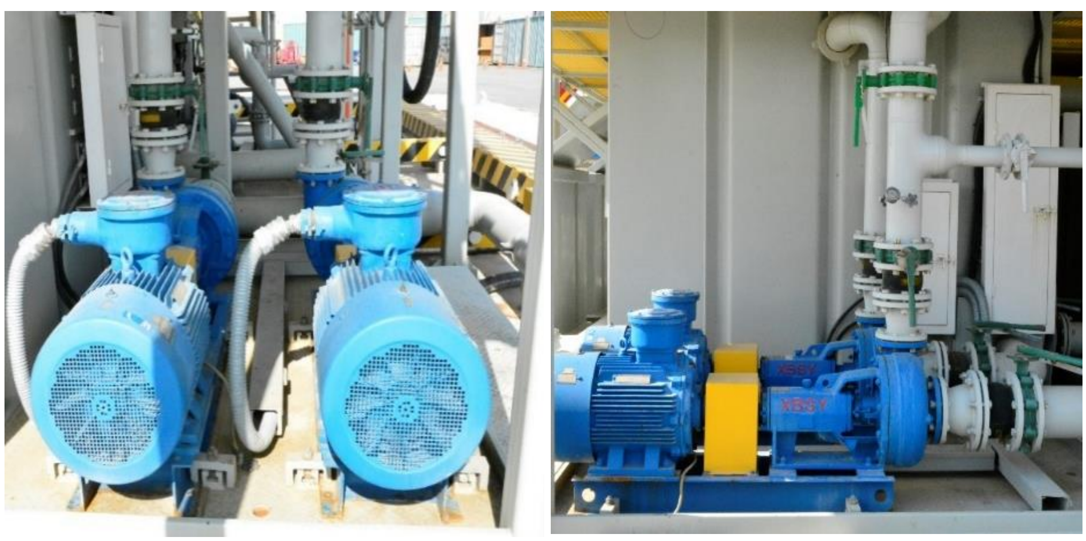


Figure 32 Mud mixing pump

5.3.3 Mud Tanks

The mud tanks are square steel tanks that store drilling fluid. They supply the fluid for the mud pumps to move through the circulating system. The volume of drilling fluid can be monitored within the tanks.

Figure 33 Mud Tanks

5.3.3.1 Suction tank

The mud tank from which mud is picked up by the suction of the mud pumps.

5.3.3.2 Intermediate tank

The mud tank from which mud might be stored in ordered to be transferred to suction tank.

5.3.3.3 Sand trap

A small pit typically located immediately after the shaker screens, which is used as a settling pit to separate coarser solids that accidentally bypass the shakers.

5.3.3.4 Settle tank

Tank which located next to sand trap and used to settle the largest drilling solids to bottom of the tank.

5.3.3.5 Trip tank

Is a small metal tank with small capacity about 20-40 bbls with 1 bbl divisions inside and it is used to monitor the well.

5.3.3.6 Slug tank

Tank which located next to suction tank and contains a volume of mud that is more dense than the mud in the drill pipe and wellbore annulus.

5.3.4 Mud Agitator

Mud agitators stir the mud to keep the weighting materials and other chemicals thoroughly mixed in the mud and attached to the majority of mud system tanks.

Figure 34 Mud Agitator

5.3.5 Mud Pumps

(Figure 35) shows the mud pumps. These are large pumps 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 35 Mud Pumps

5.3.6 Piping and Hoses

Metal pipes and hoses transport the fluids on the rig. There are high pressure and low-pressure pipes. The pipes are attached to the sides of the tanks, buildings, or derrick and secured with clamps and safety lines/slings.

The hoses used in the circulating system are usually high-pressure hoses. They connect the metal pipes to the equipment (Figure 36). These hoses must be secured with safety lines [9].

Figure 36 Piping & Hoses

5.3.7 Standpipe manifold

The mud discharged from the pump manifold flows into the standpipe through the standpipe manifold.

Figure 37 Standpipe Manifold

5.3.8 Stand pipe

In this picture (Figure 38) you can see that the standpipe is a metal pipe attached to the side of the derrick by a clamp. A gooseneck fitting (a curved connection) connects to the top of the standpipe. Drilling fluid flows into the standpipe from the manifold at the bottom and out through the gooseneck to the rotary hose. The standpipe also keeps the rotary hose clear of the rig floor as the Kelly travels up and down the derrick.

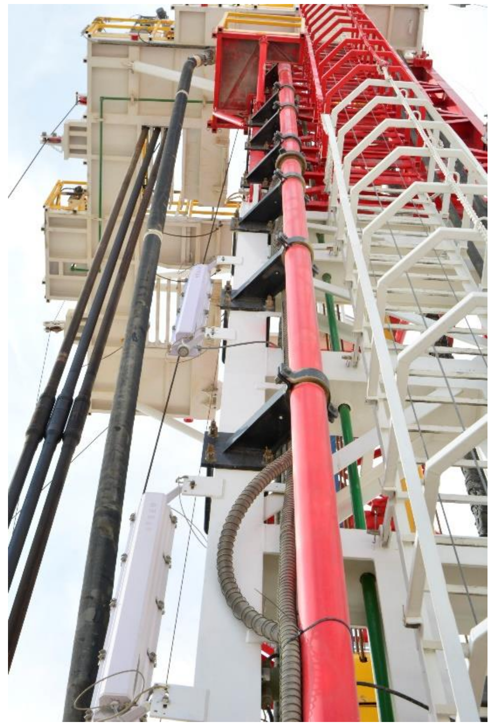


Figure 38 Standpipe

5.3.9 Rotary Hose

The rotary hose transports drilling fluid from the standpipe into the swivel. From there, the fluids go down into and through the Kelly into the drill string. As shown in (Figure 39), one end of the rotary hose connects to the standpipe gooseneck and the other end connects to the swivel. The rotary hose must be flexible and withstand high pressures. Safety chains and clamps secure the ends of the rotary hose to the derrick and the swivel. These chains/clamps will hold the hose if the connection breaks. They will prevent the loose hose from injuring crew members or damaging equipment during emergencies [11].

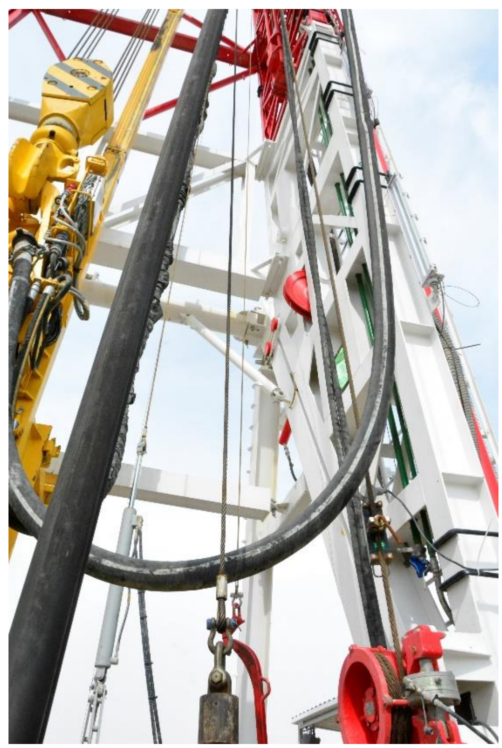


Figure 39 Rotary Hose

5.3.10 Swivel

The swivel connects the Kelly and drill string to the hoisting system.

It allows the drill string to rotate while it is connected to the rotary hose. This provides a continuing flow of mud to the drill string while drilling takes place.

In the circulating process, mud flows from the rotary hose, through the swivel, the Kelly, the drill pipe, and the collars to the bit. 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 carried by the hoisting system.

Figure 40 Swivels

5.3.11 Drill String

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

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. The drill pipes, or ***tubulars***, are long steel pipes that have a ***threaded*** connection 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. Drilling fluid is pumped down through the drill pipe to the bit at the bottom of the hole. 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. The bit is screwed onto large diameter, heavy pipe called drill collars. The bit and drill collars are called the “Bottom Hole Assembly” or BHA. The drill collars provide the weight to push the drill bit into the rock as it is rotated. Between drill pipes and large diameter drill collars we usually connect transition pipes which are called heavy weight drill pipes (HWDP) To drill through the rock, the drill string rotates and applies weight to the bit. The interaction between the bit and the rock formation generates a great deal of heat from the friction. Mud flows down the drill string and out the bit to keep it lubricated and cooled.

Figure 41 Drill String

5.3.12 Mud Return Line

Mud exiting the bit force cuttings at the bottom of the well up the annulus back to the surface and into the mud return line. Mud flows down the mud return line to the shale shakers and solids control equipment for cuttings removal and cleaning [12].

Figure 42 Return flow line

5.3.13 Solids Control Equipment

Most rigs use solids control equipment (to remove solids from the mud) when heavy drilling fluids are in circulation. These are:

- Shale shaker
- Degasser
- Mud-Gas Separator
- Desander, Desilter, and Mud Cleaner
- Centrifuge [13]

5.3.14.1 Shale shaker

The shale shaker has a set of trays with a filter, or screens that vibrate. As the screens vibrate mud filters through them and flows onto the next solid control and mud conditioning equipment. The screens remove cuttings from the mud and deposit them into reserve pit [14].

Figure 43 Shale Shakers

5.3.14.2 Desander, Desilter, and Mud Cleaner

Shale shakers remove large cuttings from the mud returns, but not smaller solid particles. The returning mud is heavier than the mud that is pumped into the well. The solids must be removed or "cleaned" from the mud to maintain a desired mud weight. To do its job correctly, the mud must not be allowed to get too heavy. To clean the mud, drillers use filtering devices known as desanders, desilters and mud cleaners. These separate the sand and shale from the mud and dump them into the reserve pit [15].

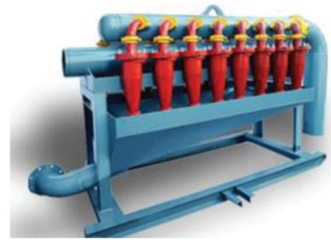
Figure 44 Mud cleaner

5.3.15 Reserve pit

Any pit not part of the active (circulatory) system. The reserve pit may be used to store spare or waste mud, base oil or brine. In operations on land, the reserve pit is usually a plastic-lined, earthen pit, in which waste mud is stored until final disposal.

5.3.1 Exercise

1. What's the name of this equipment?
    - A. Agitator
    - B. Desilter
    - C. Desander
    - D. Mud pump



---

2. What's the name of this equipment?
    - A. Agitator
    - B. Desilter
    - C. Desander
    - D. Mud pump

---

3. What's the name of this equipment?
    - a. Mud pump
    - b. Desander
    - c. Stand pipe
    - d. Mud return line.

---

4. What's the name of this equipment?
    - a. Swivel
    - b. Shale shaker
    - c. Drilling line
    - d. Stand pipe manifold

---

5. What's the name of this equipment?
    - a. stand pipe
    - b. Mud pump
    - c. Shale shaker
    - d. Rotary hose

6. What's the name of this equipment?
    a. Stand pipe
    b. Rotary hose
    c. Shale shaker
    d. Rotary hose

7. What's the name of this equipment?
    a. Mud pump
    b. Swivel
    c. Shale shaker
    d. Rotary hose

8. .... supply the fluid for the mud pumps to move through the circulating system.
    a. Stand pipe
    b. Solid control equipment
    c. Mud tank
    d. Rotary hose

9. .... stir the mud to keep the weighting materials and other chemicals thoroughly mixed in the mud.
    a. Mud Agitator
    b. Mud tank
    c. Stand pipe
    d. Rotary hose

10. .... a metal pipe attached to the side of the derrick by a clamp it allows mud to flow into the rotary hose through the goose neck attached in swivel.
    a. Stand pipe
    b. Mud Agitator
    c. Mud tank
    d. Rotary hose

11. .... has a set of trays with a filter, or screens that vibrate. As the screens vibrate mud filters through them and flows onto the next solid control and mud conditioning equipment.
    a. Mud Agitator
    b. Shale shaker
    c. Drilling mud
    d. Rotary hose

5.4 ROTATING SYSTEMS

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

- ❖ Types of rotation drive system (Kelly & top drive)
- ❖ Drill string (BHA & Drill pipe)
- ❖ Drilling Console

Types of rotation drive mechanism

5.4.1 Kelly drive system

It's was the most common type used to rotate the drill string and drill the well.

The main component of this system is:

a- Swivel
b- Kelly.
c- Kelly bushing.
d- Master bushing.
e- Rotary table.

As the rotary table turns, the master bushing rotates, which in turn rotates the Kelly bushing, Kelly, as well as the rest of the drill string.

The rotation of the Kelly bar rotates the drill string to drill the hole.

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.

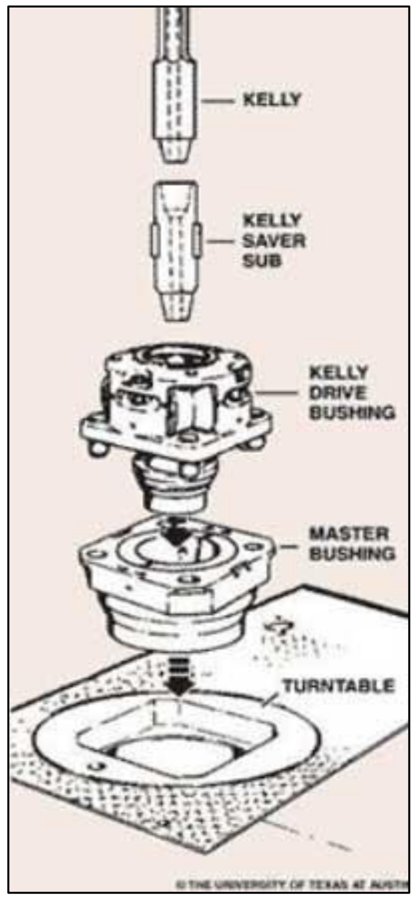


Figure 45 Kelly drive system components

5.4.1.1 The Swivel

The rotary tool that is hung from the hook of the traveling block to suspend the drill string, permit it to rotate freely and prevents the hook, travelling block, drilling line & crown block from rotation.

Figure 46 Swivel

5.4.1.2 Kelly

The heavy steel member, usually four or six-sided that is suspended from the Swivel through the Rotary Table and connected to the top most joint of drill pipe to turn the drill string as the rotary table turns.

The Kelly bar moves up and down it slides through a Kelly bushing and the Kelly transfers rotation from the rig to the drill string.

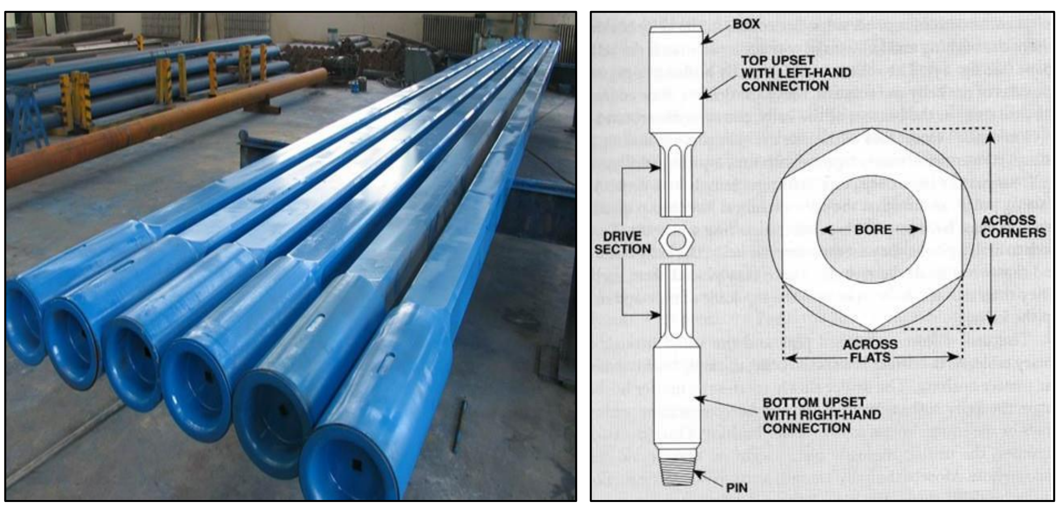


Figure 47 Kelly

5.4.1.3 Kelly bushing

A device that when fitted to master bushing transmits rotation to the Kelly and simultaneously permits vertical movement of the Kelly to make hole.

The Kelly bushing contains four studs that stick out on each corner of the bushing, enabling it fit snuggly and securely inside the master bushing.

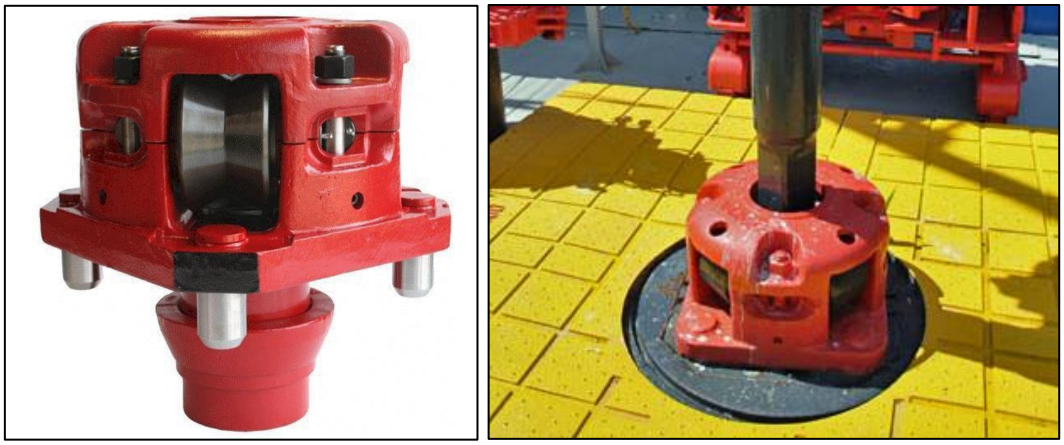


Figure 48 Kelly bushing

5.4.1.4 Master bushing

A device that fits into the rotary table to accommodate the slips and drive the Kelly bushing so that the rotating motion of the rotary table can be transmitted to the Kelly.

The master bushing fits into the rotary table and transfers rotation to the Kelly bushing.

The Kelly bushing fits into the master bushing and transfers the rotation to the Kelly bar.

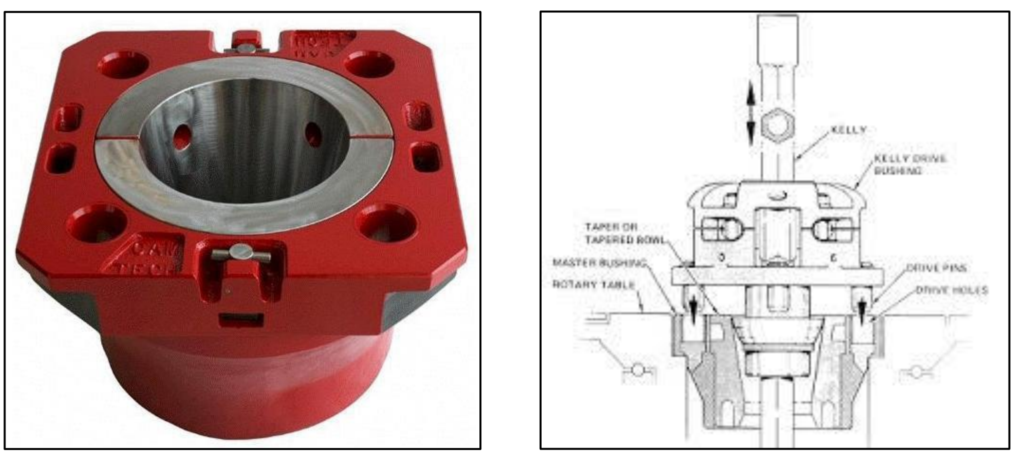


Figure 49 Master bushing

5.4.1.5 Rotary table

Equipment used to turn the drill string and support the drilling assembly.

The rotary table is driven by a motor to drive shaft and rotates master bushing which rotate the Kelly and drill string.

The rotary table used to hang the drill string by slips inserted into the master bushing.

Rotary table should have the capacity to suspend / hang the drill string.

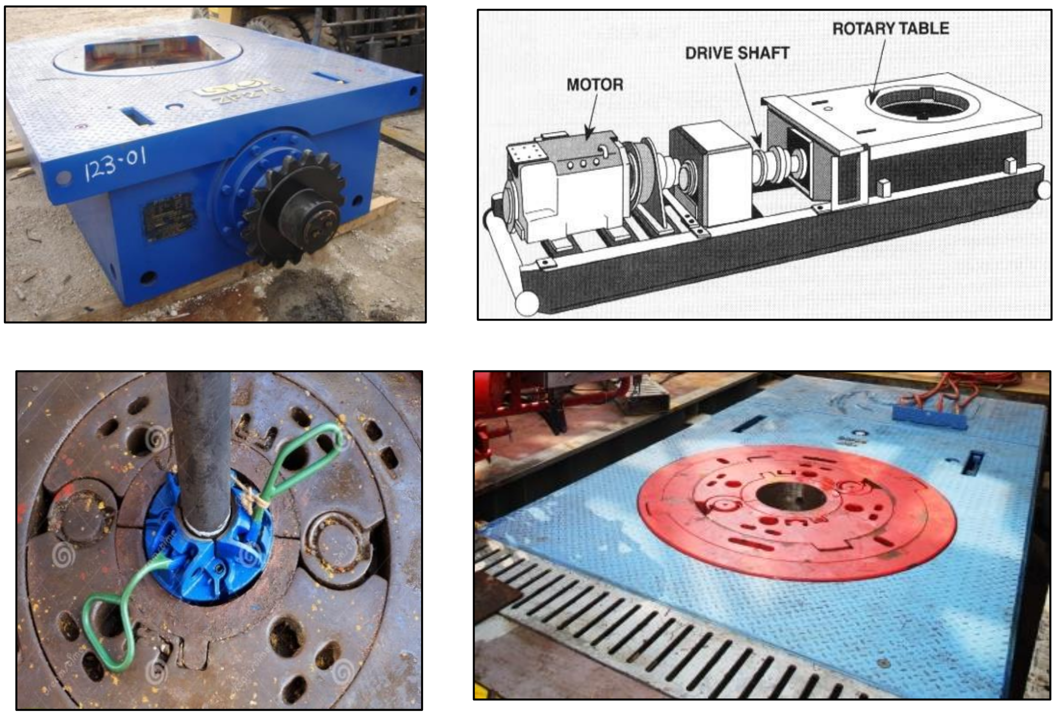


Figure 50 Rotary table

5.4.2 Top drive system

A top drive is a mechanical device on a drilling rig that provides clockwise torque to the drill string to drill a borehole.

It is an alternative to the rotary table and Kelly drive.

It is located at the swivel's place below the traveling block and moves vertically up and down the derrick.

The top drive allows the drilling rig to drill the longer section of a stand of drill pipe in one operation.

A rotary table type rig can only drill 30-foot (9.1 m) (single drill pipe) sections of drill pipe whereas a top drive can drill 60–90-foot (18–27 m) stands (double and triple drill pipe respectively, a triple being three joints of drill pipe screwed together), depending on the drilling rig size.

Handling longer sections of drill pipe enables a drilling rig to make greater daily progress because up to 90-foot (27 m) can be drilled at a time, thus requiring fewer "connections" to add another 30-foot (9.1 m) of drill pipe.

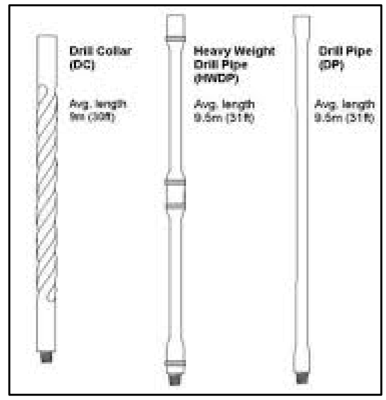
Another advantage of top drive system is time efficiency. When the bit progresses under a Kelly drive, the entire string must be withdrawn from the well bore for the length of the Kelly to add one more length of drill pipe.

Another advantage of top drive system is time efficiency. When the bit progresses under a Kelly drive, the entire string must be withdrawn from the well bore for the length of the Kelly to add one more length of drill pipe.

Figure 51 Top Drive System

5.4.3 Drill String

The drill bit, drill pipe, and any other equipment that goes in the hole to drill is what makes up the drill string.



To drill the well, the drill string is rotated by the rig from the surface.

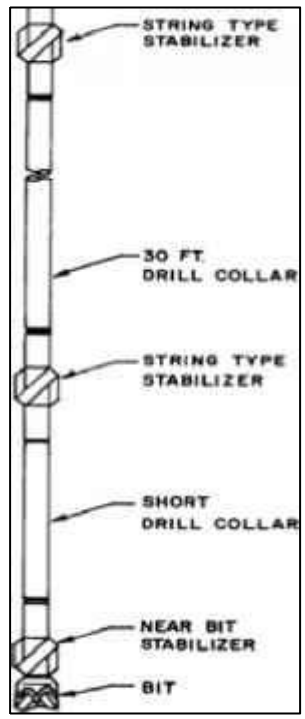
The drill string consists of two main parts

A- BHA "Bottom Hole Assembly"

1- Drill Bit.
2- Drill Collar.
3- Stabilizer.
4- Reamer.
5- Jar.
6- Heavy weight drill pipe (HWDP)
7- Subs.

B- Drill pipes

5.4.3.1 BHA "Bottom Hole Assembly"



The lower portion of the drill string, consisting of (from the bottom up in a vertical well) the bit, bit sub, a mud motor (in certain cases), stabilizers, drill collar, heavy-weight drill pipe, jarring devices ("jars") and crossovers for various thread forms.

The bottom hole assembly must provide force for the bit to break the rock (weight on bit), survive a hostile mechanical environment and provide the driller with directional control of the well.

The Information for each component of BHA such as

A- Outer diameter (OD)
B- Inside diameter (ID)
C- Length (L)
D- Serial number (Sr. No.)
E- Fish neck OD & Length (F.N)
F- Cumulative length of BHA.

Should be recorded in **BHA Tally sheet** and to be presented to Senior tool pusher (S.T.P) and Rig Foreman.

BHA Sheet.

DATE: ______ WELL: ________________

BIT No. ______ TOTAL WEIGHT OF BHA : ______

BHA No. ______ WEIGHT BELOW JARS : ______

BHA ITEM	LENGTH	TOTAL LENGTH	OD	ID	F/N LENGTH	F/N OD	REMARKS - S/No

5.4.3.2 Drill Bit

The tool used to crush or cut rock, everything on a drilling rig directly or indirectly assists the bit in crushing or cutting the rock

The diameter of the bit determines the diameter of the hole.

The drill bit cuts the rock as it rotates at the bottom of the hole.

The bit is on the bottom of the drill string and must be changed when it becomes excessively dull or stops making progress.

Most bits work by scraping or crushing the rock, or both, usually as part of a rotational motion.

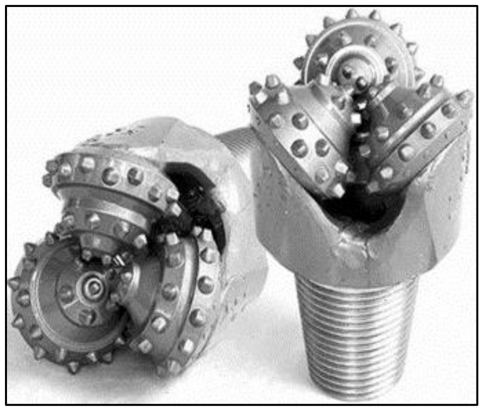


Figure 52 Drill bits

5.4.3.3 Drill collar

A component of a drill string that provides **weight on bit (WOB)** for drilling.

Drill collars are thick-walled tubular pieces machined from solid bars of steel, usually plain carbon steel but sometimes of nonmagnetic nickel-copper alloy or other nonmagnetic premium alloys.

Drill collar have a ***threaded*** connection on the top and bottom, so they can be joined together it called Pin & box.

Drill collar is identified by the following:

DC - 9 ½'' - #217 ib./ft - 30' -7 5/8" REG - Spiral -789

Drill collar outer diameter: 9 ½ inch.
Drill collar nominal weight: 217 ib./ft.
Drill collar length: 30 feet.
Drill collar thread connection size & type: 7 5/8'' Regular.
Drill collar type: Spiral.
Drill collar Serial number: 789

Figure 53 Drill collar

5.4.3.4 Stabilizer

A drilling stabilizer is a piece of downhole equipment used in the bottom hole assembly (BHA) of a drill string.

It mechanically stabilizes the BHA in the borehole to avoid unintentional sidetracking, vibrations, and ensure the quality of the hole being drilled (Control hole deviation).

It is composed of a hollow cylindrical body and stabilizing blades, both made of high-strength steel. The blades can be either straight or spiraled and are hard faced for wear resistance.

Figure 54 Stabilizer

5.4.3.5 Reamer

A reamer is a piece of equipment attached to drill string.

The purpose of the reamer is to keep hole in gauge and enlarge a pilot hole to accommodate the required pipe size.

There're two main types of reamers

1- Near bit reamer "Between bit and drill collar"

   It used to keep the hole full gauge and protect gauge of tools above it.

2- String reamer "Between drill collar and drill pipe"

   It used to reaming out dog legs, key seat and ledges.

Figure 55 Reamer

5.4.3.6 Jar

A mechanical device used downhole to deliver an impact load to another downhole component, especially when that component is **stuck**.

There are two primary types, hydraulic and mechanical jars.

While their respective designs are quite different, their operation is similar.

Energy is stored in the drill string and suddenly released by the jar when it fires.

Figure 56 Jar

5.4.3.7 Heavy weight drill pipe (HWDP)

Between drill pipes and large diameter drill collars we usually connect transition pipes which are called heavy weight drill pipes (HWDP).

A type of drill pipes whose walls are thicker and collars are longer than conventional drill pipe.

HWDP tends to be stronger and has higher tensile strength than conventional drill pipe, so it is placed near the top of a long drill string for additional support.

HWDP is work as transition pipe between BHA and drill pipe.

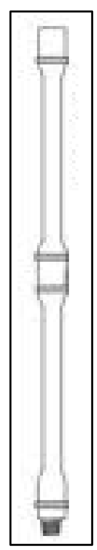


Figure 57 Heavy weight drill pipe

5.4.3.8 Subs.

A short, threaded piece of pipe used to adapt parts of the drill string that cannot otherwise be screwed together because of difference in thread size or design.

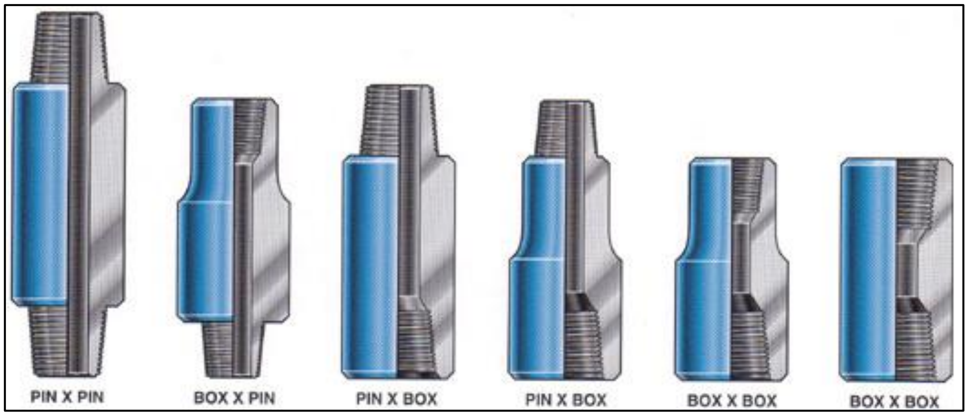


Figure 58 Different types of subs

There're many different types of subs such as:

1. Bit Sub

A short drill string component ("sub") has **double box** sub used to connect the drill bit with drill collar and contain the float valve inside.

For example

This bit sub is 7 5/8'' Reg Box X 7 5/8''

---

2. Crossover Sub

A short drill string component ("sub") has pin & box ends and used to connect two different types of tubular (different size or thread type).

---

3. Kelly Saver Sub

A short drill string component ("sub") attached at the end of Kelly to protect Kelly from wearing due to frequent connection/disconnection of drill pipes.

4. Lifting Sub

A short drill string component that is temporarily connected to the top of a tool assembly that is to be lifted vertically.

Figure 59 Lifting sub

6-Shock sub

The Shock Sub impact and vibration reduction sub is a drill string component that absorbs and dampens the variable axial dynamic loads produced by the drill bit during routine drilling and milling operations. It is most beneficial when drilling in hard rock, broken formations, and intermittent hard and soft streaks. Reducing the impact loads helps to increase ROP; improve borehole quality; and extend the life of the cutting structure, bearings, connections, and surface equipment—all translating to a lower cost of drilling per foot.

Figure 60 Shock sub

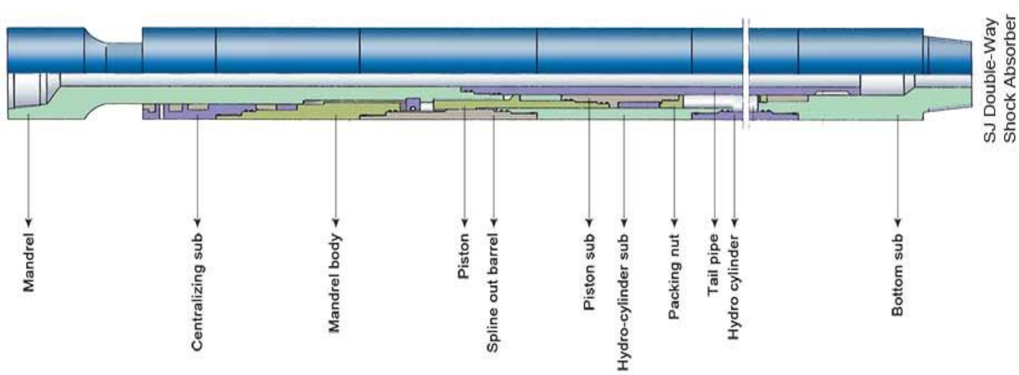


Figure 61 Shock sub components

5.4.3.9 Float valve (NRV)

A Float Valve or **non-return valve** (NRV) is a valve that is used to prevent backflow during a drilling operation. The float valve is inserted into the bit sub before running the drill string into the hole.

It allows the mud to flow from up to down and it prevents the opposite flow.

There're two common types of NRV:

1- Flapper type
2- Plunger type

It prevents back flow of mud or any other fluid from drill string and prevent the bit plugging.

Figure 62 Float valve

5.4.3.10 Drill pipe

Tubular steel conduit fitted with special threaded ends called tool joints.

The drill pipe connects the rig surface equipment with the bottom hole assembly, both to pump drilling fluid to the bit and to be able to raise, lower and rotate the bottom hole assembly (BHA) and bit.

The drill pipe comes in different sizes, strengths, and weight for drilling different sizes and depth of hole.

The drill pipe grades are identified by symbols and number and refers to minimum yield strength.

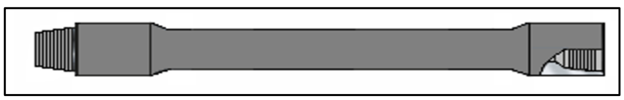
The drill pipe grade is D-55, E-75, X-95, G-105 and S-135.

The Number refers to the minimum yield strength in thousands psi it measures drill pipe strength.

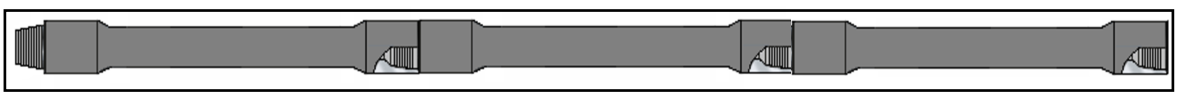
A larger diameter hole requires a larger diameter drill pipe, as the hole is drilled deeper, more drill pipes are added to the drill string on the rig floor.

If the well is deeper, then the drill pipe needs to be stronger.

The drill pipe length usually varied from 29 to 33 feet, to save the time of rig we connect three joints of drill pipe together and treated as one part **(one stand = 3 drill pipes which is approximately 91 feet)**.



Single Joint of drill pipe



Stand of drill pipe = 3 joints of drill pipes

Figure 63 Drill pipe single and stands

Drill pipe is identified by the following:

DP – 5'' - X 95 - #19.50 ib./ft - 32' -3 1/2" IF -1789

Drill pipe outer diameter: 5 inches.

Drill pipe grade: X-95

Drill pipe nominal weight: 19.50 ib./ft.

Drill pipe length: 32 feet.

Drill pipe thread connection size & type: 3 ½'' IF.

Drill pipe Serial number: 1789

5.4.4 Drilling Console

You have learned about some of the main equipment used to drill a well.

The driller operates this equipment from a ***console*** on the rig floor.

Sensors display equipment information on gauges on the driller's console.

The driller uses the information to monitor the condition and status of the equipment and make decisions on what action needs to be taken.

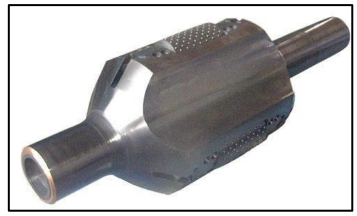
All the driller's controls are in the console

Some rigs are automated and use more computerized controls.

Figure 64 Drilling console

5.4.5 Exercise

1. What's the name of this equipment?
    a. Reamer
    b. Float valve
    c. Stabilizer
    d. Kelly bushing



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2. What's the name of this equipment?
    a. Reamer
    b. Float valve
    c. Stabilizer
    d. Kelly bushing

---

3. What's the function of equipment in picture?
    a. It used to rotate the drill string.
    b. It used to free the drill string in case of stuck.
    c. It used to drill the hole.
    d. It used to connect two different types of tubular.

---

4. What's the name of this equipment?
    a. Drill bit
    b. Drilling jar.
    c. Mud pump.
    d. Draw-work.

---

5. What's the name of this equipment?
    a. Drilling jar.
    b. Drill bit
    c. Mud pump.
    d. Cross over sub.

6. What's the name of this equipment?
    a. Rotary table.
    b. Kelly bushing.
    c. Master bushing.
    d. Kelly.

7. What's the name of this equipment?
    a. Kelly bushing.
    b. Drill string.
    c. Swivel
    d. Kelly.

8. What's the name of this equipment?
    a. Drill bit.
    b. Drill collar.
    c. Top drive system.
    d. Mud pump.

9. What's the name of this equipment?
    a. Drill collar.
    b. Drill bit.
    c. Drill pipe.
    d. Draw work.

10. What's the name of this equipment?
    a. Drill collar.
    b. PDC bit.
    c. Tri-cone bit.
    d. Drill pipe.

---

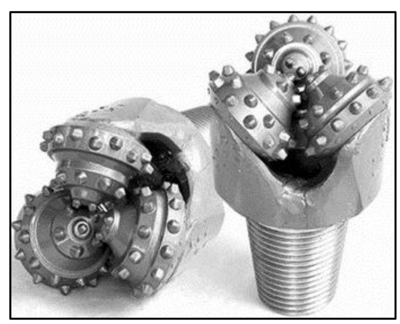
11. What's the name of this equipment?
    a. Stabilizer.
    b. Reamer.
    c. Top drive system.
    d. MAST.

---

12. What's the name of this equipment?
    a. Drill string.
    b. Top drive system.
    c. Float valve (NRV)
    d. Draw work

---

13. What's the name of this equipment?
    a. PDC Bit.
    b. Mud pump.
    c. Reamer.
    d. Tri-Cone Bit



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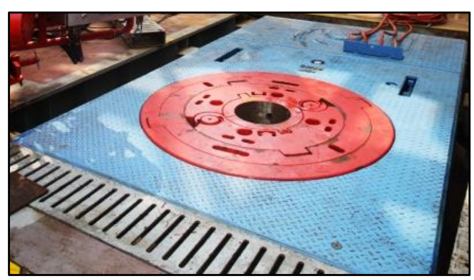
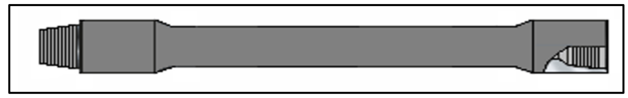
14. What's the name of this equipment?
    a. Rotary hose.
    b. Rotary table.
    c. Top drive system.
    d. Kelly bushing.



15. What's the name of this equipment?
    a. Stand of drill pipe.
    b. Drilling jar.
    c. Single joint of drill pipe.
    d. Kelly bushing.



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16. …………………… suspend the drill string, permit it to rotate freely and prevents the hook, travelling block, drilling line & crown block from rotation.
    a. Rotary table.
    b. Kelly bushing.
    c. Swivel
    d. Kelly

---

17. ……………………A device that when fitted to master bushing transmits rotation to the Kelly and simultaneously permits vertical movement of the Kelly to make hole.
    a. Rotary table.
    b. Kelly bushing.
    c. Swivel
    d. Kelly

---

18. …………………Equipment used to turn the drill string and suspend the drilling assembly by slips.
    a. Kelly bushing.
    b. Rotary table.
    c. Swivel
    d. Kelly

---

19. ……………………..A device that fits into the rotary table to accommodate the slips and drive the Kelly bushing so that the rotating motion of the rotary table can be transmitted to the Kelly.
    a. Master bushing.
    b. Rotary table.
    c. Swivel
    d. Kelly

---

20. drive is a mechanical device on a drilling rig that provides clockwise torque to the drill string to drill a borehole. It is an alternative to the rotary table and Kelly drive.
    a. Swivel
    b. Top drive system
    c. Kelly drive system.
    d. Kelly

---

21. ……………………..is consists of The drill bit, drill pipe, and any other equipment that goes in the hole to drill hole.
    a. BHA
    b. Mud pump
    c. Drill string
    d. Swivel

22. What's the name of this equipment?
    a. Reamer.
    b. Drill collar.
    c. Stabilizer.
    d. Master bushing.

---

23. What's the name of this equipment?
    a. Driller console.
    b. Draw work.
    c. Stabilizer.
    d. Mud pump.

---

24. What's the name of this equipment?
    a. Drill collar.
    b. Drill bit.
    c. HWDP.
    d. Crown block.

---

25. What's the name of this equipment?
    a. Swivel.
    b. Stabilizer.
    c. Driller console.
    d. Kelly

5.5 WELL CONTROL SYSTEM

"Well control" means preventing fluid or gas from underground escaping the well. 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. This gives the rig crew valuable time to react and fix the problem.

❖ Overview on well control

Well control and blowout prevention have become particularly important topics in the hydrocarbon production industry for many reasons.

Among these reasons are higher drilling costs, waste of natural resources, and the possible loss of human life when kicks and blowouts occur.

Well control is the technique used in oil and gas operations such as drilling, well workover, and well completions for maintaining the fluid column hydrostatic pressure and formation pressure to prevent influx of formation fluids into the wellbore.

This technique involves the estimation of formation fluid pressures, the strength of the subsurface formations and the use of casing and mud density to offset those pressures in a predictable fashion.

Understanding of pressure and pressure relationships are very important in well control.

One concern is the increasing number of governmental regulations and restrictions placed on the hydrocarbon industry, partially as a result of recent, much-publicized well-control incidents. For these and other reasons, it is important that drilling personnel understand well-control principles and the procedures to follow to properly control potential blowouts.

The key elements that can be used to control kicks and prevent blowouts are based on the work of a blowout specialist and are briefly presented below:

Quickly shut in the well.

When in doubt, shut down and get help. Kicks occur as frequently while drilling as they do while tripping out of the hole.

Many small kicks turn into big blowouts because of improper handling.

Act cautiously to avoid mistakes—take your time to get it right the first time.

You may not have another opportunity to do it correctly.

❖ History of well control

Gushers were an icon of oil exploration during the late 19th and early 20th centuries.

During that era, the simple drilling techniques such as cable-tool drilling and the lack of blowout preventers meant that drillers could not control high-pressure reservoirs.

When these high-pressure zones were breached, the oil or natural gas would travel up the well at a high rate, forcing out the drill string and creating a gusher.

A well which began as a gusher was said to have "blown in": for instance, the Lakeview Gusher blew in in 1910.

These uncapped wells could produce large amounts of oil, often shooting 200 feet (60 m) or higher into the air.

A blowout primarily composed of natural gas was known as a gas gusher.

Despite being symbols of new-found wealth, gushers were dangerous and wasteful.

They killed workmen involved in drilling, destroyed equipment, and coated the landscape with thousands of barrels of oil; additionally, the explosive concussion released by the well when it pierces an oil/gas reservoir has been responsible for a number of oilmen losing their hearing entirely; standing too near to the drilling rig at the moment it drills into the oil reservoir is extremely hazardous.

Figure 65 Impact of blowout on environment

The impact on wildlife is very hard to quantify but can only be estimated to be mild in the most optimistic models—realistically, the ecological impact is estimated by scientists across the ideological spectrum to be severe, profound, and lasting.

To complicate matters further, the free-flowing oil was—and is—in danger of igniting.

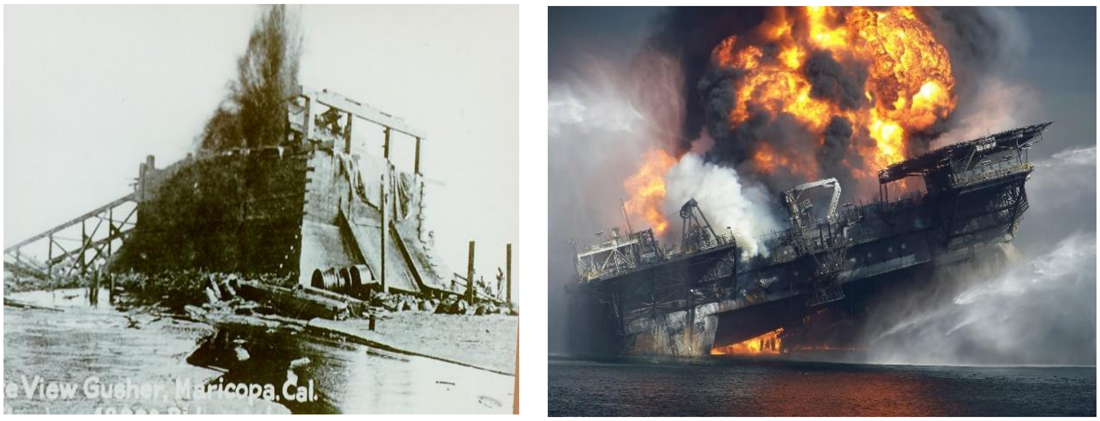


Figure 66 Rigs blowout

One dramatic account of a blowout and fire reads, with a roar like a hundred express trains racing across the countryside, the well blew out, spewing oil in all directions.

The derrick simply evaporated, casings wilted like lettuce out of water, as heavy machinery writhed and twisted into grotesque shapes in the blazing inferno.

The development of rotary drilling techniques where the density of the drilling fluid is sufficient to overcome the downhole pressure of a newly penetrated zone meant that gushers became avoidable.

If, however, the fluid density was not adequate, or fluids were lost to the formation, then there was still a significant risk of a well blowout.

In 1924 the first successful blowout preventer was brought to market.

The BOP valve affixed to the wellhead could be closed in the event of drilling into a high pressure zone, and the well fluids contained.

Well control techniques could be used to regain control of the well. As the technology developed, blowout preventers became standard equipment, and gushers became a thing of the past.

In the modern petroleum industry, uncontrollable wells became known as blowouts and are comparatively rare. There has been significant improvement in technology, well control techniques, and personnel training which has helped to prevent their occurring.

❖ Well control classifications

Well Control can be classified into two main topics

A- Principles and Procedures.

Part of well control concerns to deliver full knowledge about the principles, the basics that should be learned and the standard procedure for dealing with wells that have a well control issue.

B- Well Control Equipment.

Part of well control concerns to deliver full knowledge about the well control equipment names, functions, installation, testing, standard operating procedure and maintenance.

Well control equipment should always be ready for immediate use.

5.5.1 Well control Principle & procedure (P&P)

- Formation fluid
- Formation properties
  - Porosity
  - Permeability
- Hydrostatic pressure
- Bottom hole pressure
- Pressure gradient
- Formation Pressure
- Fracture pressure
- Types of drilling
  - Over balance
  - Balance
  - Under balance
- Kick
- Blow out
- Primary well control
- Secondary well control

5.5.1.1 Formations fluid

- In order to understand the well control, we have to study some of keys definition.
- Formations fluid means any fluid that occurs in the pores of a rock, this fluid might be gas, oil or/and water.
- Strata containing different fluids, such as various saturations of oil, gas and water, may be encountered in the process of drilling an oil or gas well.
- Fluids found in the target reservoir formation are referred to as reservoir fluids.

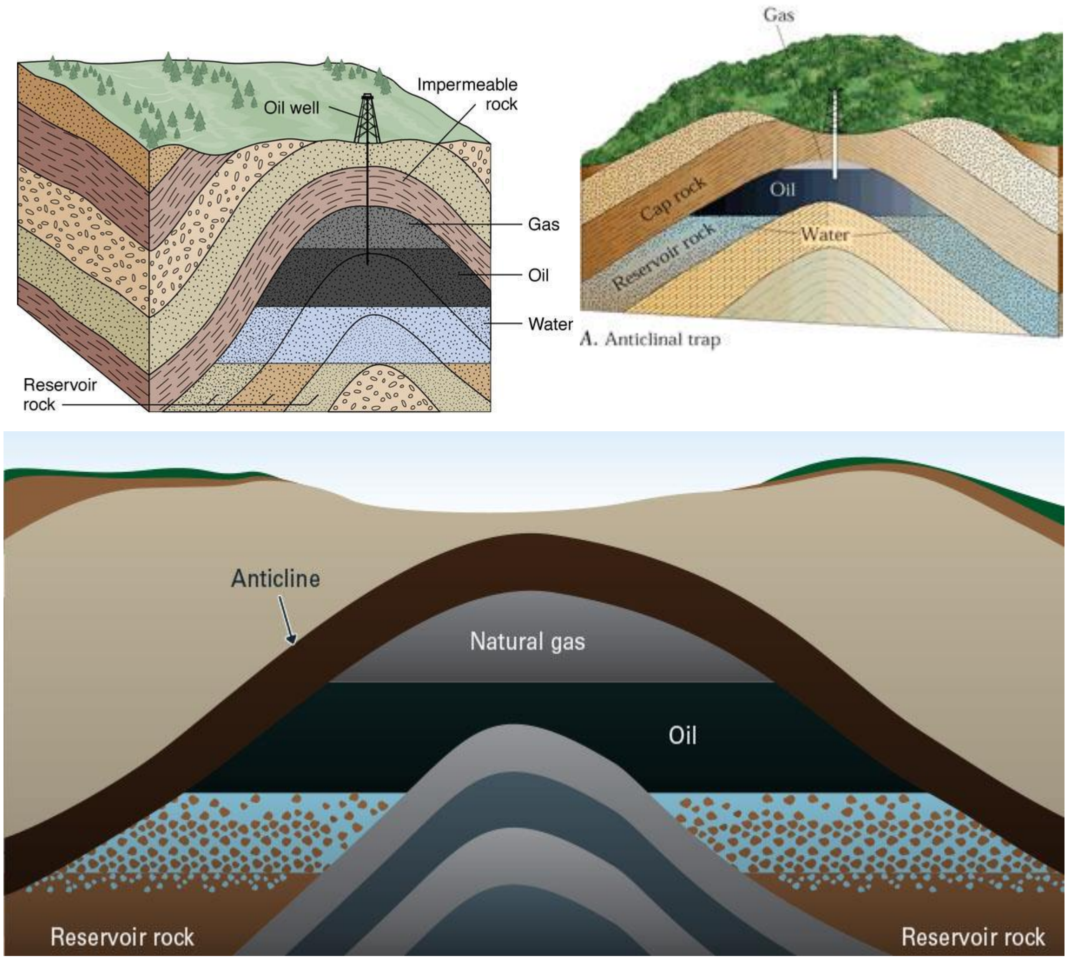


Figure 67 Formation fluid content

5.5.1.2 Formation properties

- To understand the formation behavior, we've to learn the rock properties.
- There're two main rock properties that's very important regarding to well control.

❖ Formation Porosity

- The percentage of pore volume or void space, or that volume within rock that can contain fluids.

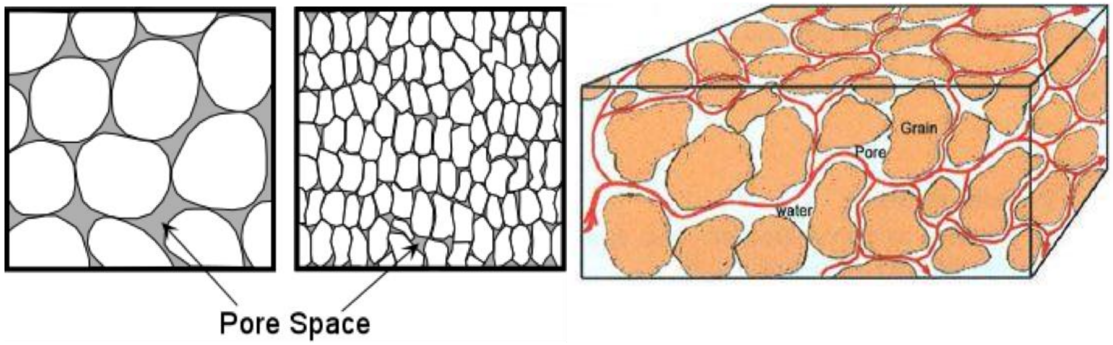
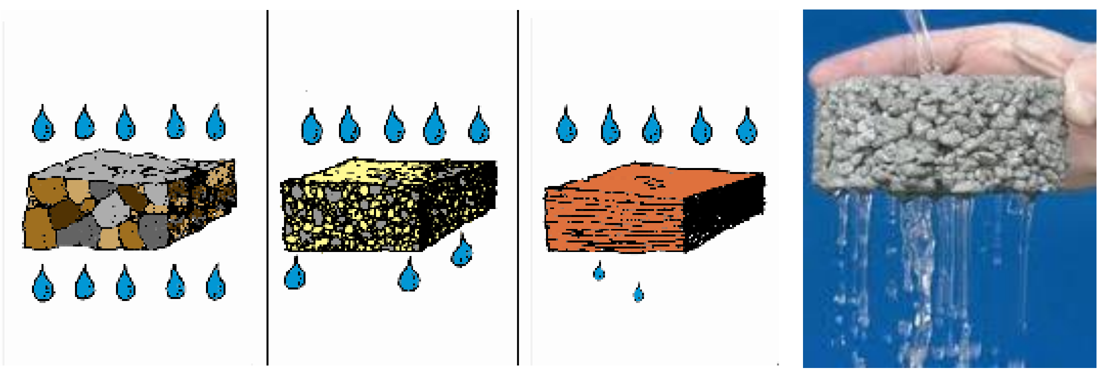


Figure 68 Formation Porosity

❖ Formation Permeability

- The ability, or measurement of a rock's ability, to transmit fluids through its void spaces



- Rock permeability is varied from formation to another and it measures in milli darcy.

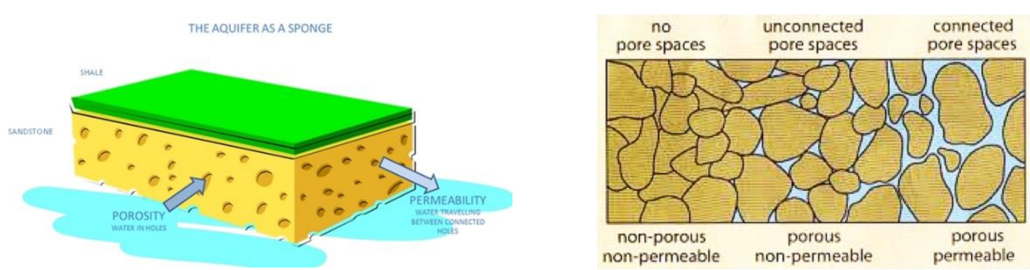


Figure 69 Formation Permeability

5.5.1.3 Hydrostatic Pressure

- The pressure exerted by the weight of mud's column.
- The hydrostatic pressure used as primary well control which used to control the formations pressure.
- Hydrostatic pressure = 0.052 x M.WT. x TVD
- Where
- 0.052: Const. (conversion factor)
- M.WT: Mud weight in PPG.
- TVD: True vertical depth in feet. (is the vertical depth from surface to target)

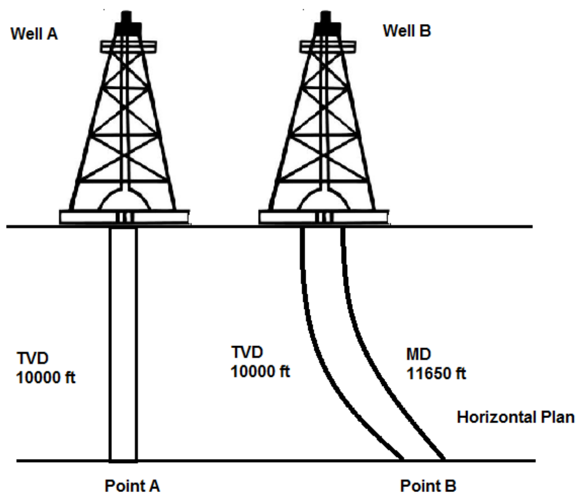


Figure 70 Hydrostatic Pressure

5.5.1.1 Bottom hole pressure (BHP)

- The pressure, usually measured in pounds per square inch (psi), at the bottom of the hole. This pressure may be calculated in a static, fluid-filled wellbore with the equation:
    - BHP = MW * Depth * 0.052
- For circulating wellbores, the BHP increases by the amount of fluid friction in the annulus.
    - BHP = (MW * Depth * 0.052) + **Annular Pressure Loss (APL)**

5.5.1.2 Pressure Gradient (PG)

- Pressure gradient is a term used to describe the pressure at specific depth, it's the change in pressure per unit of depth, typically in units of psi/ft.
- The pressure gradient can be determined by the following equation
    - PG = Pressure/depth
- Or it can be inferred from the hydrostatic pressure equation:
    - HP = 0.052*MW*TVD
    - HP / TVD = 0.052*MW
    - PG = HP / TVD = 0.052*MW

5.5.1.3 Formation Pressure

- The fluid pressure in the pore spaces of the formation.
- The formation is classified according to the pressure gradient.
- The normal formation pressure gradient is equal to weight of sea water column which is equals to **0.465** psi/ft.
- If the pressure gradient of formations is 0.465 psi/ft so the formation is considered as normal formations pressure.
- If the pressure gradient of the formation is higher than 0.465 psi/ft. so the formation is considered as abnormal formation pressure.
- If the pressure gradient of the formation is lower than 0.465 psi/ft. so the formation is considered as subnormal formation pressure.

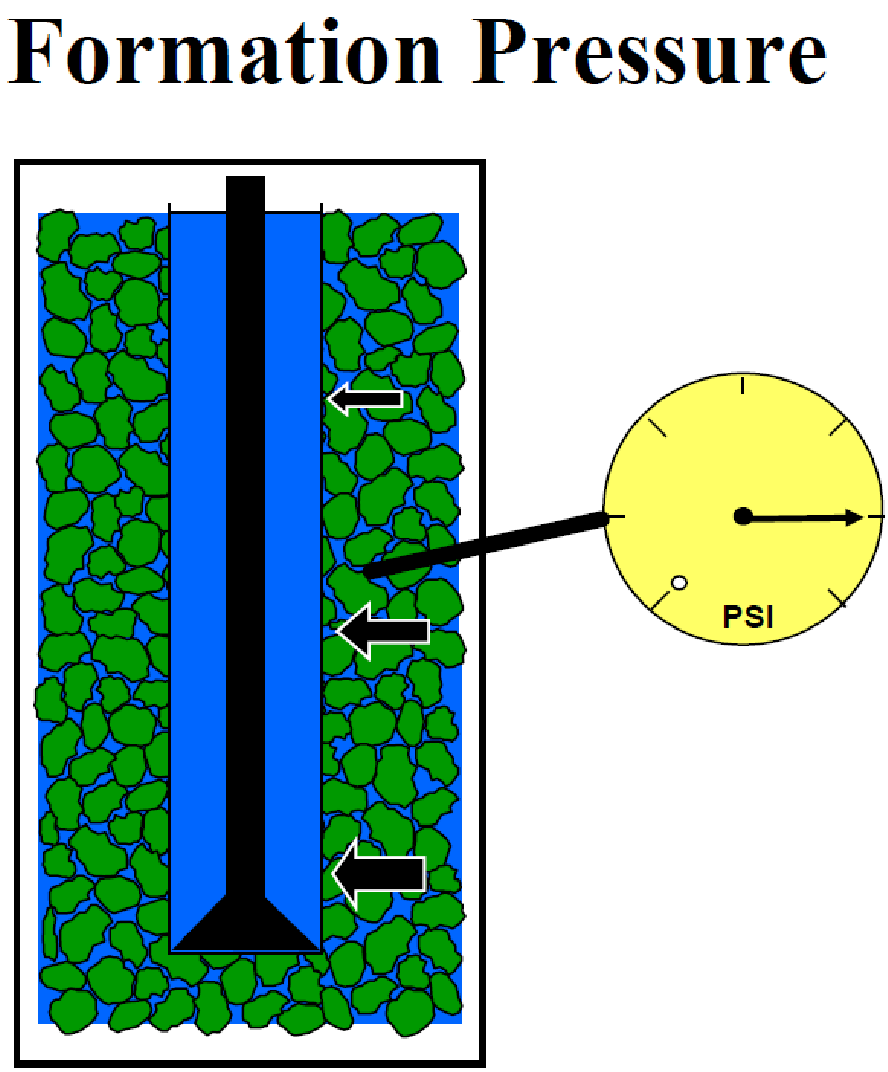


Figure 71 Formation Pressure

5.5.1.4 Fracture Pressure

- The Pressure above which circulation of fluids will cause the rock formation to fracture hydraulically.
- The fracture pressure is determined by Leak off test (LOT).
- If the hydrostatic pressure exceeds the fracture pressure loss of circulation will occur which means loss of the drilling fluid into the formation.
- The loss of circulation might be cured by pumping loss circulating material (LCM) or CMT plug.

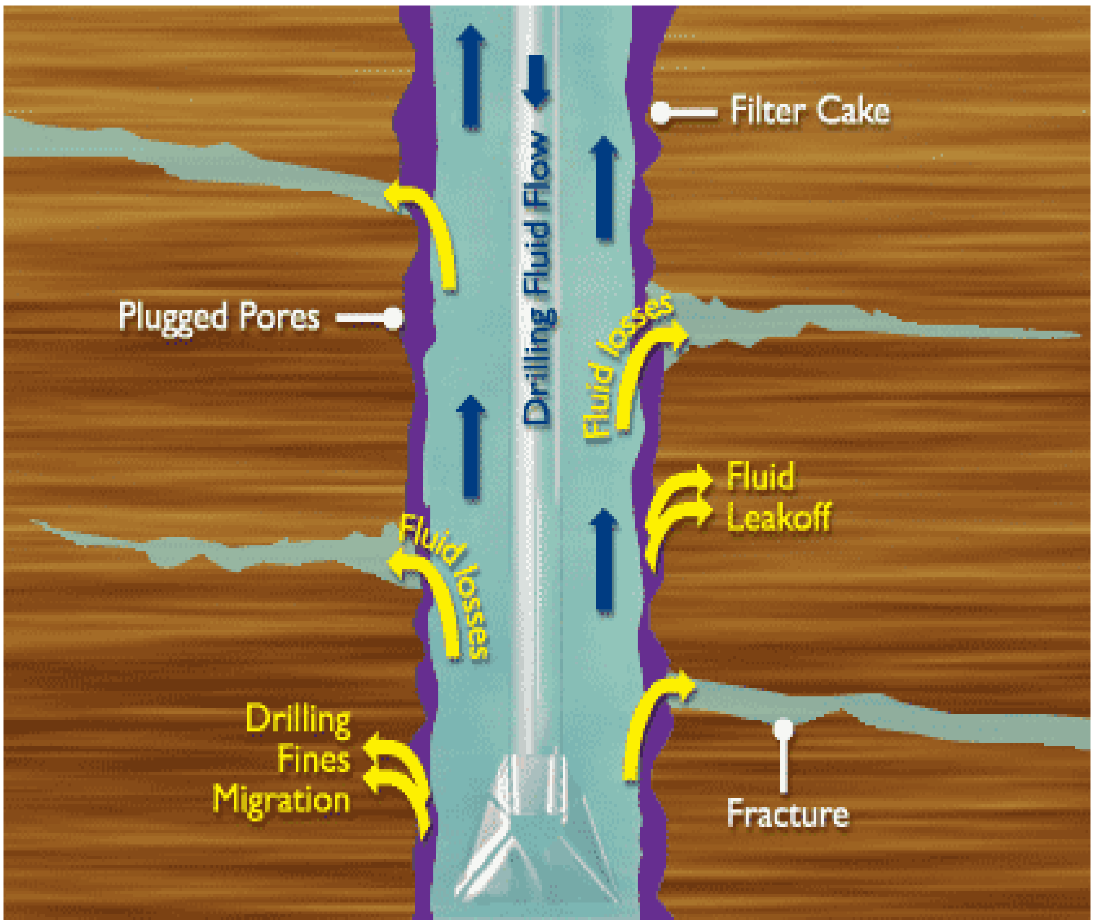
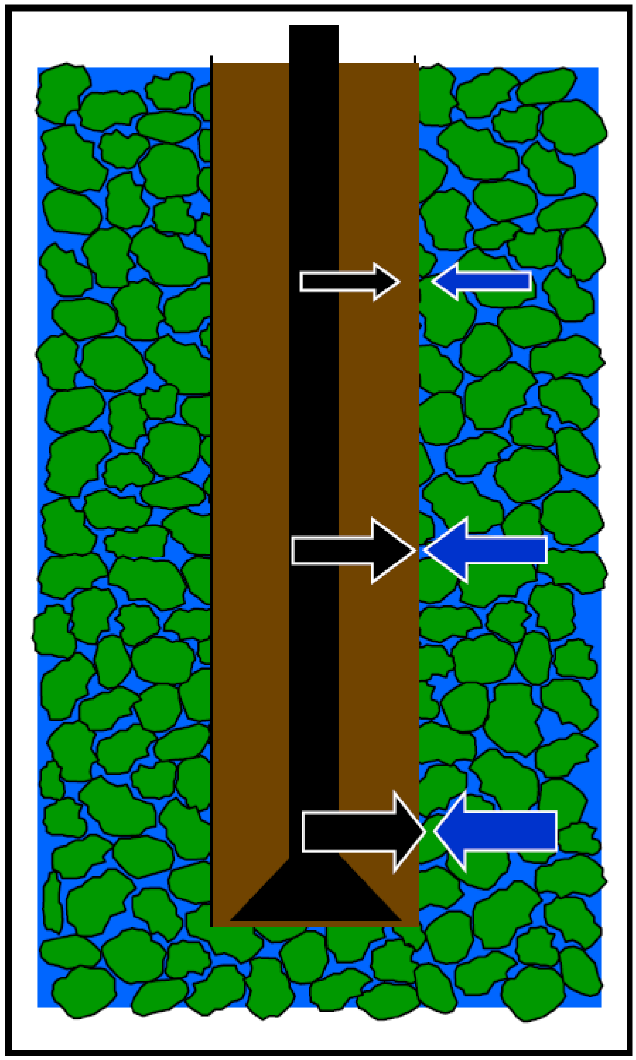


Figure 72 Fracture Pressure

5.5.1.5 Types of Drilling

1- Balance Drilling

- Which means drilling with hydrostatic pressure is approximately equals to formation pressure.
- It's too hard and very risky to achieve this type of drilling because there's possibility to lose some of the mud column which might cause kick situation.

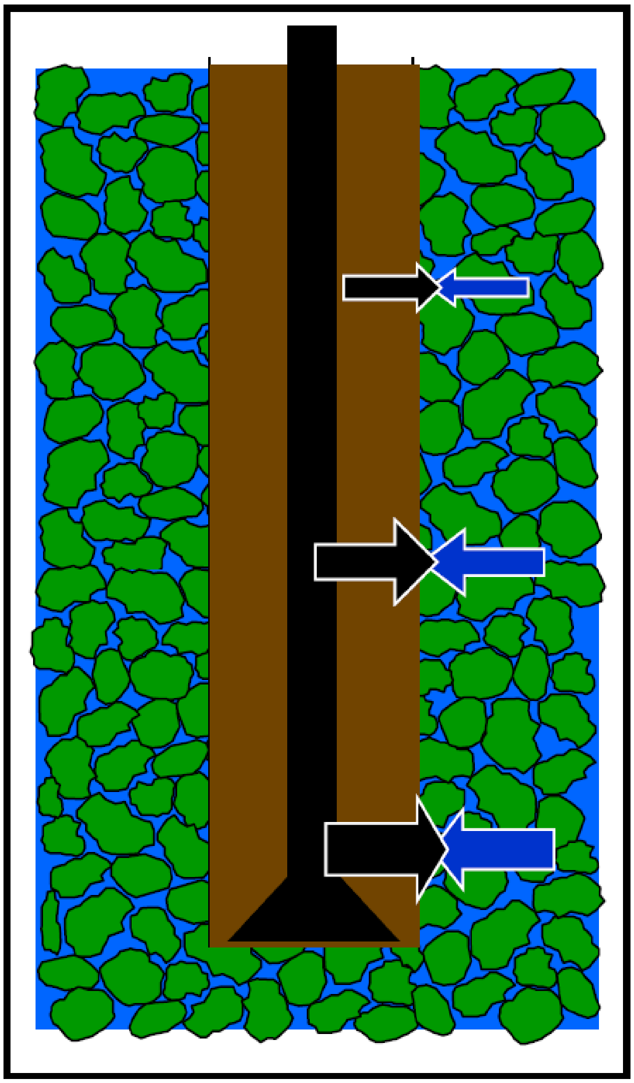


Mud Hydrostatic = Formation Pressure

Figure 73 Balance drilling

2- Overbalance drilling

- Which means drilling with hydrostatic pressure is higher than to formation pressure.
- The most common types of drilling is used to drill the well safely (from well control side of view)
- In this case the hydrostatic pressure is higher than the formation pressure and less than fracture pressure.

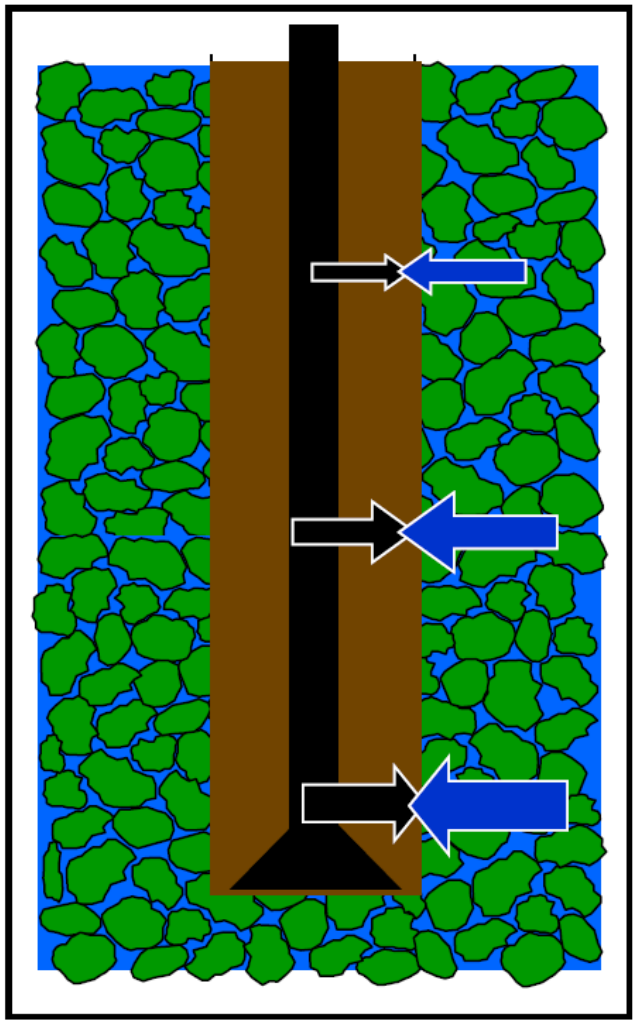


Mud Hydrostatic > Formation Pressure

Figure 74 Over balance drilling

3- Underbalance drilling

- Which means drilling with hydrostatic pressure is less than formation pressure.
- As the well is being drilled, formation fluid flows into the wellbore and up to the surface. This is the opposite of the usual situation, where the wellbore is kept at a pressure above the formation to prevent formation fluid entering the well.
- The main advantage of using UBD is Increases rate of penetration (ROP) and eliminates the formation damage.



Mud Hydrostatic < Formation Pressure

Figure 75 Under balance drilling

5.5.1.6 Kick

A “kick” is an undesirable flow of formation fluid into the well bore.

There’re many causes of kick such as: -

1- Failure to keep hole full.
2- Low density fluid.
3- Loss of circulation.
4- Gas cut mud.
5- Surging / Swabbing.
6- Abnormal Pressure zone.
7- Lack of crew knowledge & training.

Once detecting the kick, the driller shut in the well in order to start the killing operation to remove the influx (kick) from the well and re-store the control on the well by new killing mud weight.

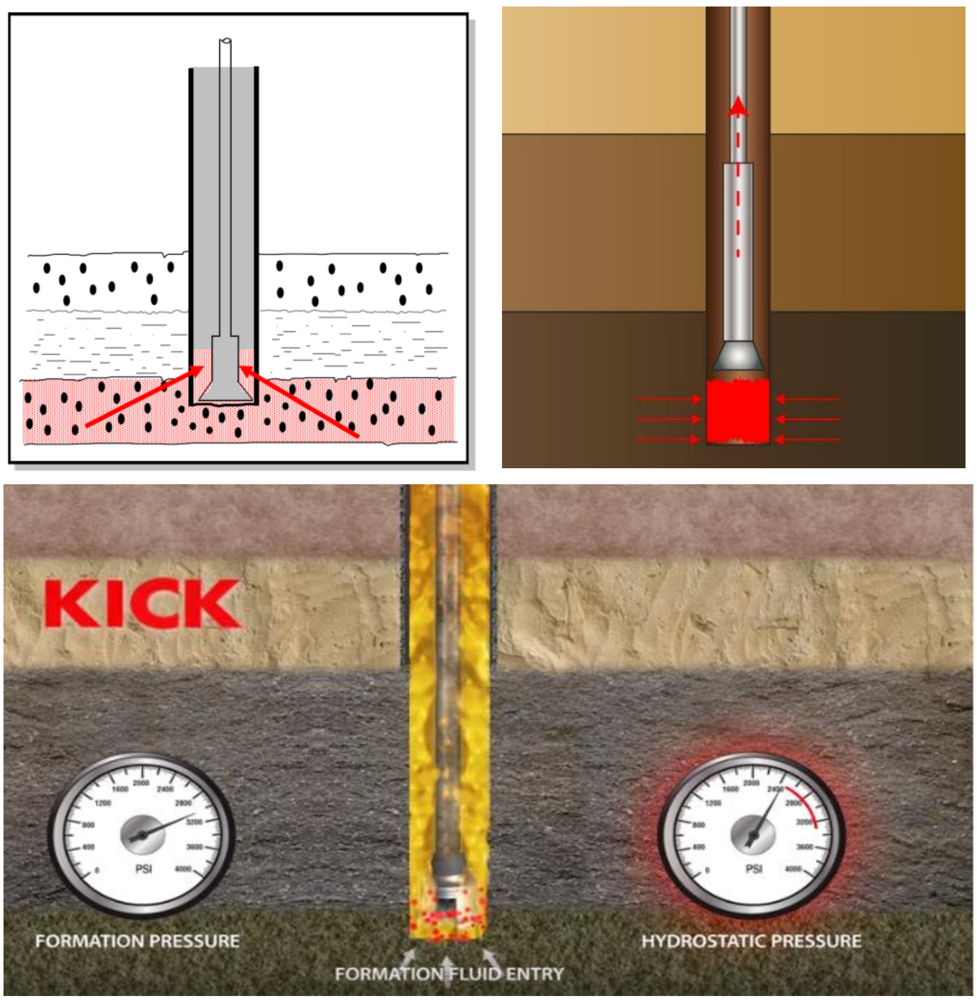


Figure 76 Kick

5.5.1.7 Blowout

- An uncontrolled exit of the formation fluids at the surface or into lower pressured subsurface zones (underground blowout).
- Uncontrolled flows cannot be contained using previously installed barriers and require specialized services intervention.
- A blowout may consist of water, oil, gas or a mixture of these.
- Blowouts may occur during all types of well activities and are not limited to drilling operations.

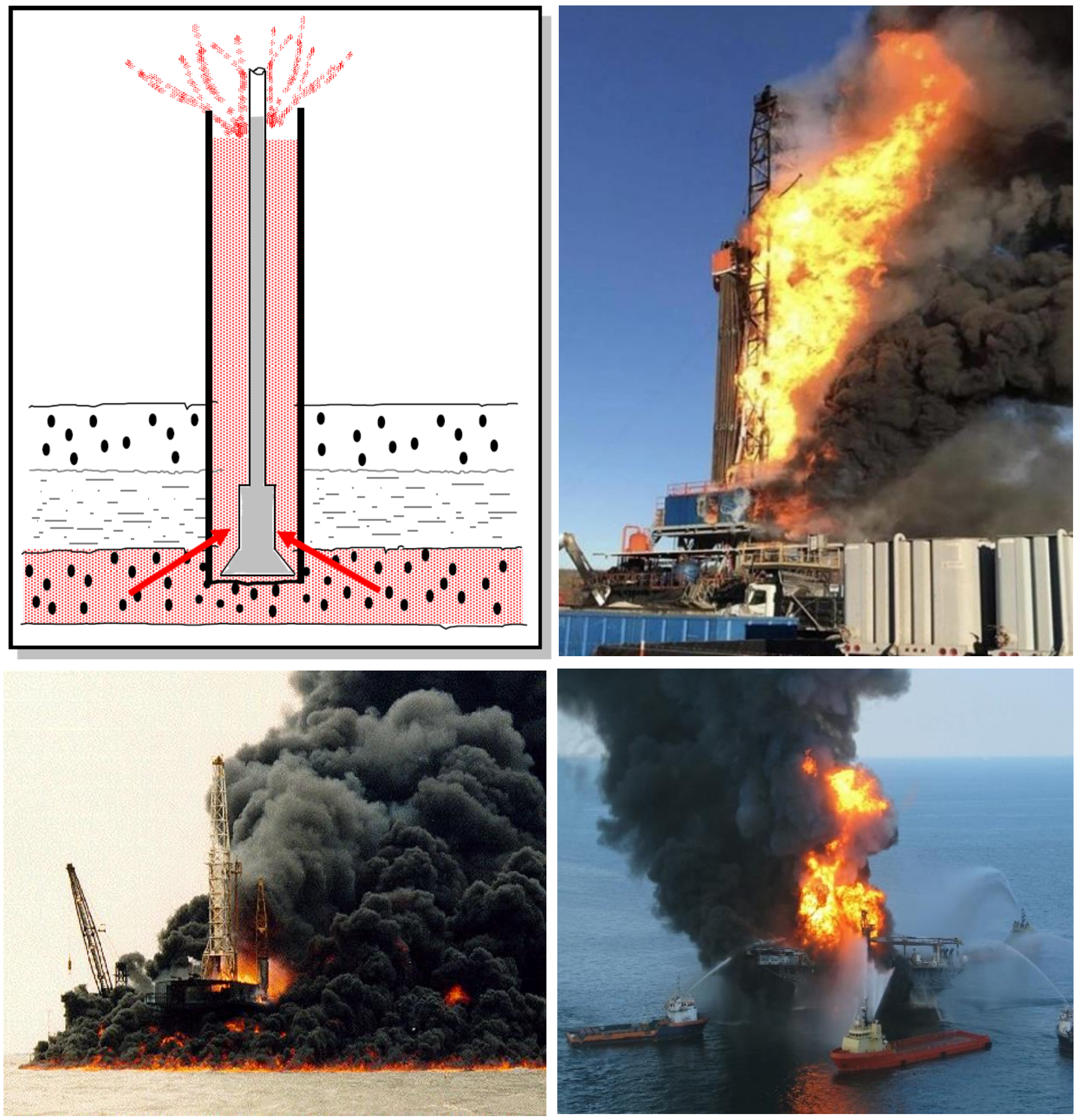


Figure 77 Blow out

5.5.1.8 Primary well control

- Hydrostatic pressure (Mud) is the primary well control (the first defensive line in well).
- Mud hydrostatic prevents formation fluids entering the wellbore.
- Hydrostatic pressure should be kept all the time higher than the formation pressure to prevent kick and blowout of the well by closely monitoring the mud weight and mud level in the well and comparing by the formation pressure.
- Hydrostatic pressure should be higher than formation pressure and lower than fracture pressure Formation pressure < Hydrostatic pressure < Fracture pressure.

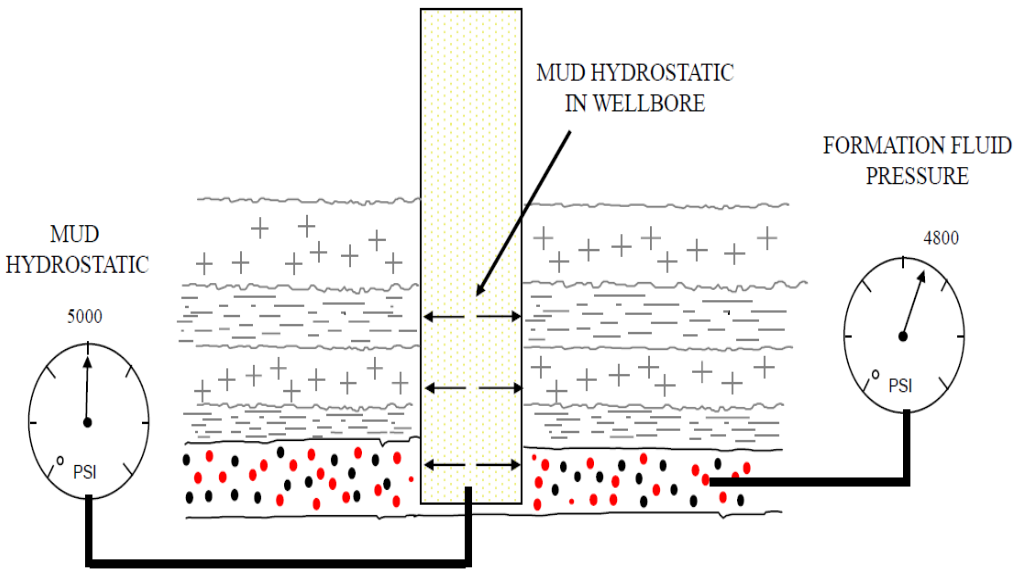


Figure 78 Primary well control

5.5.1.9 Secondary well control

- BOP or (Blowout preventer) is considered as secondary well control which is used in case the primary well control (mud) has failed to perform his function.
- BOP is activated to shut the well and prevent formation fluids flowing at the surface and cause harm to people or damage the rig and its equipment.
- The next operations is to record the pressure coming from the well and prepare new mud with higher mud weight to kill the well and restore the primary well control.

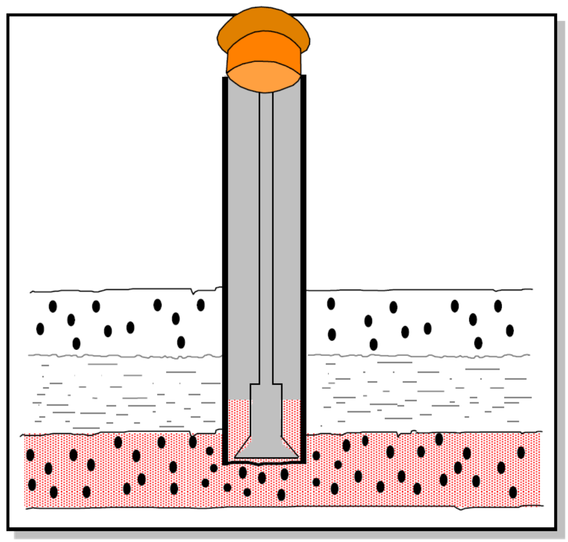


Figure 79 Secondary well control

5.5.2 Well control equipment

- Diverter
- BOP Stack
- Annular Preventer
- Single/double ram
- Types of rams
- Drilling spool (mud cross)
- Kill line
- Choke line
- Accumulator unit (Koomey Unit)
- BOP Remote Control panel
- Choke manifold
- Remote choke control panel (SWACO)
- Mud Gas separator
- Full opening safety valve
- I-BOP

Figure 80 Blowout Preventer (BOP)

5.5.2.1 Diverter

- The diverter is an low pressure annular preventer with a large piping system underneath and it usually used in top hole drilling when shallow gas is expected and it also depends on the regulations and operator policies
- The diverter should be used only when the well cannot be shut in because of fear of formation breakdown or lost circulation.
- It's installed on Conductor casing prior to drill surface section.
- It is utilized to divert the kick from the rig (not shut in equipment) and it required the conductor pipe to be installed.
- The large diameter pipe typically has two directions diverting the wellbore fluid out of the rig (figure 81).
- The vent line should have large diameter, straight and short in length.
- When the shallow gas is detected the vent line (downwind) should be activated first then close the diverter.

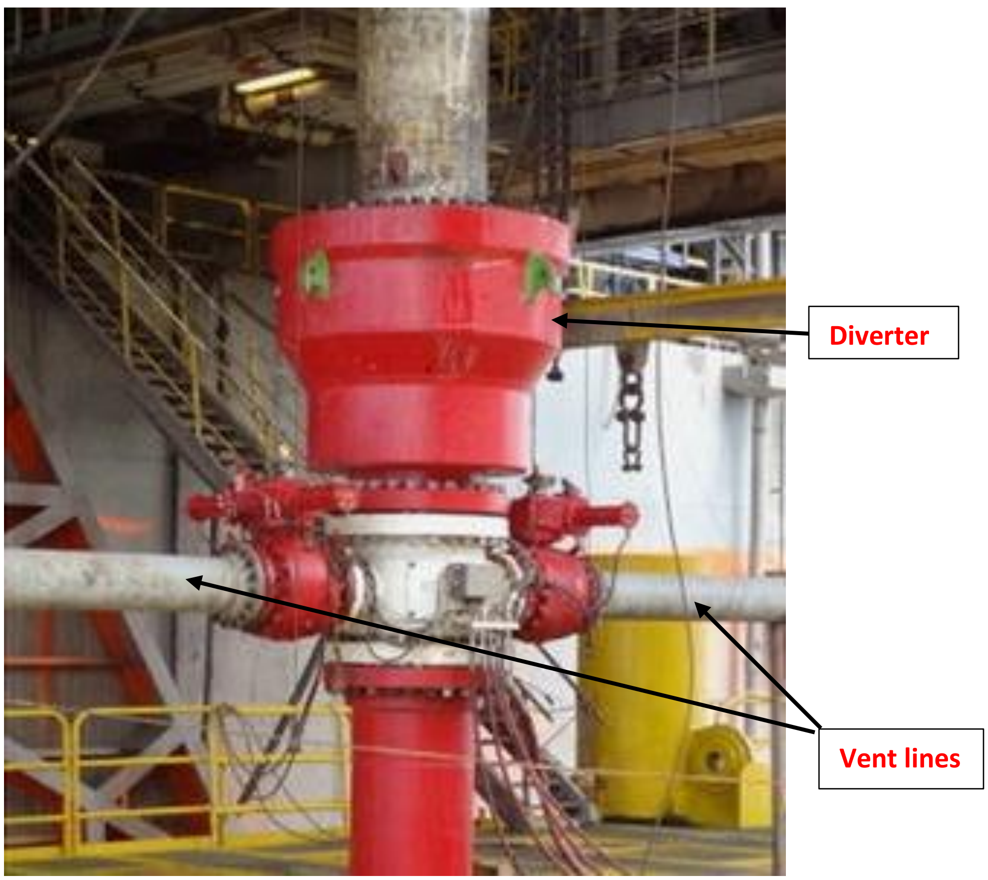


Figure 81 Diverter

5.5.2.2 *BOP Stack*

- The blow-out preventer (BOP) is shown, the BOP is the largest part of the well control equipment. It prevents high pressure from escaping from the well and possibly causing a disaster.
- A set of two or more BOPs used to ensure pressure control of a well.
- A typical stack might consist of one to six ram-type preventers and, optionally, one or two annular-type preventers.
- The configuration of the stack preventers is optimized to provide maximum pressure integrity, safety and flexibility in the event of a well control incident.
- The most common BOP stack configuration is from top (Annular Preventer, Upper pipe ram, Blind shear ram, Mud cross, kill line, choke line, manual and hydraulic valves, Bottom pipe ram).
- The BOP is installed after drilling surface hole and setting surface casing.

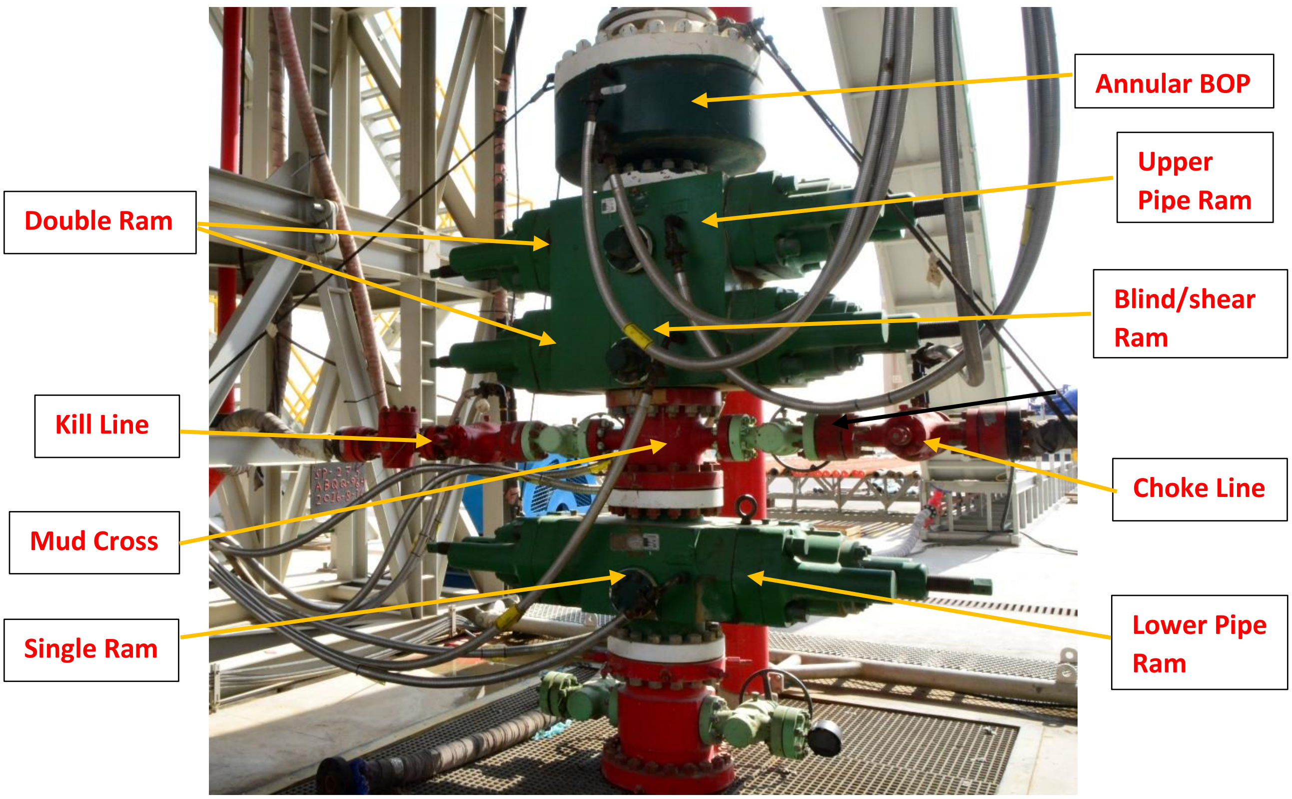


Figure 82 BOP Stack

5.5.2.3 Annular Preventer

- A large valve used to control wellbore fluids. In this type of valve, the sealing element resembles a large rubber doughnut that is mechanically squeezed inward to seal on either pipe (drill collar, drill pipe, casing, or tubing) or the open hole.
- The ability to seal on a variety of pipe sizes is one advantage the annular blowout preventer has over the ram blowout preventer.
- Most blowout preventer (BOP) stacks contain at least one annular BOP at the top of the BOP stack.
- It can shut in the well on itself (in case of there is no tubular in hole) but the rubber should be replaced after.
- It cannot seal around the reamer and stabilizer.

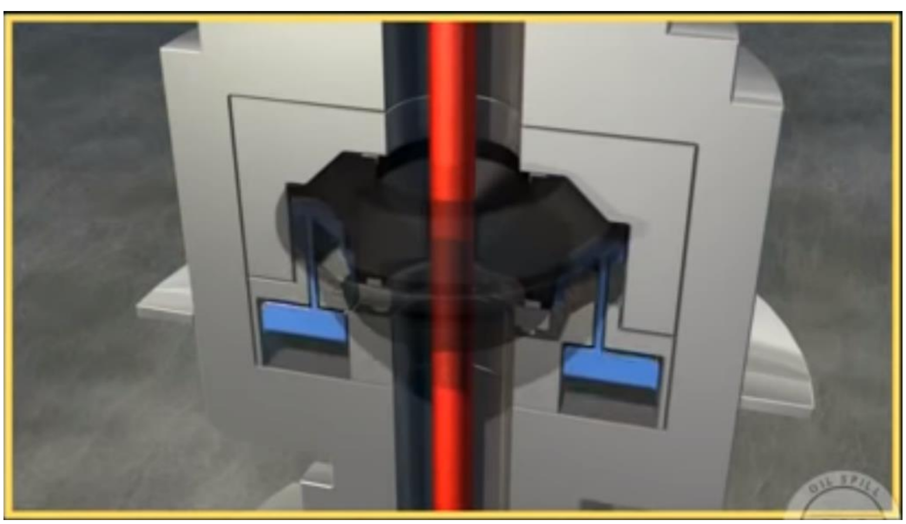


Figure 83 Annular BOP

5.5.2.4 Single / Double Ram BOP

- Ram preventers are commonly available in single-, double.
- Single Ram BOP is usually containing one pipe ram and it's usually installed at the bottom of BOP Stack (Lower Ram).
- Double Ram BOP is containing usually one pipe ram and one blind shear ram.
- Single ram BOP is distinguished by it has separate flange to be connected with BOP stack through it but the double ram has two ram body is welded (doesn't have separate flange for every ram BOP body) it's considered as one part.

Figure 84 Single Ram BOP

Figure 85 Double Ram BOP

5.5.2.5 Types of ram

A- Fixed Pipe Ram

- A type of sealing element in high-pressure split seal blowout preventers that is manufactured with a half-circle hole on the edge (to mate with another horizontally opposed pipe ram) sized to fit around drill pipe.
- Most pipe rams fit only one size or a small range of drill pipe sizes and do not close properly around drill pipe tool joints or drill collars.

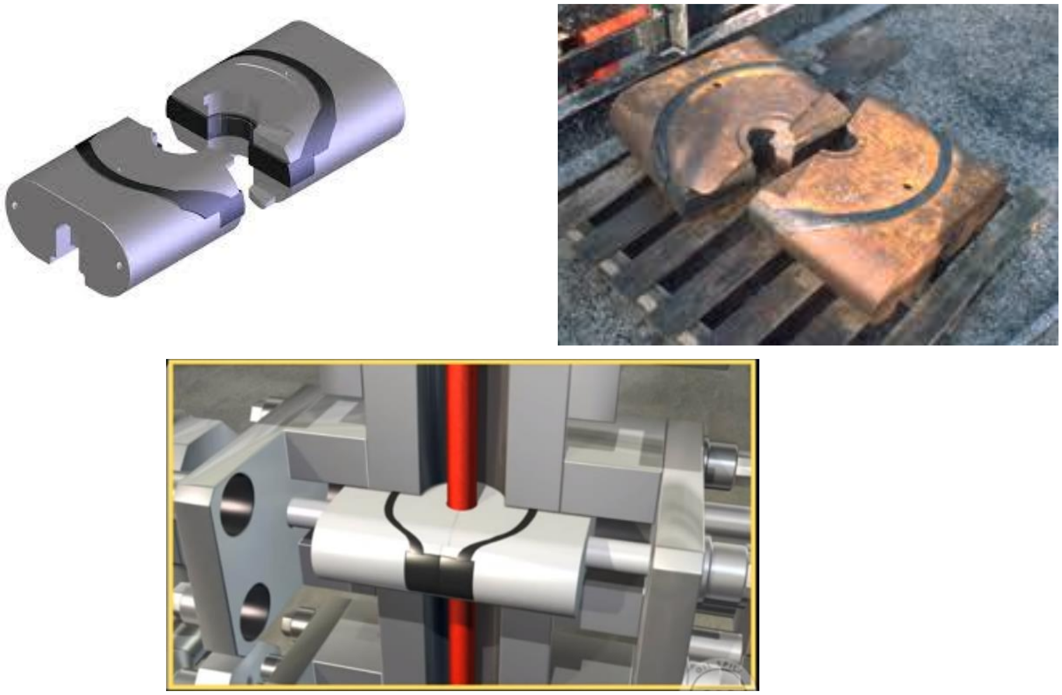


Figure 86 Pipe Ram

B- Variable Bore Ram

- A relatively new style is the variable bore ram, which is designed and manufactured to properly seal on a wider range of pipe sizes. For example VBR 3 ½'' to 7''

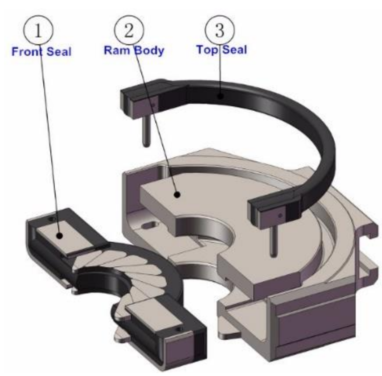


Figure 87 Variable Bore Ram

C- Blind Ram

- Two blocks of steel that meet in the center of the wellbore to seal the well have a hole.
- It used to seal off wellbore in case there's no pipe in the well.
- If the blind ram is activated with drill pipe in hole so it will cause collapse for the opposite body but it will never seal / shut the well.

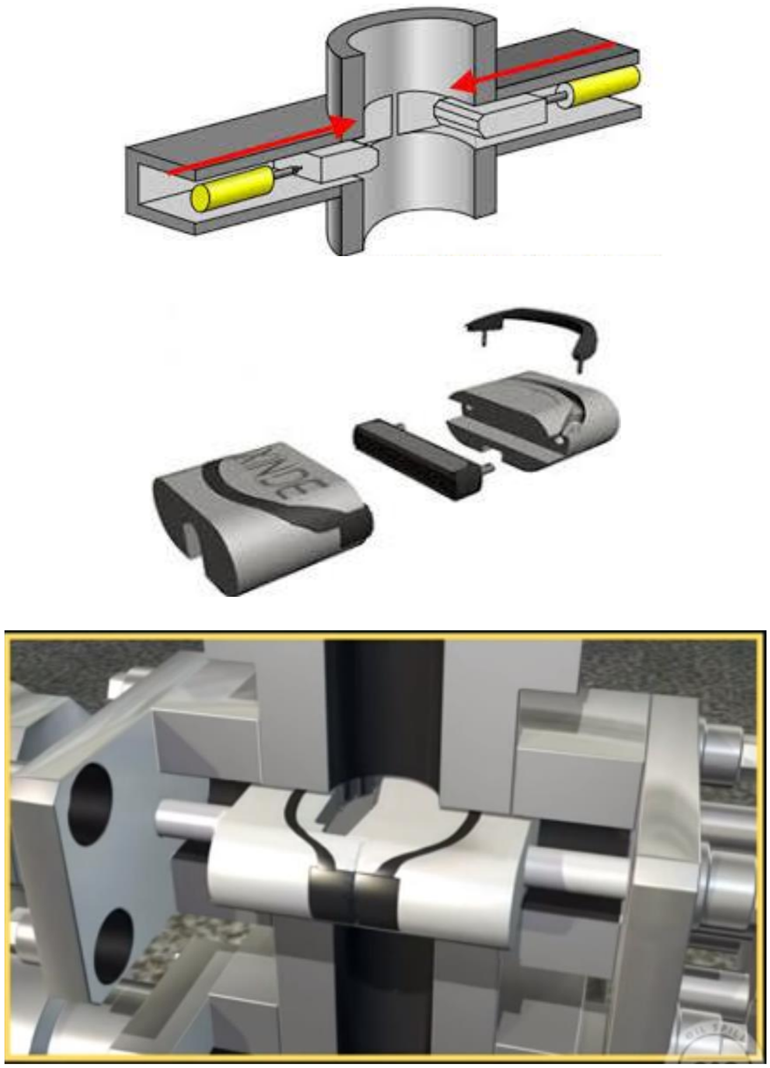


Figure 88 Blind Ram

D- Blind shear Ram

- A blowout preventer (BOP) closing element fitted with hardened tool steel blades designed to cut the drill pipe or tubing when the BOP is closed, and then fully close to provide isolation or sealing of the wellbore.
- This is the last resort of well control before evacuating the rig site.

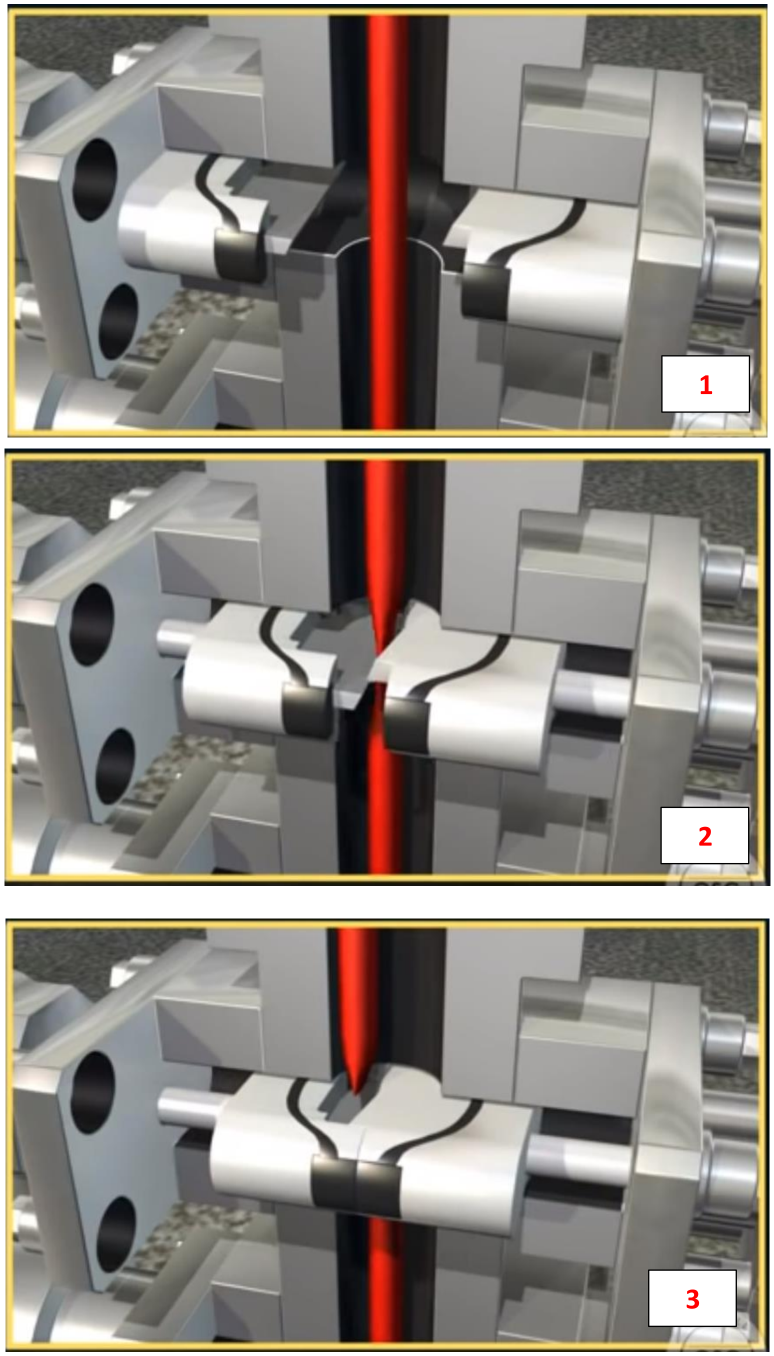


Figure 89 Blind Shear Ram

5.5.2.6 Drilling Spool (Mud Cross)

- Pressure-containing piece of equipment having end connections with or without side outlet connections, used below or between drill-through equipment and it serve as a spacer or crossover.
- It is allowing the choke and kill lines to be connected to BOP Stack.
- This tool is characterized by size, end type (studded/flanged) and rate working pressure.
- For example, this connection of mud cross is 11'' x 5000 psi (flange end).
- Ring gasket is a mechanical seal which fills the space between two or more mating surfaces, generally to prevent leakage.
- There's specific ring gasket size is fits to specific size of flange.

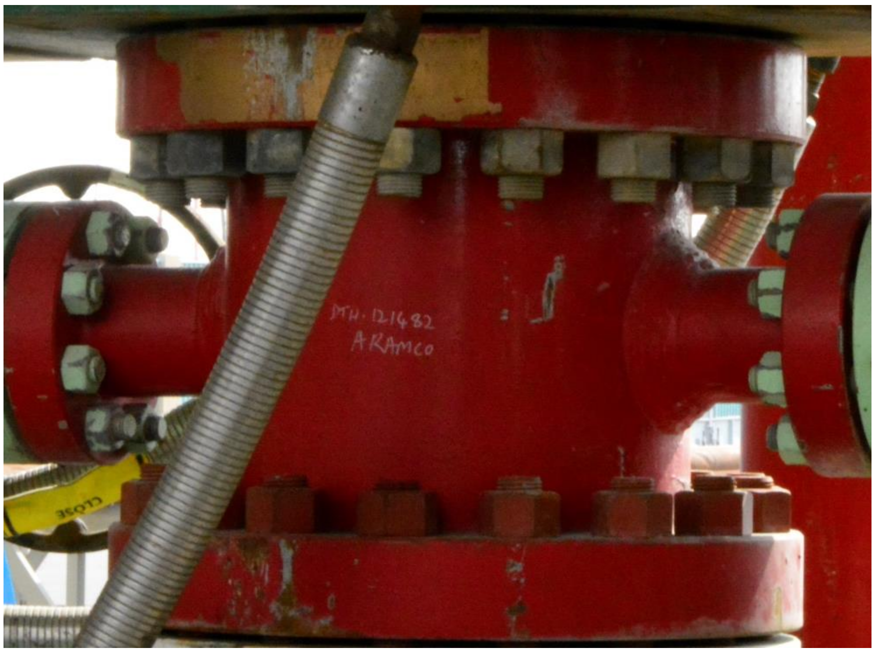


Figure 90 Mud Cross (Drilling Spool)

Figure 91 Ring Gasket

5.5.2.7 Kill line

- A high-pressure pipe leading from an outlet on the BOP stack to the high-pressure rig pumps and it used If the drill pipe is inaccessible.
- During normal well control operations, kill fluid is pumped through the drill string and annular fluid is taken out of the well through the choke line to the choke, which drops the fluid pressure to atmospheric pressure.

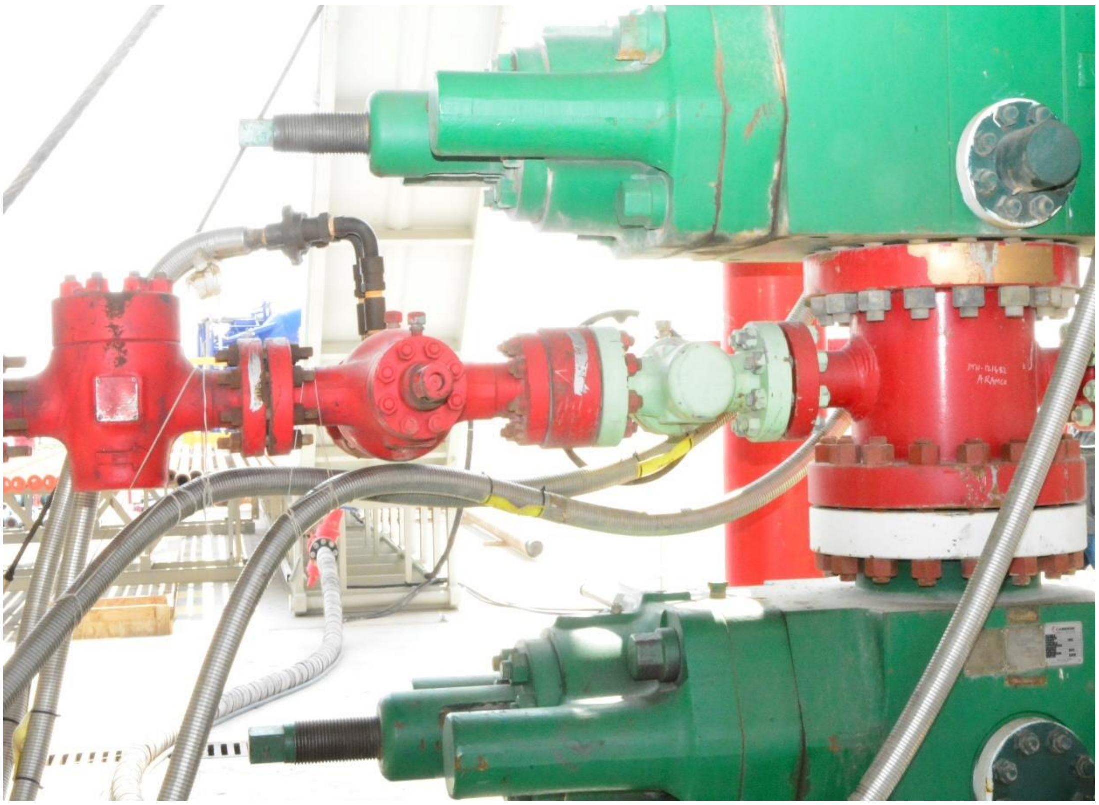


Figure 92 Kill line

5.5.2.8 Choke line

- A high-pressure pipe leading from an outlet on the BOP stack to the backpressure choke and associated manifold.
- During well-control operations, the fluid under pressure in the wellbore flows out of the well through the choke line to the choke manifold, reducing the fluid pressure to atmospheric pressure.

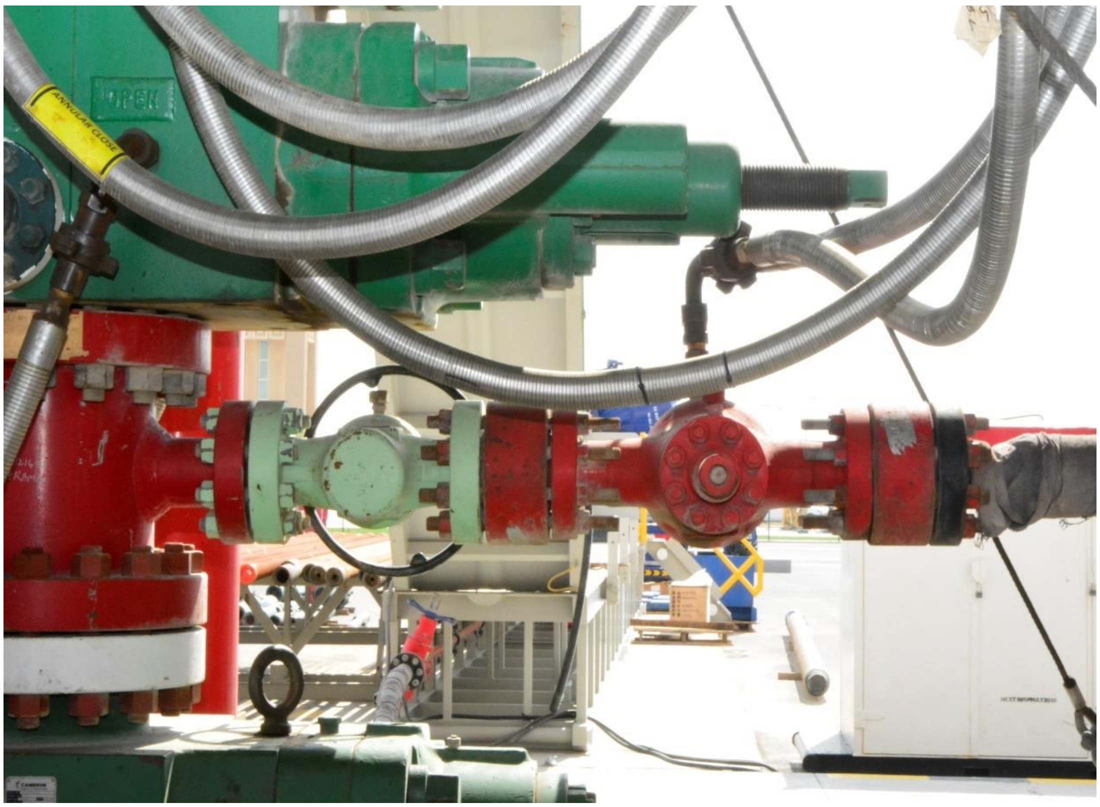


Figure 93 Choke line

5.5.2.9 Accumulator Unit (Koomey unit)

- An accumulator or Koomey unit is a unit used to hydraulically operate Rams BOP, Annular BOP, HCR and some hydraulic equipment.
- Energy is stored by compressing a pre-charged gas bladder with hydraulic fluid from the operating or charging system to allow accumulator to operate BOP in case of emergency.
- The accumulator stores pressurized hydraulic fluid that opens and closes the valves in the BOP. High pressure pumps in the accumulator pressurize the hydraulic fluid into vessels called bottles.
- Handles on the accumulator operate the BOP equipment. The BOP can also be operated from control panels located around the rig.

Figure 94 Accumulator Unit

5.5.2.10 BOP Remote Control Panel

- A device placed on the rig floor that can be operated by the driller to close BOP, it has control hand wheels all these controls operate the preventers on the BOP stack remotely by hydraulics from an accumulator unit.
- When the hand wheels is operated it direct air pressure to actuating cylinders that turn the control valves on the main BOP control unit, located a safe distance from the rig.
- A BOP control panel in located next to the doghouse and/or the tool-pusher and foreman office that the driller can access quickly.
- There may be other locations around the rig that the BOP can be controlled from in an emergency.
- The preventers can also be closed manually by using hand-wheels on the BOP.

Figure 95 BOP Remote Control Panel

5.5.2.11 Choke Manifold

- A set of high-pressure valves and associated piping that usually includes at least two adjustable chokes, arranged such that one adjustable choke may be isolated and taken out of service for repair and refurbishment while well flow is directed through the other one.
- The function of choke manifold is to hold back pressure while circulating up the kick, regulate the flow of gas or fluid escaping from the well through the BOP and then the flow is sent to equipment that removes the gas from the mud.

Figure 96 Choke Manifold

5.5.2.12 Remote choke control panel (SWACO)

- A set of controls, usually placed on the rig floor, or elsewhere on location, that is manipulated to control the amount of drilling fluid being circulated through the choke manifold.
- This procedure is necessary when a kick is being circulated out of a well.

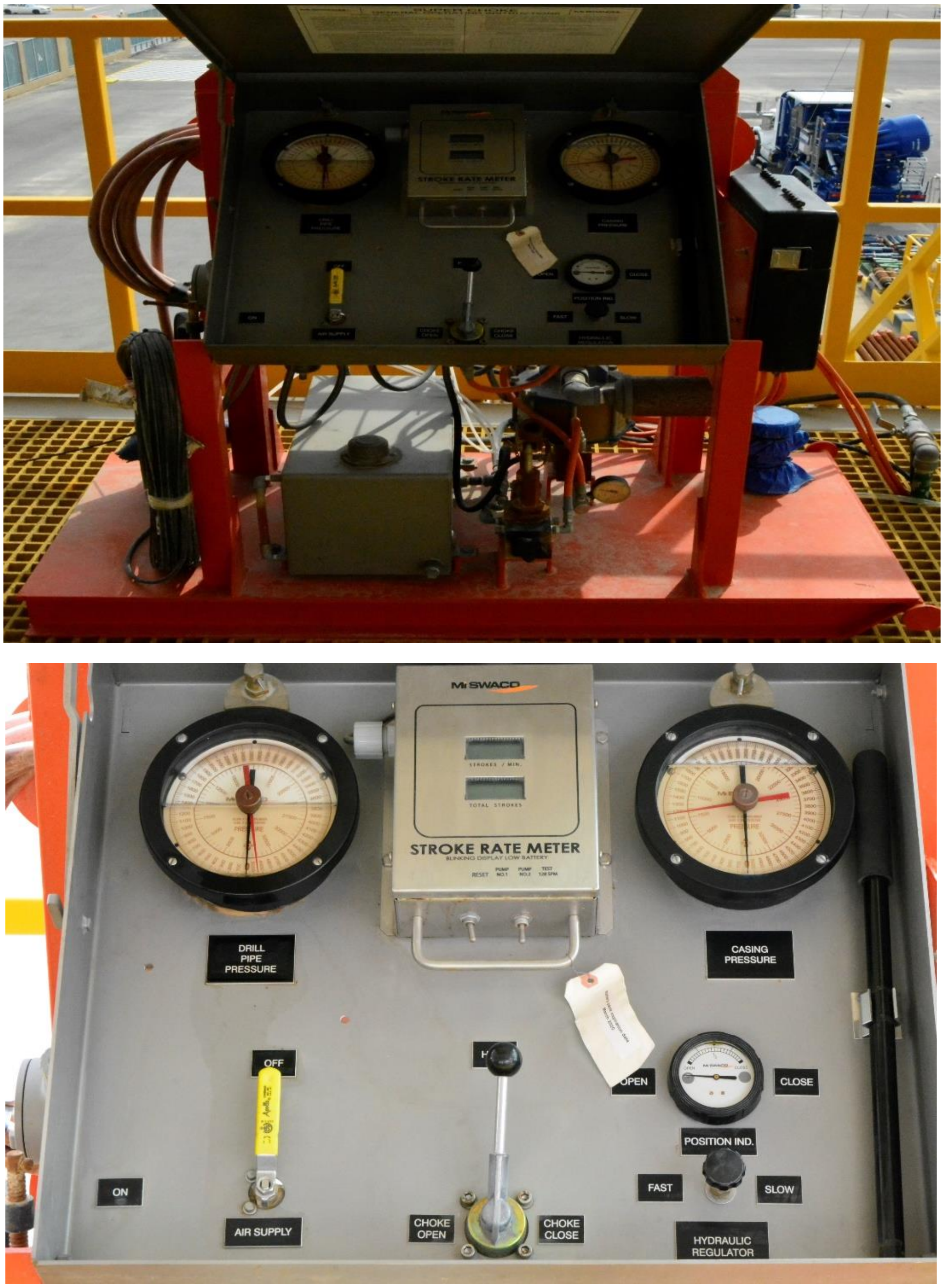
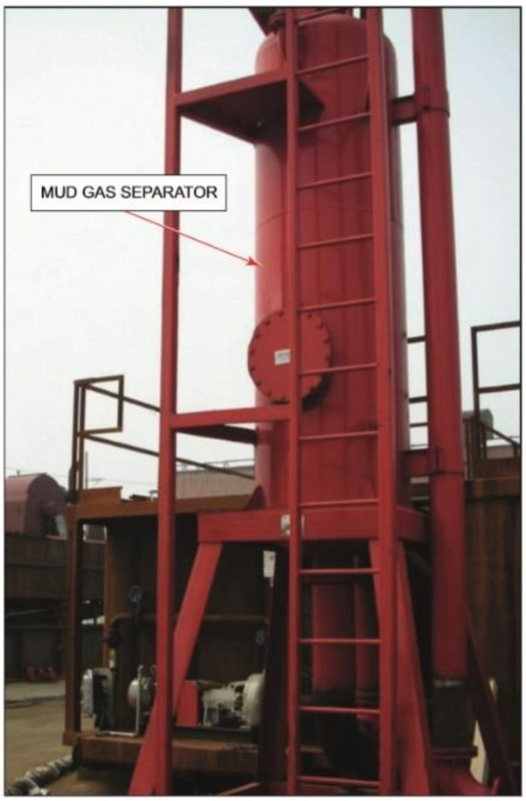


Figure 97 Remote choke control panel (SWACO)

5.5.2.13 Mud Gas Separator

- A device placed after choke manifold captures and separates the large volumes of free gas within the drilling fluid.
- If there is a "kick" situation, this vessel separates the mud and the gas by allowing it to flow over baffle plates.
- This equipment separates the gas from the mud as it exits the well, the mud flows into the MGS near the top. As the mud falls, it hits baffle plates inside the MGS. This agitates the mud and allows the gas to escape from the mud. The gas exits at the top of the MGS. The separated gas is sent to pits for burning off the gas, called flare pits.
- The gas then is forced to flow through a line, venting to a flare and the mud then is returned to tanks.



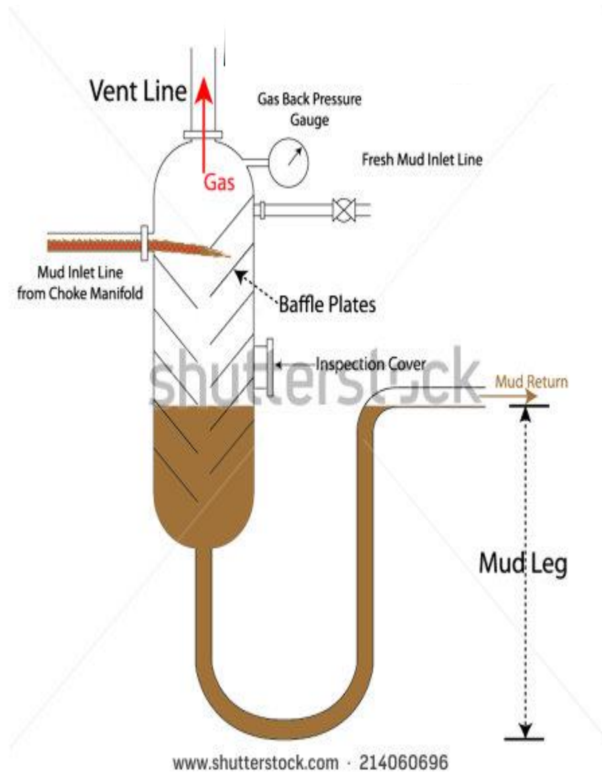


Figure 98 Mud Gas Separator

5.5.2.14 Full Opening Safety Valve (Gray-valve)

- It is a ball valve designed for high pressure condition and it can hold pressure from both directions.
- It used in well control situation if the well is kicks while tripping operations.
- It always kept in open position with its Alan-key.
- This is a manually operated ball valve that connects to the top of the drill string during well control operations.
- It is connected when there is a sign that there is gas or fluid entering the well. The stabbing valve is stored on the rig floor in the open position, ready for use. Once connected to the drill string, the ball valve is closed. The gray valve prevents gas or fluid from coming up through the drill string. Mud cannot be pumped through the stabbing valve when it is closed.

Figure 99 Full opening safety valve (Gray valve)

5.5.2.15 I-BOP

- This valve is a non-return valve (check valve) <u>installed above the FOSV</u> allowing pumping drilling fluid through the valve into the drill string.
- Once IBOP is installed, FOSV can be opened, so that the driller can pump fluid into the well, I-BOP prevents upward flow and the more widely used type is “**dart-type**”.
- With the IBOP valve installed in the drill string, it allows you to strip in hole without mud flowing through the drill sting.

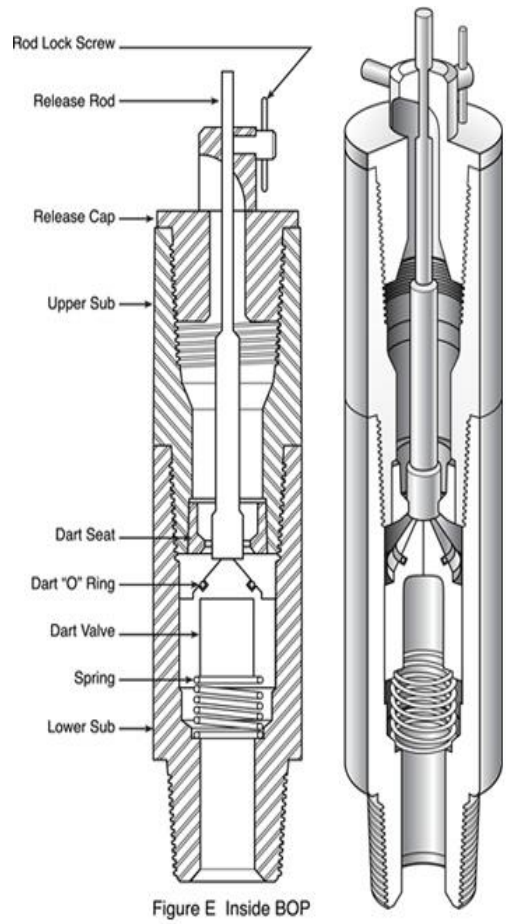


Figure 100 I-BOP

5.5.3 Exercise

1. What's the Primary well control?
    a. BOP (blowout preventer).
    b. Drilling fluid (mud).
    c. Casing.
    d. Cement.

---

2. What's the Secondary well control?
    a. Drilling fluid (mud).
    b. Casing.
    c. Cement.
    d. BOP (blowout preventer).

---

3. ………….. is the fluid pressure in the pore spaces of the formation.
    a. Formation fluid
    b. Rock Porosity
    c. Formation pressure
    d. BOP

---

4. ………….is the percentage of pore volume or void space, or that volume within rock that can contain fluids.
    a. Formation fluid
    b. Rock Permeability
    c. Rock Porosity
    d. Formation pressure

---

5. ……………any fluid that occurs in the pores of a rock, this fluid might be gas, oil or/and water.
    a. Formation fluids
    b. Rock Permeability
    c. Rock Porosity
    d. Formation pressure

---

6. What's the name of this equipment?
    a. Blind Shear Ram
    b. Mud Cross
    c. BOP
    d. Blind Ram

---

7. …………is the ability, or measurement of a rock's ability, to transmit fluids through its void spaces.
    a. Rock Permeability
    b. Formation fluid
    c. Rock Porosity
    d. Formation pressure

---

8. ……………….. is an uncontrolled exit of the formation fluids at the surface.
    a. blowout
    b. overbalance drilling
    c. underbalance drilling
    d. kick

9. Over balance drilling is the common type of drilling regards to well control and it means the hydrostatic pressure is ……………….. formation pressure.
    a. Equals to
    b. Higher than
    c. Lower than

10. …………….is an undesirable flow of formation fluid into the well bore.
    a. Blowout
    b. Formation pressure
    c. Kick
    d. Porosity

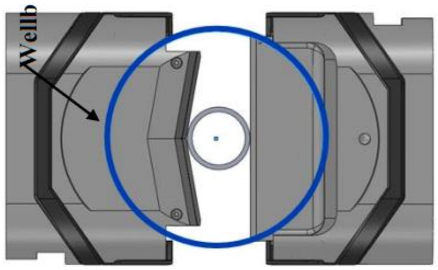
11. ……………. is Pressure above which circulation of fluids will cause the rock formation to fracture hydraulically.
    a. Formation fluid
    b. Rock Porosity
    c. Formation pressure
    d. BOP

12. Under balance drilling is the common type of drilling regards to well control and it means the hydrostatic pressure is …….. formation pressure.
    a. Equals to
    b. Higher than
    c. Lower than

13. Under balance drilling is the common type of drilling regards to well control and it means the formation pressure is ……………the hydrostatic pressure.
    a. Equals to
    b. Higher than
    c. Lower than

14. What's the hydrostatic pressure for well has TVD = 7590 ft. and mud weight = 8.9 ppg?
    a. ……………………… ppg.

15. What's the name of this equipment?
    a. Blind / shear ram.
    b. Blind ram.
    c. Fixed Pipe ram.
    d. Variable bore ram.



16. Over balance drilling is the common type of drilling regards to well control and it means the formation pressure is ……………the hydrostatic pressure.
    a. Equals to
    b. Higher than
    c. Lower than

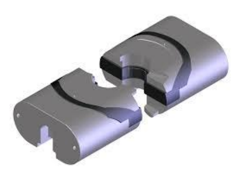
17. What's the hydrostatic pressure for well has MD = 7590 ft., TVD = 7359 ft. and Mud weight = 9.9 ppg?
    a. ……………………… ppg.

18. What's the name of this equipment?
    a. Remote choke panel (SWACO).
    b. Accumulator Unit (Koomey Unit).
    c. Blowout Preventer (BOP).
    d. BOP Remote Control Panel.

19. Well has formation pressure is 2970 psi at depth of 5970 ft. (TVD) and mud weight used for drilling is 8.9 ppg. The drilling now is ………………
    a. Balance.
    b. Over balance.
    c. Under balance.
    d. None of above.

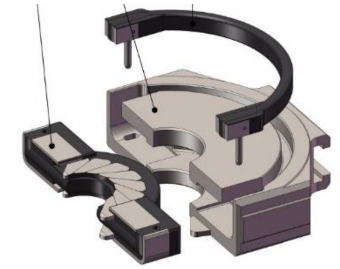
20. What's the name of this equipment?
    a. Remote choke panel (SWACO)
    b. Accumulator Unit (Koomey Unit)
    c. Full Opening Safety Valve (FOSV)
    d. Blowout Preventer (BOP)

21. What's the name of this equipment?
    a. Double ram BOP.
    b. Blind shear ram.
    c. Fixed Pipe ram
    d. Blind ram.



22. What's the name of this equipment?
    a. Full Opening Safety valve (FOSV)
    b. I-BOP
    c. Mud Cross.
    d. BOP stack.

23. What's the name of this equipment?
    a. Fixed pipe ram.
    b. Blind ram.
    c. Blind / shear ram.
    d. Variable bore ram.



24. What does BOP stands for?
    a. Base of preventer.
    b. Blowout Pressure.
    c. Base of pressure.
    d. Blowout preventer.

25. What's the name of this equipment?
    a. Double Ram.
    b. Diverter.
    c. Annular Preventer.
    d. Blind/Shear Ram.

26. What's the name of this equipment?
    a. Remote choke panel (SWACO)
    b. Accumulator Unit (Koomey Unit)
    c. Choke Manifold.
    d. Blowout Preventer (BOP)

27. What's the function of diverter system?
    a. To shut in the well.
    b. To drill the hole.
    c. To support casing.
    d. To divert the kick from the rig.

28. What's the function of Blowout preventer (BOP)?
    a. To secure the well.
    b. To drill the hole.
    c. To support casing.
    d. To divert the kick from the rig.

29. What's the name of this equipment?
    a. Remote choke panel (SWACO).
    b. Mud Gas Separator.
    c. Accumulator Unit (Koomey Unit).
    d. BOP Stack.

30. What's the name of this equipment?
    a. I-BOP.
    b. Drilling Spool (Mud cross).
    c. BOP Stack.
    d. Full Opening Safety Valve (FOSV).

31. What's the name of this equipment?
    a. Remote choke panel (SWACO).
    b. Accumulator Unit (Koomey Unit).
    c. Full Opening Safety Valve (FOSV).
    d. Blowout Preventer (BOP).

32. What's the name of this equipment?
    a. Remote choke panel (SWACO).
    b. Accumulator (Koomey Unit).
    c. Full Opening Safety Valve (FOSV).
    d. Blowout Preventer (BOP).

33. What's the name of this equipment?
    a. BOP Stack.
    b. Diverter.
    c. Accumulator Unit (Koomey unit).
    d. Choke manifold.

5.6 HANDLING EQUIPMENT & TOOLS

Equipment used to move, make and break connection, suspend tubular on the rig.

These include the following:

1. Elevator Links	2. Elevator
3. Drill pipe slips	4. Drill collar and casing slips
5. Safety Clamp	6. Chain tong
7. Rig tong	8. Iron Roughneck
10. Drill pipe Spinner	11. Kelly Spinner
11. Tugger/Winch	12. Bit Breaker

5.6.1 Elevator links

Equipment attached onto the Traveling Block in order to suspend the Elevators.

Figure 101 Elevator links

5.6.2 Elevator

Clamps that grip a stand of casing, tubing, drillpipe or drill collars so that the stand or joint can be raised from or lowered into the hole opening of the rotary table.

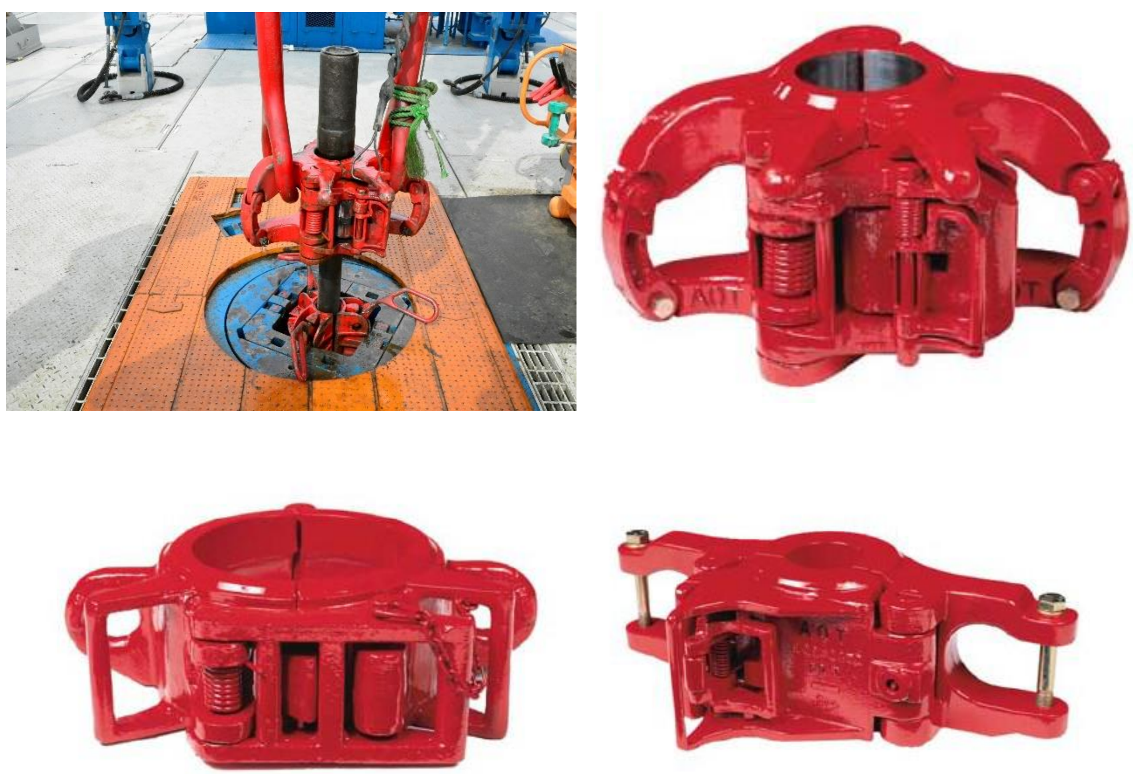


Figure 102 Elevators

5.6.3 Drill pipe slips

A wedge shape piece of metal with teeth or other gripping elements that are used to prevent pipe from slipping down into hole or to hold the pipe in place.

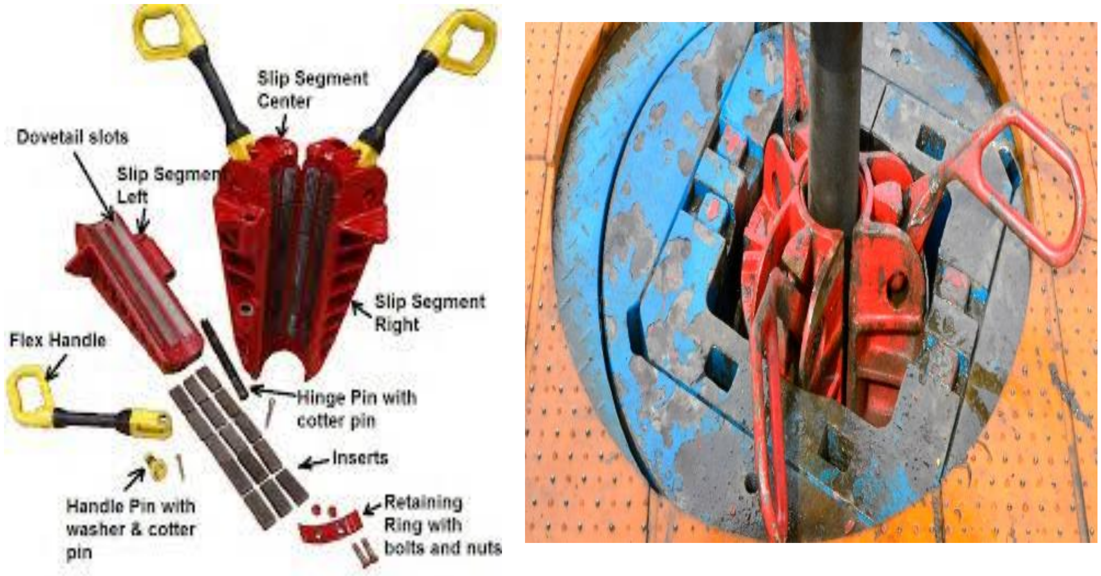


Figure 103 Drill pipe slips

5.6.4 Drill collar & Casing slips

A wedge shape piece of metal with teeth or other gripping elements that are used to prevent pipe from slipping down into hole or to hold the pipe in place.

Figure 104 Drill collar and casing slips

5.6.5 Safety Clamp

The are used on tubulars above the slips to prevent dropping the string should the slips fail to hold.

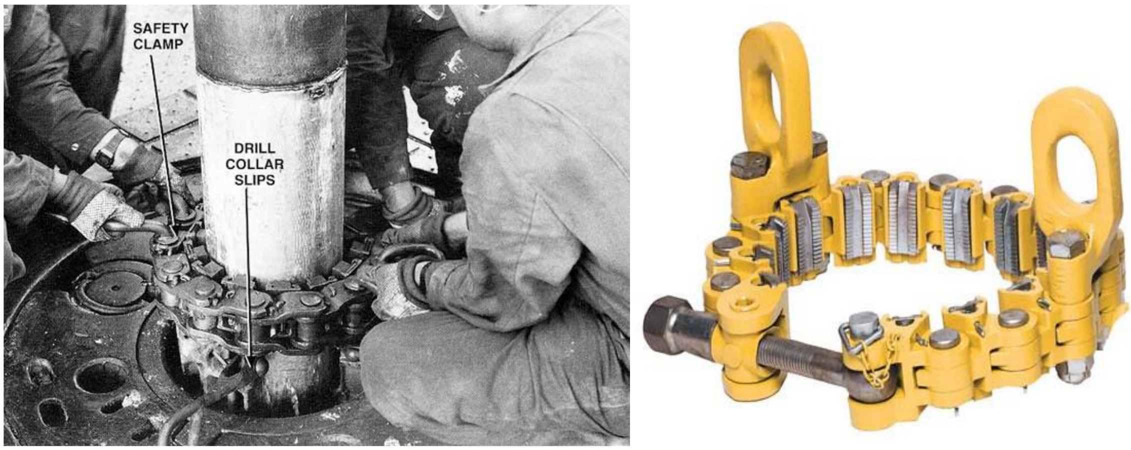


Figure 105 Drill collar safety clamp

5.6.6 Chain tong

a pipe wrench used for turning large pipes; an adjustable chain circles the pipe with its ends connected to the head whose teeth engage the pipe.

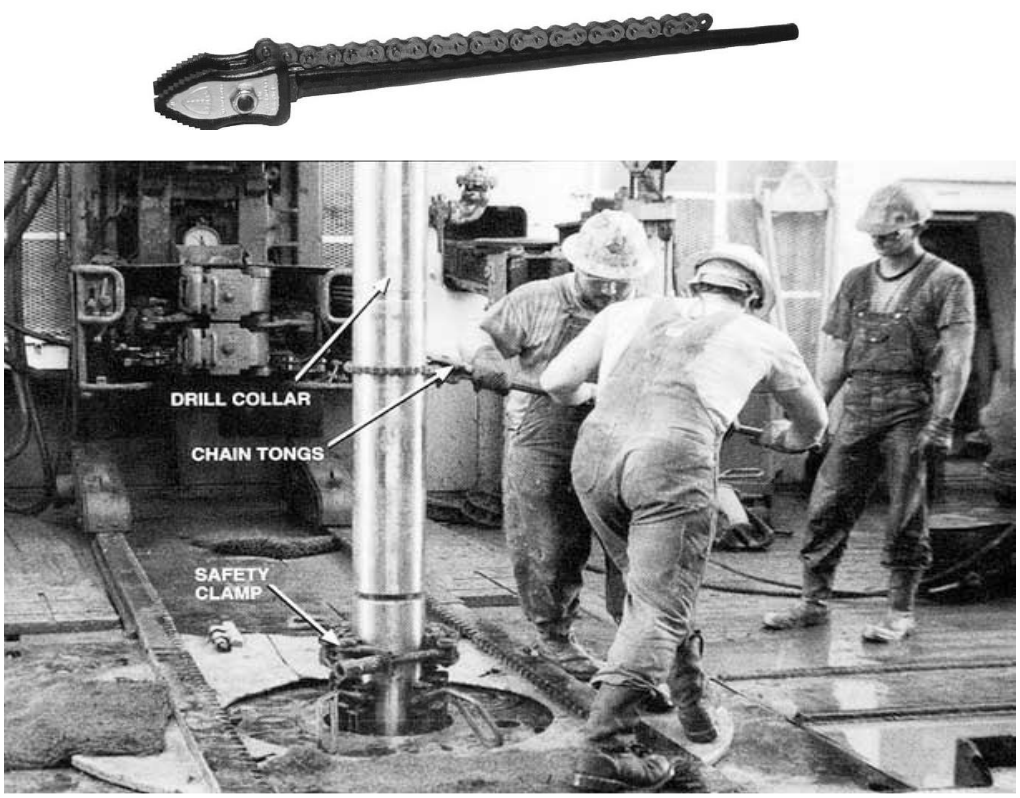


Figure 106 Chain tong and usage on rig floor

5.6.7 Rig Tong

Large-capacity, self-locking wrenches used to grip drill string components and apply torque. As with opposing pipe wrenches for a plumber, the tongs must be used in opposing pairs.

As a matter of efficiency, one set of tongs is essentially tied off with a cable or chain to the derrick, and the other is actively pulled with mechanical catheads.

The breakout tongs are the active tongs during breakout (or loosening) operations. The makeup tongs are active during makeup (or tightening) operations.

Figure 107 Rig tong and Make-up connection operations

5.6.8 Iron Roughneck

A pneumatically operated machine that replaces the functions performed by the Kelly Spinner, Drillpipe Spinner and Tongs.

Figure 108 Iron roughneck

5.6.9 Drill pipe Spinner

A pneumatically operated device usually suspended on the rig floor it used to make fast connections and spin off of drill pipes.

Figure 109 Drill pipe spinner

5.6.10 Kelly Spinner

A pneumatically operated device mounted on top of the kelly that when actuated causes the kelly to spin.

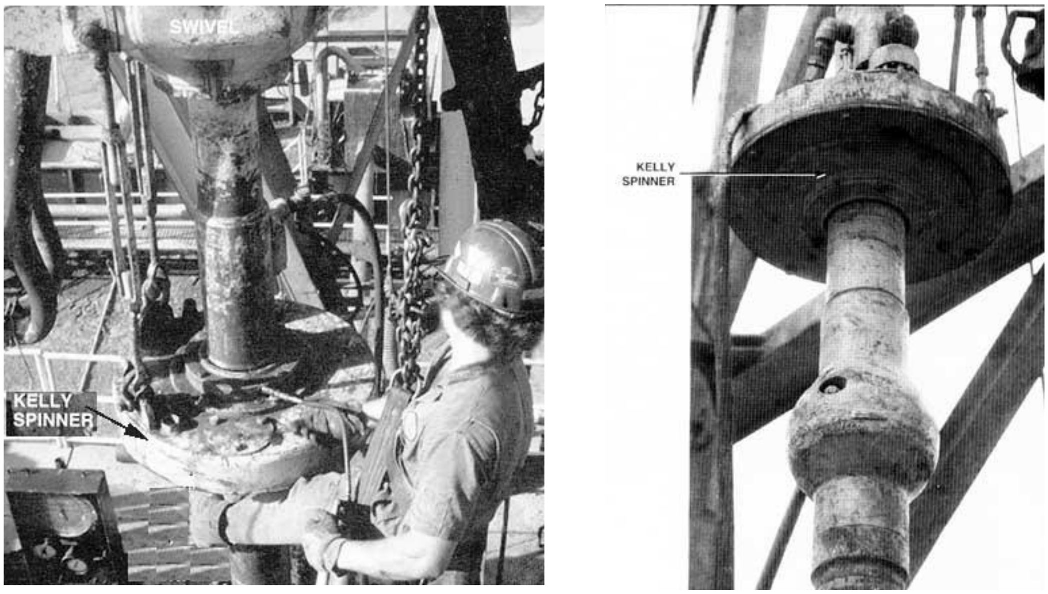


Figure 110 Kelly spinner

5.6.11 Tugger/Winch

A pneumatically operated drum with wire rope spooled onto it to move or lift heavy objects on the rig floor.

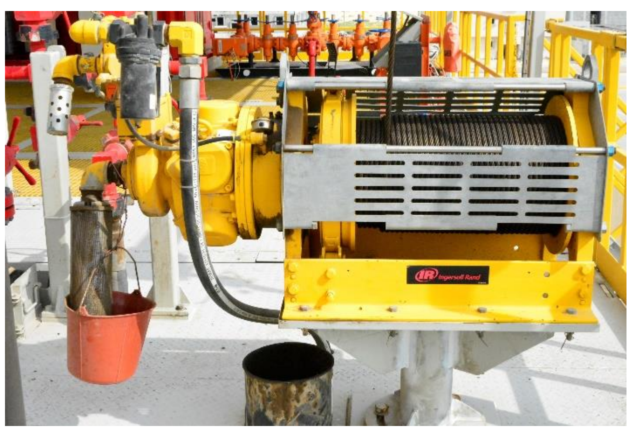


Figure 111 Air winch

5.6.12 Bit breaker

A device that is placed on top of the rotary table to enable the bit to made up to drill string.

Figure 112 Bit breaker

5.6.1 Hammer

A tool with a heavy metal head mounted at right angles at the end of a handle, used for jobs such as breaking things and driving in nails.

Figure 113 Hammer

5.6.2 Hammer wrench

A wrench or spanner is a tool used to provide grip and mechanical advantage in applying torque to turn objects—usually rotary fasteners, such as nuts and bolts—or keep them from turning.

Figure 114 Hammer wrench

5.6.3 Pipe wrench

A pipe wrench is any of several types of wrench that are designed to turn threaded pipe and pipe fittings for assembly (tightening) or disassembly (loosening).

Figure 115 Pipe wrench

5.6.4 Exercise

1. What's the name of this equipment?
    a. Elevator
    b. Iron roughneck
    c. Drillpipe spinner
    d. Bit breaker

2. What's the name of this equipment?
    a. Elevator links
    b. Iron roughneck
    c. Slips
    d. Bit breaker

3. What's the name of this equipment?
    a. Rig tong
    b. Chain tong
    c. Slips
    d. Elevator

4. What's the name of this equipment?
    a. Bit breaker
    b. Tugger/winch
    c. Elevator
    d. Power tong

5. What's the name of this equipment?
    a. Bit breaker
    b. Chain tong
    c. Tugger/winch
    d. Power tong

6. What's the name of this equipment?
    a. Chain tong
    b. Bit breaker
    c. Elevator
    d. Tugger/winch

---

7. What's the name of this equipment?
    a. Bit breaker
    b. Chain tong
    c. Rig tong
    d. Tugger/winch

---

8. What's the name of this equipment?
    a. Bit breaker
    b. Safety clamp
    c. Elevator
    d. Tugger/winch

---

9. What's the name of this equipment?
    a. Bit breaker
    b. Elevator
    c. Tugger/winch
    d. Casing slips

---

10. What's the name of this equipment?
    a. Bit breaker
    b. Elevator
    c. Tugger/winch
    d. Casing slips

5.7 SUMMARY

Rotary drilling is a complicated process that involves in five major rig systems. These systems are rig power system, hoisting system, circulating system, rotating system and well control system. Each one of these systems has a number of components. The rig personnel is expected to be familiar not only, with the rotary drilling process but also, should be able to identify the five major rig systems, their components, as well as their functions.

6. EXERCISE SET-1

1. Which one of the following systems is used to take the cuttings out of the hole?
   a) Power System
   b) Circulating system
   c) Rotating system
   d) Hoisting system

2. Which one of the following systems is used to prevent the well blow out?
   a) Power System
   b) Circulating system
   c) Well control system
   d) Rotating system

3. Shale Shaker belongs to which one of the following rig systems?
   a) Power System
   b) Circulating system
   c) Well control system
   d) Rotating system

4. Rotary table belongs to which one of the following rig systems?
   a) Power System
   b) Circulating system
   c) Well control system
   d) Rotating system

5. Crown block belongs to which one of the following rig systems?
   a) Power System
   b) Hoisting System
   c) Well control system
   d) Rotating system

6. Choke manifold belongs to which one of the following rig systems?
   a) Power System
   b) Circulating system
   c) Well control system
   d) Rotating system

7. Fast line belongs to which one of the following rig systems?
   a) Power System
   b) Hoisting System
   c) Well control system
   d) Rotating system

8. Diesel Engines belongs to which one of the following rig systems?
   a) Power System
   b) Circulating system
   c) Well control system
   d) Rotating system

---

9. MGS belongs to which one of the following rig systems?
   a) Power System
   b) Circulating system
   c) Well control system
   d) Rotating system

---

10. Master bushing belongs to which one of the following rig systems?
   a) Power System
   b) Circulating system
   c) Well control system
   d) Rotating system

---

11. Identify the equipment?
   a) Power tong
   b) Kelly
   c) Master bushing
   d) Kelly bushing

---

12. Identify the equipment?
   a) Swivel
   b) Mast
   c) Master bushing
   d) Kelly bushing

---

13. Identify the equipment?
   a) Drilling console
   b) Cement pump
   c) Drawworks
   d) MGS

14. Identify the equipment?

    a) Well Head
    b) X-mass tree
    c) Cement head
    d) BOP

---

15. Identify the equipment?

    a) BOP control panel
    b) Drilling console
    c) Remote choke panel
    d) BOP

---

16. Identify the equipment?

    a) Cement Pump
    b) Generator
    c) Accumulator
    d) Mud Pump

---

17. Identify the equipment?

    a) Cement Pump
    b) Accumulator
    c) Generator
    d) Mud Pump

---

18. The ___________ is in charge of the drilling fluid on the rig and in the hole.

    a) Electrician
    b) Mechanic
    c) Mud Engineer
    d) Rigman

---

19. The ___________assists the rest of the rig crew to ensure the drilling rig is operating properly and efficiently.
    a) Rigman
    b) Assistant Driller
    c) Driller
    d) Senior Driller

20. It is the job of the ___________to perform maintenance that is required in the SCR room.

   a) Tool pusher
   b) Driller
   c) Electrician
   d) Rigman

---

21. The mud engineer is in charge of the ___________ on the rig.

   a) Drilling fluid
   b) Maintenance
   c) Drill-crew
   d) Motors

---

22. The ___________ is the entry level position on the rig crew.

   a) Foreman
   b) Toolpusher
   c) Driller
   d) Rigman

---

23. The ___________ directs the work performed by the drill crew.

   a) Mechanic
   b) Assistant driller
   c) Rigman
   d) Toolpusher

---

24. Identify the rig type.

   a) Drill ship
   b) Submersible rig
   c) Jack-up
   d) Land rig

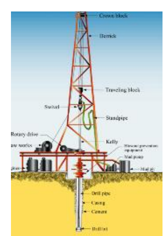
25. Identify the rig type.

a) Drill ship
b) Submersible rig
c) Jack-up
d) Land rig

26. Identify the rig type.

a) Drill ship
b) Submersible rig
c) Land rig
d) Jack-up

27. Identify the rig type.



a) Drill ship
b) Submersible rig
c) Land rig
d) Jack-up

28. The SCR room is a ___________ area that can only be entered by authorized personnel
a) mud tank
b) high pressure
c) non-hazardous
d) high voltage

29. The ___________ is used to prevent high pressure from escaping from the well.
a) ROP
b) VFD
c) SCR
d) BOP

30. The drilling rig is based around a ___________ that is positioned over the well location.
    a) substructure
    b) pit
    c) pipe rack
    d) mud tank

---

31. The ___________ supports the crown and hoisting equipment.
    a) SCR room
    b) mud tank
    c) derrick
    d) catwalk

---

32. The ___________ is where drill-pipe comes from the pipe ramp onto the rig floor.
    a) crown block
    b) V-Door
    c) drawworks
    d) catwalk

---

33. The ___________ system pumps mud into the hole as it is drilled.
    a) hoisting
    b) circulating
    c) rotating
    d) power

---

34. The ___________ is inserted into the rotary table and transfers rotation to the kelly bushing.
    a) master bushing
    b) tong
    c) traveling block
    d) swivel

---

35. Rotating the ___________is what raises and lowers the traveling block.
    a) rotary table
    b) drawworks
    c) swivel
    d) bit

7. GENERAL & RIG MATHEMATICS

7.1 GENERAL MATHEMATICS

7.1.1 ADDITION

This is concerned with putting things together. The symbol we use is +

for example 7 + 3 = 10.

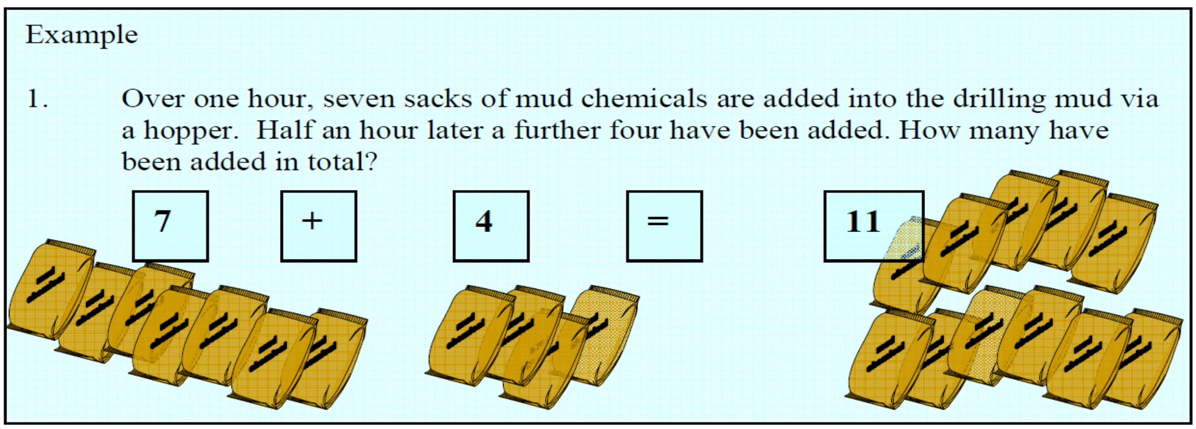
Example

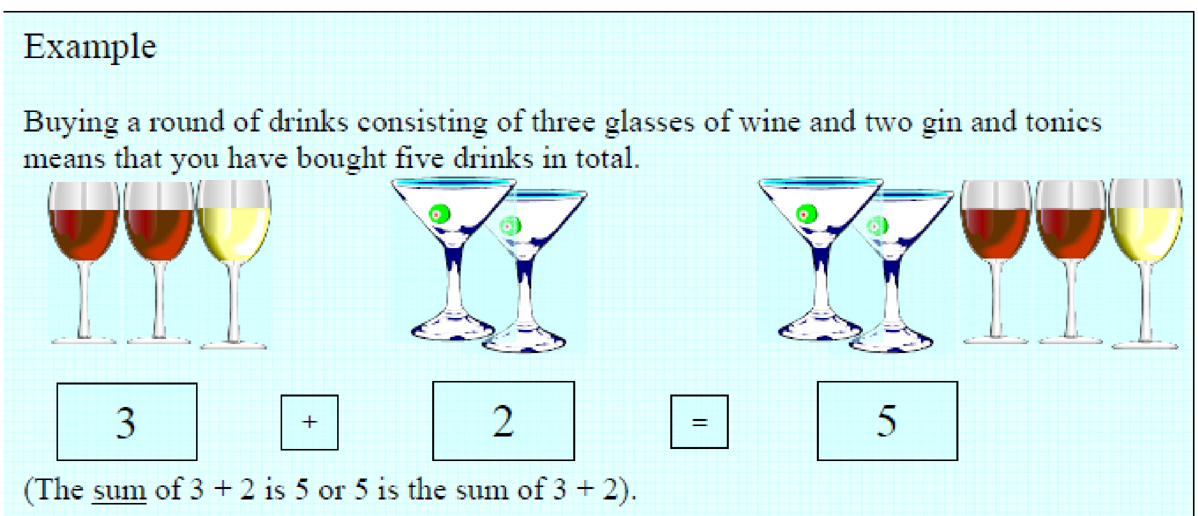
Buying a round of drinks consisting of three glasses of wine and two gin and tonics

means that you have bought five drinks in total.

(The sum of 3 + 2 is 5 or 5 is the sum of 3 + 2).

3 + 2 = 5





Example - Manual addition

Add 1,831 and 247 and 699 (1,831 + 247 + 699)

Again to make the calculation easier the numbers should be written underneath each other lining up the thousands, hundreds, tens and units in columns. (You can draw a grid if this makes it easier)

```
THTU
1,831
  247
  699
2,777
```

Thousands	Hundreds	Tens	Units
1	8	3	1
	2	4	7
	6	9	9

```
THTU
1,83 1
  24 7
  69₁9
     7
```

Start with the units column on the right hand side and add downwards:

$1 + 7 = 8, 8 + 9 = 17$

This is seven units and one ten, the 7 is written under the line at the bottom of the units column, the 1 is written above the line in the tens column to be added into that column.

This can also be done by adding upwards so that $9 + 7 = 16, 16 + 1 = 17$.

Then the tens column is added, then the hundreds and the thousands etc.

```
1 8 3 1        This can       1 8 3 1
  2 4 7        also be          2 4 7
₁6₁9₁9         written as       6 9 9
2 7 7 7                       2 7 7 7
                               1 1 1
```

Example - Calculator addition

The sequence of keys to press to do the above calculation on a calculator is:

1	8	3	1	+	2	4	7	+	6	9	9	=

The display will show

2777.

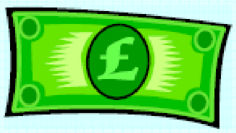
7.1.1 SUBTRACTION

This is concerned with taking things away.

The symbol we use is -, for example 3 – 1 = 2.

Example

The five drinks that you bought before costs you £10.77. You give the barman £15 then you take away the £10.77 to calculate how much change you should have.



£15	-	£10.77	=	£4.23

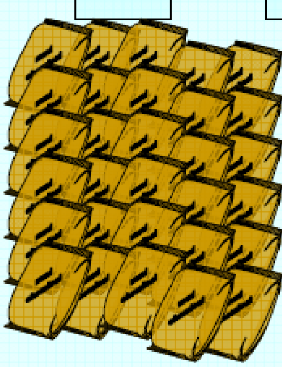
(£4.23 is the difference between £15 and £10.77)

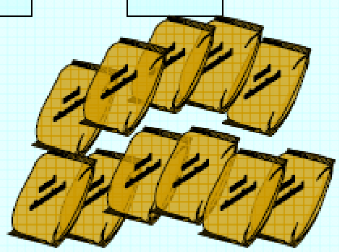
Example

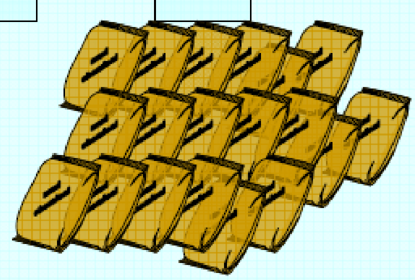
The eleven sacks of mud chemicals added to the drilling mud previously were removed from a pallet holding 30 sacks.

How many sacks are left?

30	-	**11**	=	**19**







Example – Manual Subtraction 1

Subtract 14 from 365 (365- 14)

The calculation should be written in the same way as the addition calculation with the units figures lined up underneath each other at the right hand side.

```
HTU
365
 14 –
  1
```

Start with the units column, 4 from 5 is 1. This is placed under the top line in the units column.

```
HTU
365
 14 –
 51
```

Next take the tens column, 1 from 6 is 5. This is placed under the top line in the tens column.

```
HTU
365
 14 –
351
```

Next take the hundreds column, 0 from 3 is 3. This is placed under the top line in the hundreds column.

The answer is 351.

One way to check you are correct is to add the answer and the number taken away together – this should equal the original number.

e.g. 351 + 14 = 365

Example – Calculator subtraction 1

3	6	5	-	1	4	=

The display will show

351.

Example - Manual subtraction 2

Subtract 86 from 945 (945 – 86

```
HTU
945
 86 –
859
```

The calculation should be written in the same way as the addition calculation with the units figures lined up underneath each other at the right hand side.

```
HTU
945
 86 –
  9
```

Start with the units column, 6 is larger than 5 and 'won't go' so we have to 'borrow' one from the tens column. This is added to the 5 to get 15. We can then take 6 away from 15 to get 9.
This is written under the line at the bottom of the units column.

The ten that we 'borrowed' now has to be 'paid back'. This can be shown in two ways

```
H T U
9 4 5
  8 6
  1
8 5 9
```

The ten is 'paid back' at the bottom. The 1 is added to the 8 to make 9, this won't go into 4 so we borrow again this time from the hundreds column. This is added to the 4 to become 14, 9 from 14 is 5. The 5 is put at the bottom of the tens column and the borrowed 10 is paid back at the bottom of the hundreds column.

```
9⁸ 4³ 5   (9 and 4 crossed out)
   8 6
8  5 9
```

In the second method we cross off the figures on the top row.

You should use whichever you are most familiar with.

```
600
  4 –
596
```

The second method can be confusing when dealing with zeros i.e. take 4 away from 600 (600 – 4), 4 from 0 won't go so we have to borrow from the next column. As the next column is also a 0 you have to go across the columns until you reach the 6. The 6 is crossed out and 5 is put in, 1 is put next to the 0 in the next column. This is then crossed out and replaced by 9 as we borrow a ten. We then continue as before.

Example - Calculator subtraction 2

The sequence of keys to press to do the above calculation on a calculator is:

9	4	5	-	8	6	=

The display will show

859.

7.1.2 MULTIPLICATION

This is a quick way of adding equal numbers. The symbol we use is **x**.

Example

6 + 6 + 6 + 6 = 24 or 4 x 6 = 24

24 is called the *product* of 4 and 6.

It can also be written as 6 x 4 this is called commutative law (and also applies to addition).

Calculator

4	x	6	=

The display will read

24.

Example

In the sack room are 3 pallets each with 25 sacks. How many sacks are there in total?

3	x	25	=	75

Commutative Law

Means it does not matter which order things are written.

For example

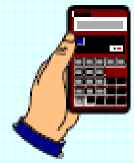
1 + 2 + 3 = 6
3 + 2 + 1 = 6
2 + 1 + 3 = 6

Or

2 x 3 x 4 = 24
4 x 3 x 2 = 24
3 x 2 x 4 = 24

This applies to both addition and multiplication, but not to subtraction and division.

Example – Calculator multiplication



214 x 8

2	1	4	x	8	=

The display shows 1712.

Example – Multiplying by ten

To multiply a whole number by 10 add a zero, this moves the figures along one column.

HTU		HTU
64	x 10	640

To multiply by 100 add two zeros, to multiply by 1,000 add 3 zeros etc.

Example – Multiplying by multiples of ten

To multiply a whole number by a number which is a multiple of 10 such as 60, 70 etc. multiply by the single figure and add a zero.

32 x 40
32 x 4 = 128
32 x 40 = 1,280

When multiplying by larger numbers e.g. 200, 3,000, 40,000, we multiply by the single figure and then add the appropriate number of zeros.

5 x 40,000
5 x 4 = 20
5 x 40,000 = 200,000

7.1.3 DIVISION

This is concerned with sharing into equal parts and the symbol we use is .

> Example
> Share £6 equally between three people
> $6 \div 3 = 2$

There are other ways to write divisions which all mean the same thing.

e.g. $6 \div 3$ is the same as $\frac{6}{3}$ is the same as $^6/_3$

These other methods of notation will be discussed further in Part 7.

> Example
>
> 16 sacks of chemical are to be added to the drilling mud.
>
> If two roustabouts both share the work equally, how many sacks will each have added?
>
> | 16 | ÷ | 2 | = | 8 |
>
> They will each have added 8 sacks.

> Example – Manual Division
> Divide 432 by 8
>
> This is the same as how many 8's are there in 432?
>
> 8 is called the *divisor*
> 432 is called the *dividend*
> the answer is called the *quotient*

```
  54      8 won't go into 4. 8's into 43 go 5. Put the 5 above the 3; 5 times
8/432     8 is 40; take 40 away from 43 leaving 3; put 3 by the 2 to make 32; 8's go
          into 32 4 times; put the 4 above the 2.
```

432 ÷ 8 = 54

```
  54        54
8/432     8/432
            40
             32
             32
```

Basic mathematical operations, such as addition, subtraction, multiplication and division will have to follow a certain calculation order. The order of mathematical operations is as following:

1. Inside the innermost parenthesis has to be calculated first,
2. Exponential operation has to be calculated next,
3. Multiplication and Division
4. Addition and Subtraction has to be done last.

Please have a look at the following three examples

7.1.4 APPLICATIONS

7.1.4.1 Parenthesis

230 + 0.052 x 10 x (4000 + 500) = 2570

Here is how:

(4000 + 500) = 4500

0.052 x 10 x 4500 = 2340

230 + 2340 = 2570

7.1.4.2 Exponential

$\pi \times 8.5^2 = 227$

Here is how:

$8.5^2 = 72.25$

3.14 x 72.5 = 228

7.1.4.3 Multiplication

$7 \times 2 + \frac{6}{3} - 5 = 11$

Here is how:

7 x 2 = 14

$\frac{6}{3} = 2$

14 + 2 – 5 = 11

7.1.5 EXERCISE

1. Calculate manually;

a. 145 + 2,035

b. 5,763 + 12 + 300

c. 389,917 + 188,709 + 45,101 + 7

d. 23 + 196

e. 448 + 21

f. 119,987 + 219,998 + 503,945 + 754,730

2. Calculate using your calculator;

a. 145 + 2,035

b. 5,763 + 12 + 300

c. 389,917 + 188,709 + 45,101 + 7

d. 23 + 196

e. 448 + 21

f. 119,987 + 219,998 + 503,945 + 754,730

3. Calculate manually;

a. 47 - 12

b. 78 - 45

c. 5,000 - 441

d. 8,001 – 4,098

e. 117,097 – 98,320

4. Calculate using your calculator;

a. 47 - 12

b. 78 - 45

c. 5,000 - 441

d. 8,001 – 4,098

e. 117,097 – 98,320

5. Now calculate manually;

a. 9 x 9

b. 4 x 9

c. 3 x 2 x 4

d. 6 x 7

e. 8 x 2

6. Now confirm using your calculator;

a. 9 x 9

b. 4 x 9

c. 3 x 2 x 4

d. 6 x 7

e. 8 x 2

7. In the sack room are 5 pallets each holding 80 sacks of mud chemicals.

a. How many sacks are there in total?
……………………………………………………………………………….. sacks

b. If 3 roustabouts add 8 sacks each to the drilling mud, how many have they added in total?
……………………………………………………………………………….. sacks

c. How many sacks are left in the sack room?
……………………………………………………………………………….. sacks

d. We estimate the requirement for these chemicals to be 10 sacks per day. How many full days will the sacks last?
……………………………………………………………………………….. sacks

e. How many sacks will be left over?
……………………………………………………………………………….. sacks

8. Simplify the mathematical expression given below and circle the correct answer.

$$450 + 0.052 \times 10.3 \times (8300 + 1200)$$

a) 4895
b) 6095
c) 38476145
d) 5538

9. Simplify the mathematical expression given below and circle the correct answer.

$$\pi \times 13.375^2$$

a) 562
b) 42
c) 178.89
d) 531

10. Simplify the mathematical expression given below and circle the correct answer.

$$12 \times 5 + \frac{8}{(8-4)}$$

a) 62
b) 84
c) 58
d) 64

11. How many gallons is 200 bbls?
Hint: 1 bbl = 42 Gallons.

a) 4.76 gallons
b) 4200 gallons
c) 8400 gallons
d) 0.21 gallons

7.2 BASIC RIG MATHEMATICS UNITS OF MEASUREMENT

Throughout the world, two systems of measurement dominate: the English system and the metric system.

Value	English	Metric (SI)
Length	Foot (ft)	Meter (m)
Weight	Pound (lb)	Gram (gm)
Capacity	Gallon (g)	Liter (l)

In the English system, for example, 1 foot equals 12 inches, 1 yard equals 3 feet or 36 inches, and 1 mile equals 5,280 feet or 1,760 yards.

In the metric system, for example, 1 meter equals 10 decimeters, 100 centimeters, or 1,000 millimeters. A kilometer equals 1,000 meters.

The metric system, unlike the English system, uses a base of 10°; thus, it is easy to convert from one unit to another. To convert from one unit to another in the English system, you must memorize or look up the values.

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

7.2.1 LENGTH CALCULATIONS

7.2.1.1 English system for measurements:

Length:

1 mile = 1760-yard

1 yard = 3 feet

1 foot = 12 inches

the inch is divided up to 32 divisions.

Weight:

1 pound = 16 ounces

Capacity:

1 barrel = 5.614 cubic feet

1 cubic foot = 7.48 gallon

1 barrel = 42 gallon

7.2.1.2 SI system for measurements:

Length:

1 kilometer = 1000 meter

1 meter = 10 decimeter

1 decimeter = 10 centimeter

1 centimeter = 10 millimeter

Weight:

1 kilogram = 1000 gram

Capacity:

1 cubic meter = 1000 liter

7.2.1.3 Conversion between SI units & English units:

Length:

1 meter = 3.281 feet

1 inch = 2.54 centimeters

Weight:

1 pound = 453.5924 gram

Capacity:

1 gallon = 3.785412 liter

7.2.1.4 Rig tape

Rig tape is a special measuring tape used in rigs to measure lengths. The difference between the ordinary measuring tape and the rig tape is that the foot in the ordinary measuring tape is divided into 12 inches, but the foot in the rig tape is divided into 10 divisions.

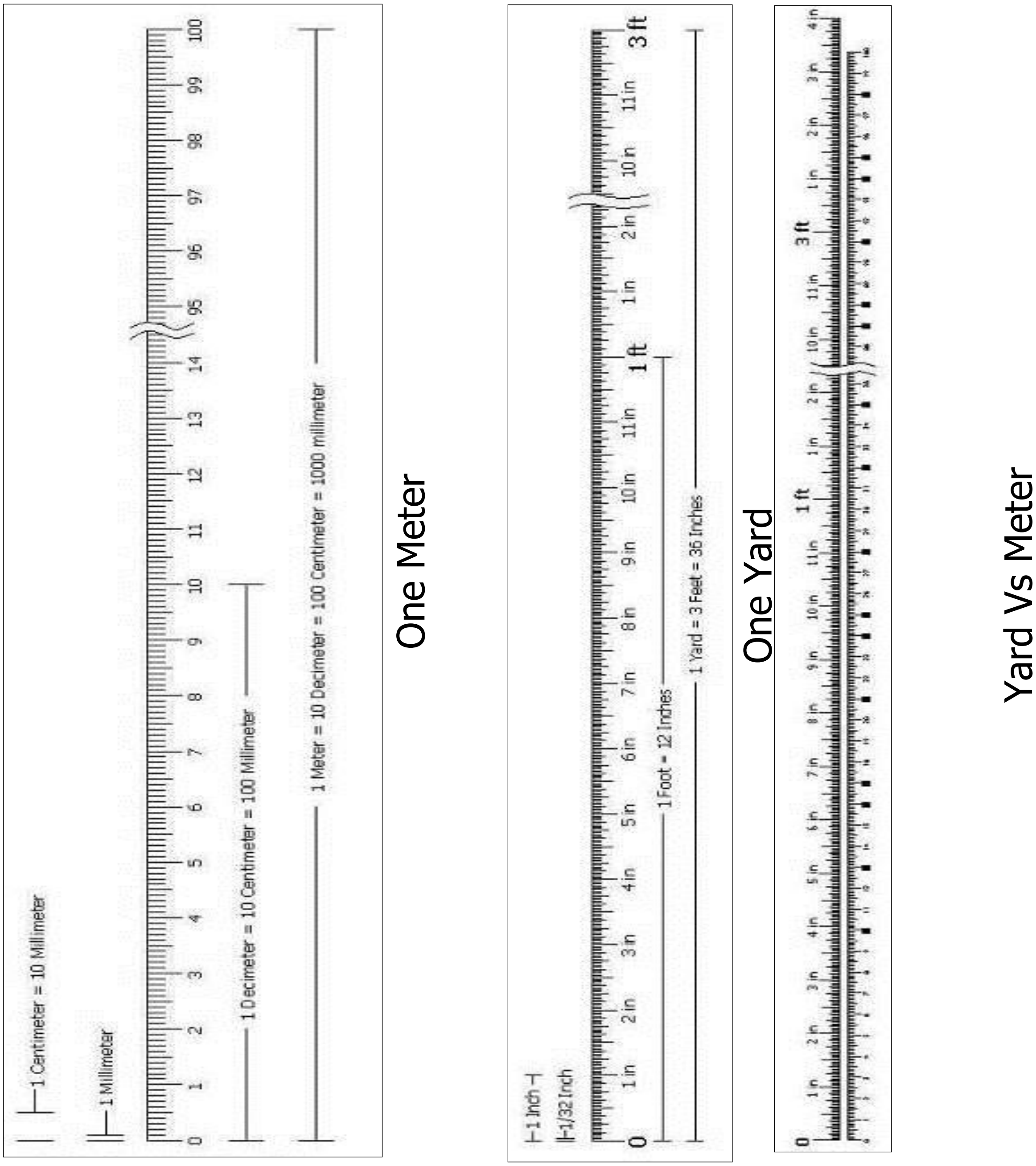


Figure 116 Rig tape

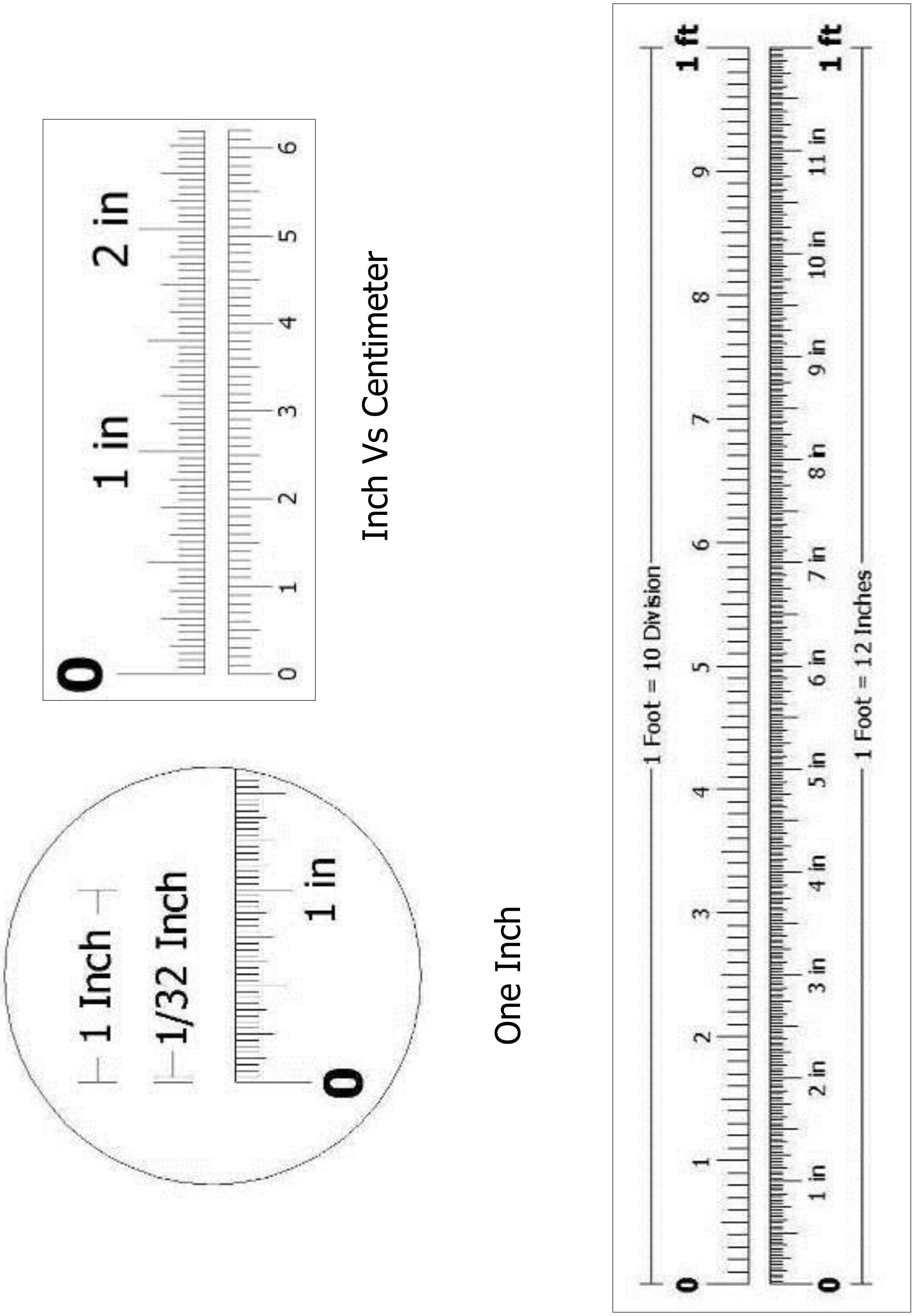
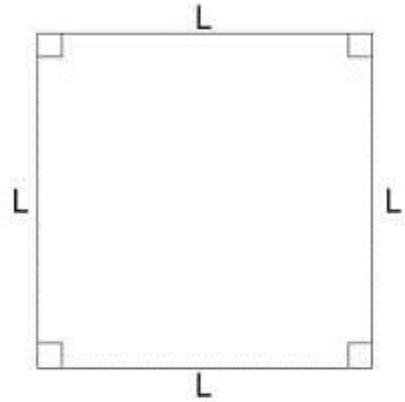


Figure 117 Differences between normal measuring and rig tape measuring

7.2.2 AREA CALCULATIONS

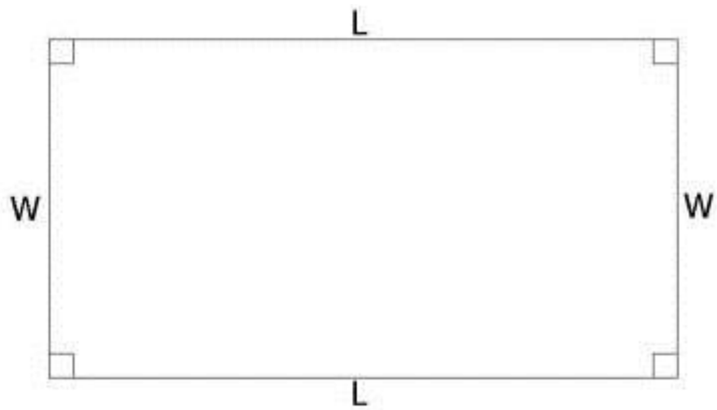
7.2.2.1 Square:

$$Area\ of\ Square = L \times L = L^2$$



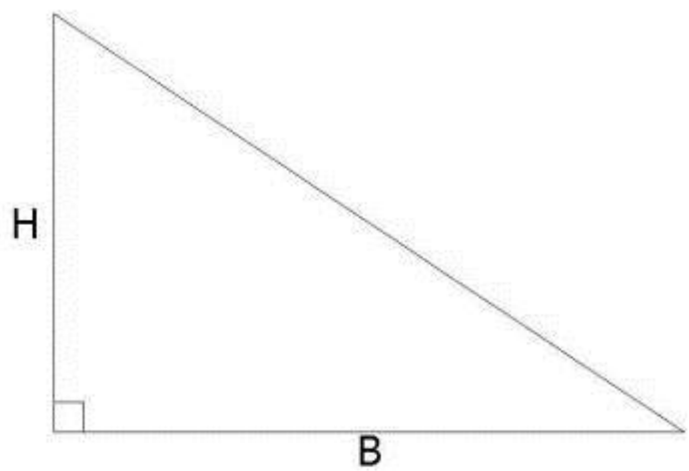
7.2.2.2 Rectangle:

$$Area\ of\ Rectangle = L \times W$$

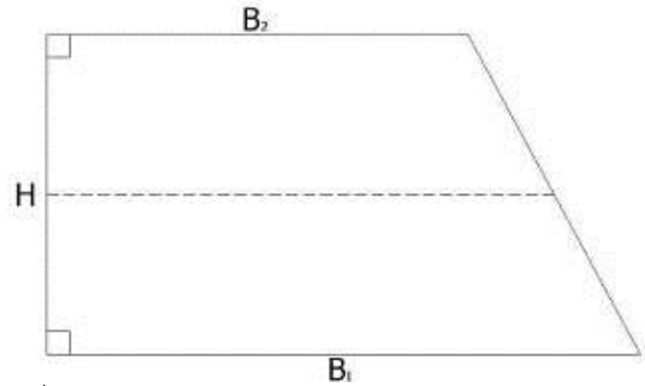


7.2.2.3 Triangle:

$$Area\ of\ Triangle = \frac{1}{2} \times B \times H$$

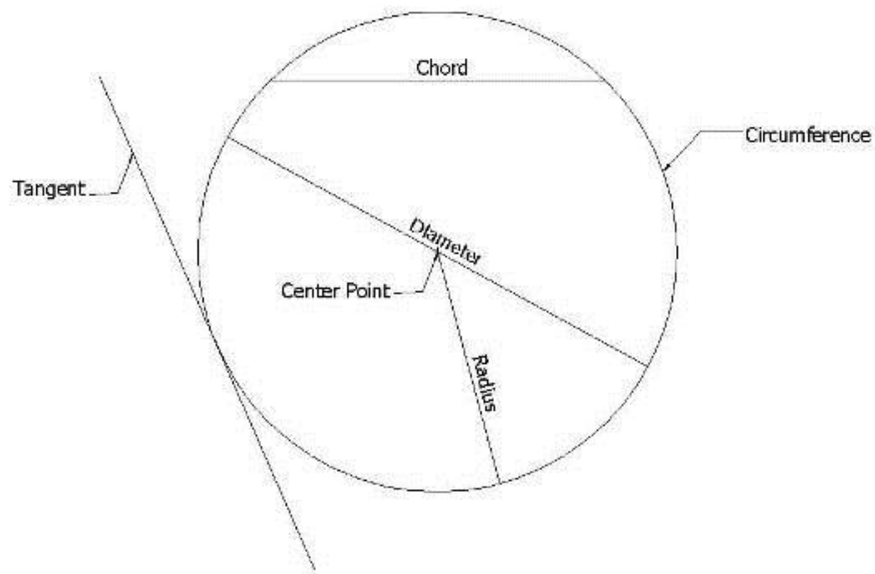


7.2.2.4 Trapezoid:



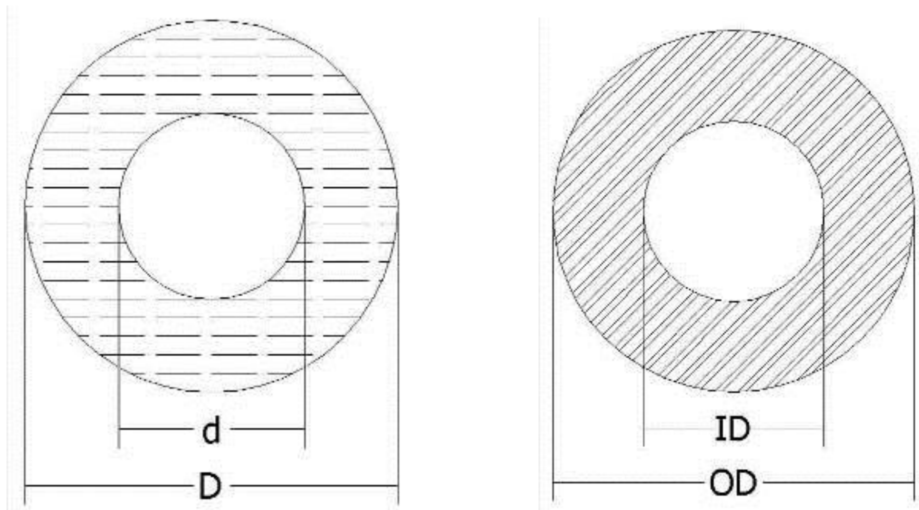
$$Area\ of\ Trapezoid = \frac{(B_1 + B_2)}{2} \times H$$

7.2.2.5 Circle



$$Area\ of\ Circle = \pi R^2$$
$$= \frac{22}{7} \times \left(\frac{D}{2}\right)^2$$
$$= \frac{22}{7 \times 4} D^2$$
$$= 0.7854\, D^2$$

7.2.2.6 Annular area & cross section area



$$Annular\ Area = Area\ of\ Circle\ (D) - Area\ of\ circle\ (d)$$

$$Annular\ Area = 0.7854D^2 - 0.7854d^2$$

$$Annular\ Area = 0.7854 * (D^2 - d^2)$$

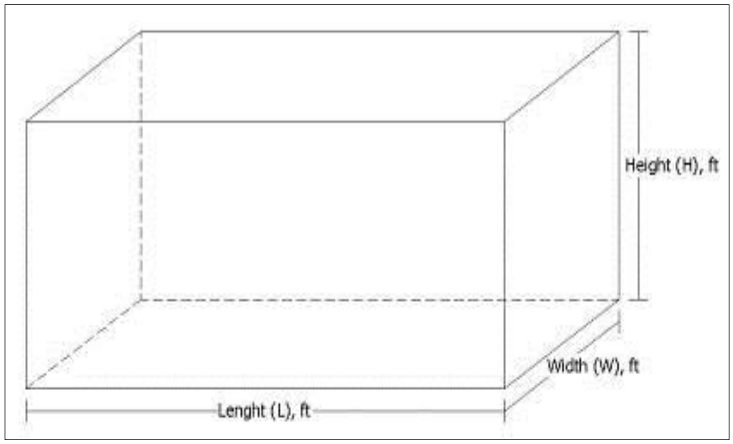
$$Cross\ Sectional\ Area = 0.7854 * (OD^2 - ID^2)$$

7.2.3 VOLUME CALCULATIONS

7.2.3.1 Volume of cuboids (Mud tanks):

Any cuboids shaped mud tank must have:

Length	(L)	طول
Width	(W)	عرض
Height	(H)	إرتفاع



Volume of mud tanks = L x W x H Cu. Ft.

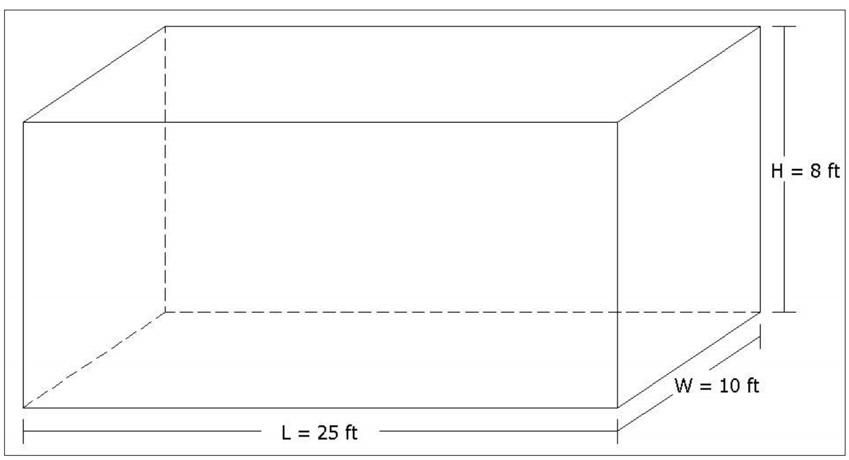
Example:

A mud tank with the following dimensions:

Length = 25 feet.

Width = 10 feet.

Height = 8 feet.



Calculate the volume (capacity) of that tank in cu.ft, bbls, bbl/ft & bbl/in.

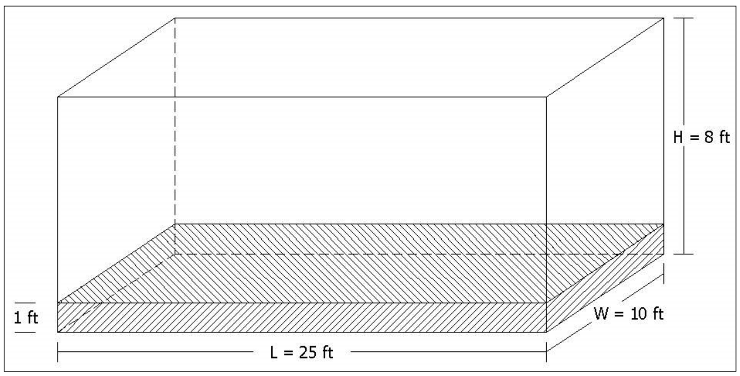
Answer:

$$Volume\ of\ mud\ tanks = L * W * H = 25 * 10 * 8 = 2000\ \ cu.ft$$

To calculate the tank volume in bbls we must divide by the conversion factor.

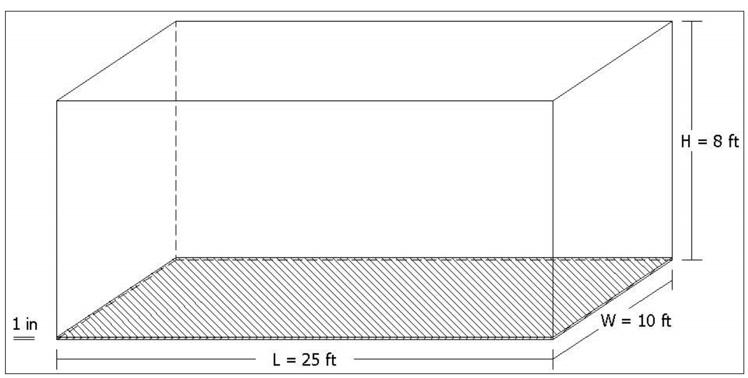
$$Volume\ of\ mud\ tanks = \frac{volume\ in\ cu.ft}{5.614} = \frac{2000}{5.614} = 356.2\ bbls$$

This means that if that mud tank is completely full it will contain 356.2 barrels, so to calculate the capacity of one-foot height of that tank we must divide the full capacity of the tank by its height.



$$Volume\ of\ mud\ tanks = \frac{volume\ in\ bbl.}{H} = \frac{356.2}{8} = 44.53\ bbls/ft.$$

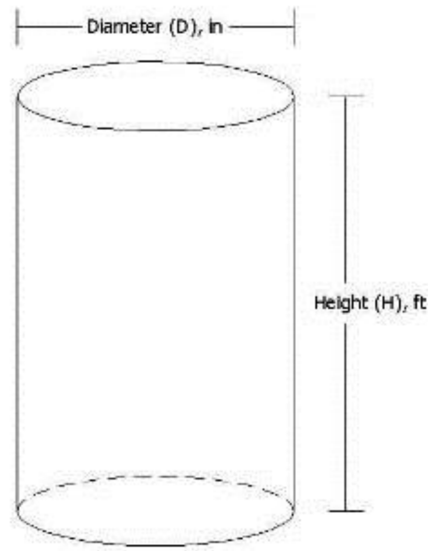
This means that every one foot height of that mud tank contains 44.53 barrels, so to calculate the capacity of one inch height of that tank we must divide the capacity of one foot height of the tank by 12.



$$Volume\ of\ mud\ tanks = \frac{volume\ in\ bbl./ft}{12} = \frac{44.53}{12} = 3.71\ bbls/in.$$

This means that every one inch height of that mud tank contains 3.71 barrels.

7.2.3.2 Volume of cylinders:



If we have a cylinder having a diameter (D) measured in inches, and height (H) measured in feet.

$$Volume\ of\ Cylinder = Area\ of\ base * Height$$

$$= 0.7854 * \left(\frac{D}{12}\right)^2 * Height \ldots Cu. ft.$$

To calculate the volume of the cylinder in barrels we should divide by 5.614.

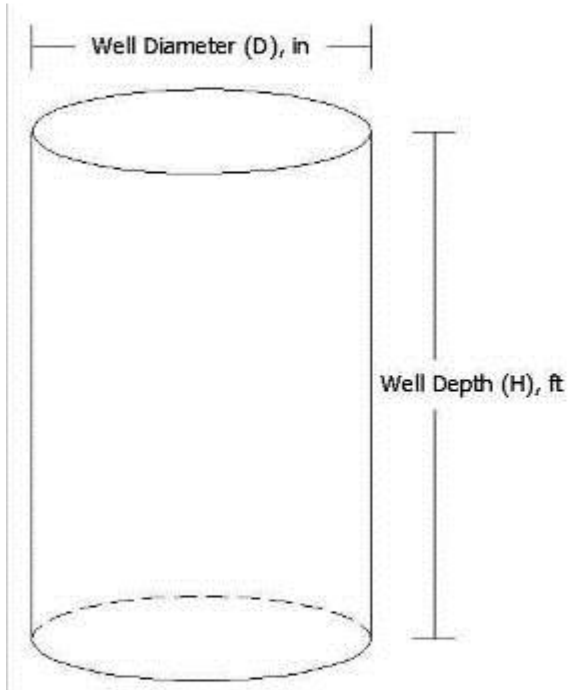
$$Volume\ of\ Cylinder = \frac{0.7854}{12 * 12 * 5.614} * D^2 * H = \frac{D^2}{1029.4} * H \ldots.. bbls.$$

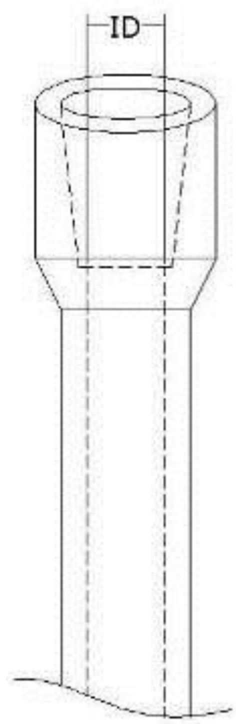
To calculate the volume of the cylinder in barrels per one foot height we should divide by the height of the cylinder.

$$Volume\ of\ Cylinder = \frac{D^2}{1029.4} * \frac{H}{H} \ldots.. bbls/ft.$$

$$= \frac{D^2}{1029.4} \ldots \ldots \ldots.. bbls/ft.$$

The cylinder volume calculations are used to calculate the capacity of the well when the drill string isn't in the well and the internal capacity of drill pipes, drill collars & casing.





$Well\ capacity = \frac{D^2}{1029.4}\ bbl/ft$

$Internal\ capacity = \frac{ID^2}{1029.4} bbl/ft$

Example

1- Calculate the capacity of 5" pipe having I.D 4.276 inches.

$$Internal\ capacity = \frac{ID^2}{1029.4} bbl/ft$$

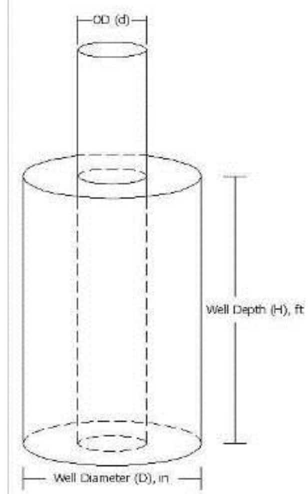
$$Internal\ capacity = \frac{4.276^2}{1029.4} \quad \frac{bbl}{ft} = 0.01776\frac{bbl}{ft}$$

2- Calculate the capacity of 36" hole.

$$Well\ capacity = \frac{D^2}{1029.4}\ bbl/ft$$

$$Well\ capacity = \frac{36^2}{1029.4}\frac{bbl}{ft} = 1.259\ bbl/ft.$$=

7.2.3.3 Annular capacity



The annular capacity of the Well is the capacity of the well when the drill string is in the well, i.e. it is the capacity between the well wall and the outer diameter of the drill string.

$$Annular\ Capcaity = \frac{D^2}{1029.4} - \frac{d^2}{1029.4} \dots\dots\dots..bbls/ft.$$

$$= \frac{D^2 - d^2}{1029.4} \dots\dots\dots\dots\dots..\dots..bbls/ft.$$

Example

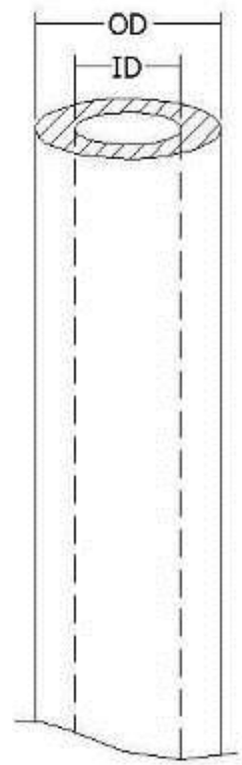
Calculate the annular volume of the following:
12.755" I.D CSG, 6 ¼" D/C = ……………………………………………… bbl/ft

Solution

$$Annular\ Capcaity\ = \frac{12.755^2 - 6.25^2}{1029.4} \dots\dots\dots\dots\dots..\dots..bbls/ft.$$

$$Annular\ Capcaity\ = 0.12009 \qquad\qquad bbls/ft.$$

7.2.3.4 Metal displacement



We need to calculate the amount of steel in one foot length of any joint (drill pipes, drill collars, casing) to determine the amount of mud needed to be pumped into the hole while POOH or amount of mud that will return to the trip tank while RIH to monitor the well condition.

$$Metal\ Displacement\ = \frac{O.D^2 - I.D^2}{1029.4} \ldots\ldots\ldots\ldots\ldots..\ldots..bbls/ft.$$

Example

Calculate the metal displacement of an 11" O.D x 3" I.D drill collar weighing 299 lb/ft.

Solution:

$$Metal\ Displacement\ = \frac{11^2 - 3^2}{1029.4} \ldots\ldots\ldots\ldots\ldots..\ldots..bbls/ft.$$

= 0.1088 bbl./ft.

7.2.4 EXERCISES

1- Calculate the value of these expressions and select your answers:

a-	$10\times 0.052\times 4.44\times 0.00192=$	a- 0.00443 b- 0.08480 c- 0.06840 d- 0.00848
b-	$10\times 0.052\times 4.44\times 0.00192\div 3.819\div 0.192=$	a- 0.59822 b- 0.00104 c- 0.00220 d- 0.00604
c-	$10\times 0.052\times 4.44\times 0.00192+3.819\times 0.192=$	a- 0.07841 b- 0.72886 c- 0.73768 d- 0.00476
d-	$38.19\times 0.00192-4.44\times 0.00192=$	a- 5.9822 b- 0.1044 c- 0.05982 d- 0.0648
e-	$10\times 0.0542\times 4.44\times 0.00192\div\left(38.19\times 0.00192-4.44\times 0.00192\right)=$	a- 0.0853 b- 0.07130 c- 0.06037 d- 0.06840
f-	$10\times 0.052\times 4.44\times 0.00192+38.19\times 0.00192-4.44\times 0.00192=$	a- 0.00443 b- 0.06841 c- 0.06923 d- 0.07775

g-	$$\frac{10\times 0.052\times 6.44\times 0.0185}{2.006\times 0.034}=$$	a- 1.82214 b- 0.90834 c- 0.03088 d- 0.6195
h-	$$\frac{(12.25^2-6.75^2)}{1029.4}\times 1000=$$	a- 101.515 b- 29.386 c- 5.3429 d- 139.21
i-	$$3500\times\frac{80^2}{65^2}=$$	a- 344615 b- 66.27 c- 4307.70 d- 5301.77
j-	$$\frac{10\times 0.052\times(4.64\times 5.614+9.08\times 5.614)}{38.19\times 7.48-4.44\times 7.48+9.08\times 7.48}=$$	a- 40.08 b- 0.125 c- 320.368 d- 0.240

2- One foot is:

a- 12 meters

b- 0.6 meters

c- 0.3 meters

d- 3.28 meters

3- Twenty-five hundred feet (2500 ft) are:

a- 761.96 meters

b- 8202.5 meters

c- 833.33 meters

d- 1000 meters

4- Five thousand five hundred and ninety two meters (5592 m) are:

a- 1704.36 feet

b- 18,347.35 feet

c- 466 feet

d- 2200.78 feet

5- Eleven hundred meters (1100 m) are:

a- 335.26 ft

b- 43,309.2 ft

c- 3300 ft

d- 3609.1 ft

6- 36 3/4 inches are:

a- 1 meters

b- 120.56 meters

c- 0.93 meters

d- 3.06 meters

7- 97.97 inches are:

a- 2.49 meters

b- 89.58 meters

c- 2.72 meters

d- 321.44 meters

8- 1745.49 feet are:

a- 5726.95 meters

b- 532 meters

c- 48.48 meters

d- 44.34 meters

9- 18 5/8 inches are:

a- 61.11 meters

b- 733.27 meters

c- 1.55 ft

d- 0.64 meters

10- 0.54 meter is:

a- 36 inches

b- 21.26 inches

c- 1.77 inches

d- 19.44 inches

11- 76 feet 11 inches are:

a- 23.44 meters

b- 252.36 meters

c- 930 inches

d- 0.51 meters

12- Calculate the area of 18 5/8 inches circle.

a- 346.89 sq.in

b- 346.89 inches

c- 272.45 sq.in

d- 110.42 sq.in

13- Calculate the area of 5” d/p.

a- 25 in

b- 25 sq.in

c- 31.83 sq.in

d- 19.64 sq.in

14- Calculate the circle area of the following:

a- 6 1/2” =………………………………………………………………………… sq.in

b- 8 1/2” =………………………………………………………………………… sq.in

c- 12 1/4” =………………………………………………………………………… sq.in

d- 26” =………………………………………………………………………… sq.in

15- Calculate the cross-sectional area of 5” d/p, 4.276” I.D.

a- 6.72 sq.in

b- 6.72 inches

c- 5.27 sq.in

d- 2.13 sq.in

16- Calculate the cross-sectional area of 10” D/C, 3” I.D.

a- 71.47 sq.in

b- 71.47 in

c- 91 sq.in

d- 91 inches

17- Calculate the annular area between:

a- 8 1/2", 5" =………………………………………………………………………… sq.in

b- 12 ¼", 8 ¼"=………………………………………………………………………… sq.in

c- 17 ½", 9 ½"=………………………………………………………………………… sq.in

18- Calculate the cross section area of:

a- 5" O.D, 4.2761" I.D =…………………………………………………. sq.in

b- 13 3/8" O.D, 12.755" I.D =…………………………………………………. sq.in

c- 18 5/8" O.D, 17.755" I.D =…………………………………………………. sq.in

19- Calculate the volume (capacity) of a tank 40 ft long, 7 ft high and 7 ft wide.

a- 280 cu.ft

b- 1960 bbls

c- 300 bbls

d- 1960 cu.ft

20- The volume of a tank 5.8 ft long, 5.8 ft wide and 8 ft high is:

a- 48 barrels

b- 269 barrels

c- 46.4 cu.ft

d- 100 barrels

21- If you have a trip tank, with 48 barrels capacity and 80 ft height, how many barrels per inch?

a- 1.45 bbl/in

b- 1.04 bbl/in

c- 0.5 bbl/in

d- 2.8 bbl/in

22- Calculate the volume of the following tanks:

a-	Length = 42 ft Width = 6.8 ft Height = 8 ft		cu.ft
			bbl
			bbl/ft
			bbl/in
b-	Length = 35 ft Width = 8 ft Height = 10 ft		cu.ft
			bbl
			bbl/ft
			bbl/in
c-	Length = 38 ft Width = 10 ft Height = 7 ft		cu.ft
			bbl
			bbl/ft
			bbl/in

23- Calculate the capacity of 5" pipe having I.D 4.276 inches.

a- 0.00742 bbl/ft

b- 0.0226 bbl/ft

c- 0.018 bbl/ft

d- 0.01776 bbl/ft

24- Calculate the capacity of 36" hole.

a- 1.296 bbl/ft

b- 1.259 bbl/ft

c- 0.1296 bbl/ft

d- 0.1258 bbl/ft

25- Find the capacity of 3" I.D drill collar.

a- 0.009 bbl/ft

b- 0.0087 bbl/ft

c- 0.02 bbl/ft

d- 0.004 bbl/ft

26- If the I.D of 5" d/p is 4.276", how many barrels would 10,000 feet hold?

a- 74 bbl

b- 178 bbl

c- 250 bbl

d- 183 bbl

27- Calculate the internal capacity of the following:

a- 2 13/16" I.D of D/C 8 1/4" O.D = ……………………………………. bbl/ft

b- 4.2761" I.D of D/P 5" O.D = ……………………………………. bbl/ft

c- 8.755" I.D of casing 9 5/8" O.D = ……………………………………. bbl/ft

d- 12.415" I.D of casing 13 3/8" O.D = ……………………………………. bbl/ft

---

28- Find the capacity between 8 ½" hole and 5" drill pipe.

a- 0.0459 bbl/ft

b- 0.072 bbl/ft

c- 0.025 bbl/ft

d- 0.047 bbl/ft

29- Calculate the annular volume of the following:

a- 26" hole, 9 ½" O.D D/C = ……………………………………………… bbl/ft

b- 17 ½" hole, 9 ½" O.D D/C = ……………………………………………… bbl/ft

c- 12.755" I.D CSG, 6 ¼" D/C = ……………………………………………… bbl/ft

d- 8.681" I.D CSG, 5" D/P = ………………………………………………… bbl/ft

30- Calculate the metal displacement of an 11" O.D x 3" I.D drill collar weighing 299 lb/ft.

a- 0.2 bbl/ft

b- 0.109 bbl/ft

c- 0.112 bbl/ft

d- 0.03 bbl/ft

31- Calculate the metal displacement of the following:

a- 13 3/8" O.D CSG, 12.755" I.D =…………………………………………. bbl/ft

b- 9 ½" O.D D/C, 2 13/16" I.D =…………………………………………. bbl/ft

c- 3 ½" O.D D/P, 2.754" I.D =…………………………………………. bbl/ft

d- 8 ½" O.D D/C, 162 lb/ft =…………………………………………. bbl/ft

e- 9 ¼" O.D D/C, 220 lb/ft =…………………………………………. bbl/ft

f- 5" O.D D/P, 22.5 lb/ft =…………………………………………. bbl/ft

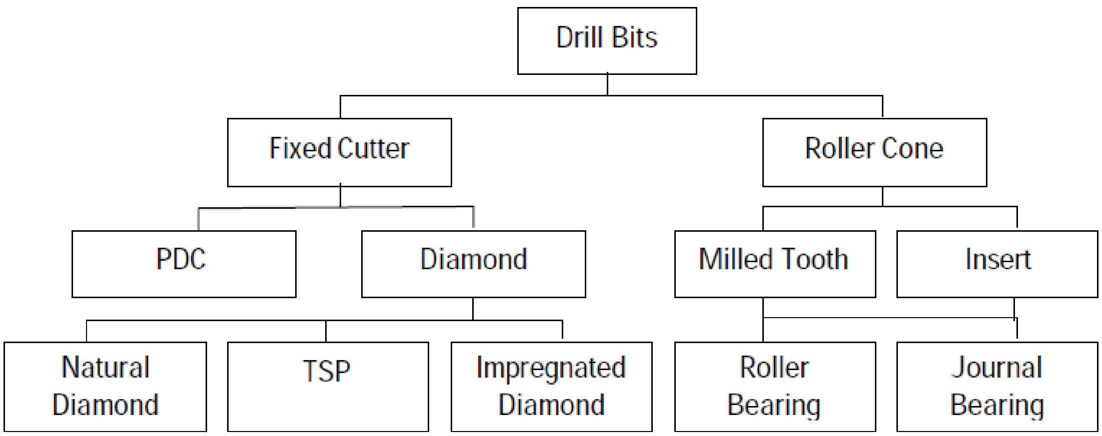
8. DRILL BITS

Rotary drilling bits are usually classified according to their designs as either fixed cutter

or roller cone bits.

All fixed cutter bits have blades that are integral with the bodies of the bits and rotate as a unit with the drill string.

Roller cone bits have two or more cones containing the cutting elements, which rotate about the axis of the cone as the bit is rotated at the bottom of the hole.



8.1 Fixed Cutter Bits

This type of bit includes Polycrystalline Diamond Compact (PDC) Bits and Diamond Bits.

An advantage of fixed cutter bits over roller cone bits is that they do not have any rolling parts which require strong and clean bearing surfaces. This is especially important in small hole sizes, where space is not available for designing strength into both the bit cutter elements and the bearings needed for a rolling cutter.

8.1.1 Polycrystalline Diamond Compact Bits (PDC)

Figure 118 Typical PDC Bit

To manufacture a PDC cutter, a special furnace heats carbon to a very high temperature

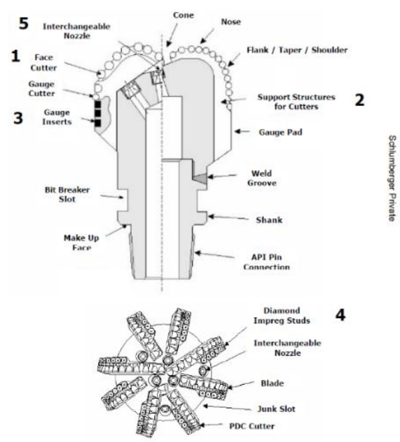
and, under great pressure, forms many tiny diamond crystals ("poly" means "many").

The manufacturer then mixes these diamond crystals with a metal powder called the catalyst

metal, and puts the mixture into a can. A layer of tungsten carbide powder mixed with diamond is added, and finally a polycrystalline wafer is put on the top.

The tiny diamond crystals in a PDC face have a random orient, thus making the PDC very

strong, sharp, and wear-resistant. It is self-sharpening because when a layer of crystals wears away, another layer with its many sharp edges is exposed.



The main disadvantage of PDCs is

1- They are less stable at high temperatures than are natural diamonds.

2- As the PDC contacts the rock during drilling and heats up, the catalyst metal expands at a different rate than that of the diamond.

Eventually, when the temperature reaches about 1,350°F (750°C), the PDC cracks. This temperature is not difficult to reach in drilling and is much lower than the temperature at which a natural diamond disintegrates (2,350°F or 1,270°C).

8.1.2 Natural Diamond Bits

Diamond is the hardest mineral known to human with a value of 10 on the Mohs scale of mineral hardness.

Diamond also possesses the highest thermal conductivity, allowing it to dissipate heat very quickly. This is a desirable property from a cutting element to prevent it from thermal fracture due to overheating.

A diamond bit is a fixed-head bit. It has a stationary (fixed) head that rotates as one piece with the drill string. It is also called a shear bit because it cuts the rock by slicing it like a knife. A diamond bit has three main parts, i.e. the cutters, the body, and the shank.

Figure 119 Natural Diamond Bit

8.1.3 Thermally Stable Polycrystalline (TSP) Bits

The newest synthetic diamond for bits is the thermally stable polycrystalline (TSP) diamond.

Its method of manufacturing is similar to that of the PDC. The difference is that the manufacturer either leaches out the catalyst metal that in a PDC helps bond the crystals or replaces it with a less-temperature-sensitive material.

A TSP is stable at higher temperatures than a PDC (almost as stable as natural stones)

because the crystals do not break apart because of expansion. While a PDC's diamond

layer will disintegrate at 1,350°F (750°C), the TSP can withstand up to 2,200°F (1,200°C).

The TSP, like the PDC, stays sharp as the tiny diamond crystals wear away.

Figure 120 Typical Thermally Stable Polycrystalline Bit

8.1.4 Impregnated Diamond Bits

Designers have taken advantage of the unique properties of each of the various materials used to make bit cutters and have combined them on one bit called the hybrid bit.

The hybrid bit has a combination of natural stones, PDC cutters, TSP, and even tungsten carbide inserts. For example, some PDC bits use natural diamonds, TSP, or tungsten carbide inserts as the gauge cutters.

Manufacturers of hybrid bits sometimes place a diamond impregnated pad or stud (not the same as a PDC stud cutter) on the bit for gauge protection.

To make such pads or studs, the manufacturer mixes grit-sized natural diamonds and tungsten carbide powder and heats them under pressure to form a replaceable pad or stud to attach to the gauge surface.

Figure 121 Typical Impregnated Diamond Bit

8.2 Roller Cone Bits

A roller cone bit is so called because it has three (or sometimes two) hollow equal-sized independently-moving cones. These metal cones have rows of cutters (steel teeth or tungsten carbide inserts) on the external surfaces. Each cone rotates, or rolls, on its own axis, and together all the cones rotate as the drill string rotates. Putting weight on the bit, and then rotating it makes the cutters scrape, gouge, or crush the formation. The geometry of the cones and the bit body depends on the Journal Angle, Cone Profile, and Offset Angle.

The bit journal is the bearing load-carrying surface. The magnitude of the journal angle affects the size of the cone: the cone size decreases as the journal angle increases. The journal angle also determines how much WOB the bit can sustain: The larger the angle, the greater the WOB. However, the smaller the journal angle, the greater is the gouging and scraping actions produced by the cones. The optimum journal angles for soft and hard-formation roller cone bits are 33o and 36o, respectively.

8.2.1 Milled Tooth Bits

Milled tooth bits have steel teeth that the manufacturer mills or cuts out of the body of the cone after the cone is cast. Some manufacturers forge the teeth from the cone.

Forging uses a heavy-duty press to compress the cone metal and form the teeth; no cutting or milling is involved. Tooth length and shape depend on the hardness of the formation the bits are designed to drill.

Long teeth are for soft formations, short teeth are for hard formations, and medium long or medium-short teeth are for medium-soft or medium-hard formations, respectively.

In soft formations, where the tooth scrapes and gouges the formation, long teeth are desirable because they can remove a lot of formation. Also, long teeth tend not to break in soft formations. In hard formations, on the other hand, where the tooth punches into the formation, short teeth are desirable because they shatter the rock without breaking themselves.

A long tooth cannot absorb as much impact as a short tooth without breaking. For medium-hard formations, tooth lengths fall somewhere between the longest and the shortest.

Figure 122 Milled tooth bit

8.2.2 Tungsten Carbide Insert Bits

Tungsten carbide insert bits (often called insert bits) are named for the tungsten carbide inserts in the cones. The inserts are small solid cylinders that have rounded or softly sharpened ends. The manufacturer presses the inserts into holes drilled in the cones.

Tungsten carbide is a gray metal powder that the manufacturer heats with a special binder and casts in a mold to make inserts. The binder is blended with the tungsten carbide powder and the blend is placed in a mold.

The mixture is then heated to melt the binder which holds (binds) the powder in place. Manufacturers can also apply tungsten carbide in layers to steel teeth and other parts of a bit that may contact the side of the wellbore.

Since tungsten carbide is much harder than steel, it withstands abrasion better and increases the life of a bit.

Insert bits have some advantages over milled-tooth bits. Tungsten carbide wears very little, so the inserts last longer than steel teeth. Also, the same tungsten carbide bit can drill many different types of formations without changing the bit often.

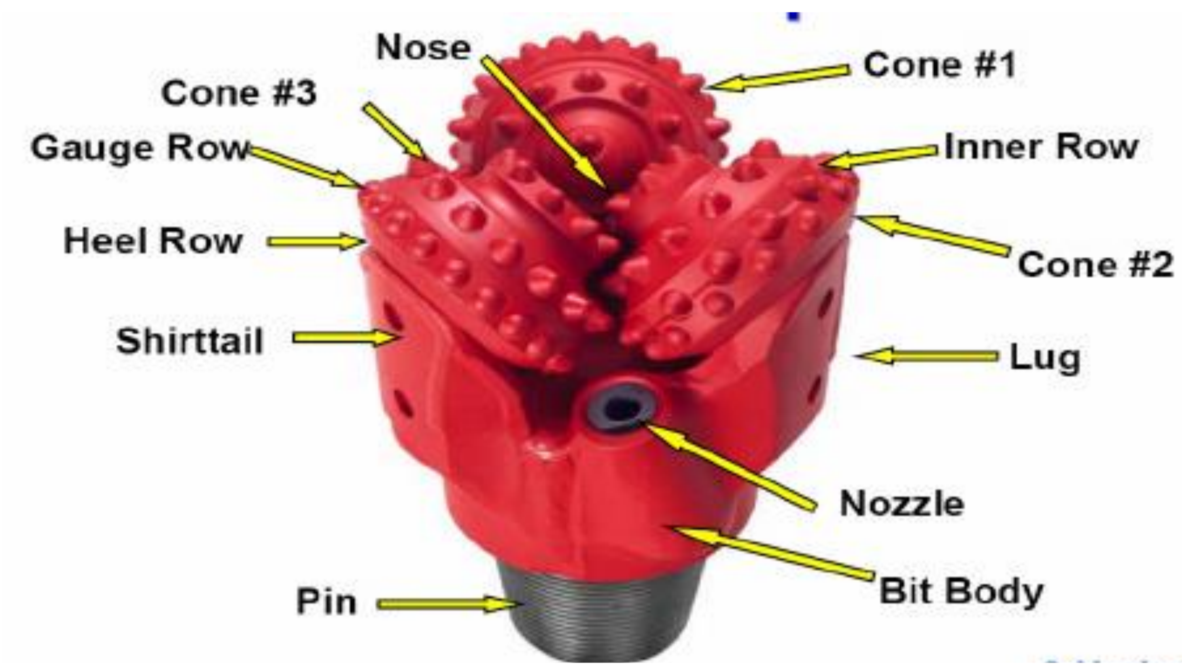


Figure 123 Tungsten Carbide Insert bit

8.3 Drill bits nozzle

The part of the bit that includes a hole or opening for drilling fluid to exit. The hole is usually small (around 0.25 in. in diameter) and the pressure of the fluid inside the bit is usually high, leading to a high exit velocity through the nozzles that creates a high-velocity jet below the nozzles. This high-velocity jet of fluid cleans both the bit teeth and the bottom of the hole. The sizes of the nozzles are usually measured in 1/32-in. increments (although some are recorded in millimeters), are always reported in "thirty-seconds" of size (i.e., fractional denominators are not reduced), and usually range from 6/32 to 32/32.

Figure 124 Various types of bit nozzle

8.1 Drill bits gauge rig

A precisely machined test device, typically fabricated from steel or similar durable material, having a specified internal or external diameter. The gauge ring is used to confirm the dimensional compatibility of tools and equipment that must pass through restrictions of a certain diameter.

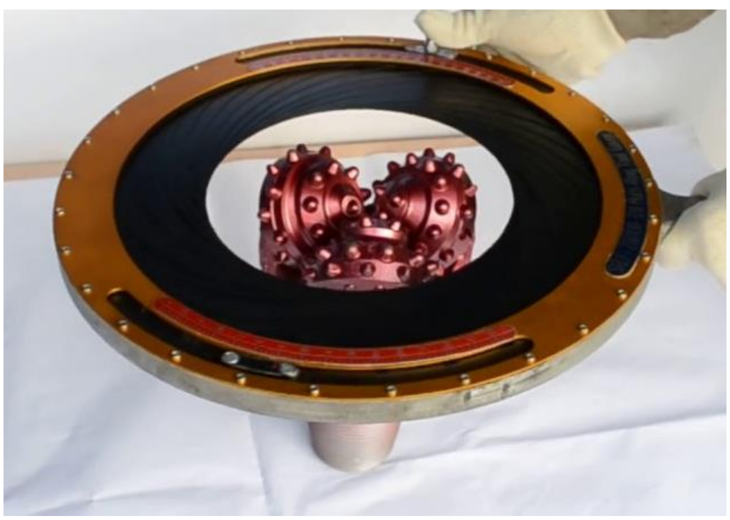


Figure 125 Drill bits gauge ring

8.2 Exercise

Match the following pictures with the names

I. Polycrystalline Diamond Compact Bit (PDC – Bit)

II. Natural Diamond Bits

III. Thermally stable polycrystalline (TSP-Bit)

IV. Tungsten carbide insert bit (TCI-Bit)

V. Milled Tooth bit

VI. Impregnated Diamond bit

9. DRILLING FLUIDS

9.1 DRILLING FLUIDS OVERVIEW

Drilling fluids are often used while drilling oil and natural gas wells and on exploration drilling rigs. Drilling fluids are also used for much simpler boreholes, such as water wells. Liquid drilling fluid is often called drilling mud. The three main categories of drilling fluids are water-based muds (which can be dispersed and non- dispersed), non-aqueous muds, usually called oil-based mud, and gaseous drilling fluid, in which a wide range of gases can be used.

The main functions of drilling fluids include providing hydrostatic pressure to prevent formation fluids from entering into the well bore, keeping the drill bit cool and clean during drilling, carrying out drill cuttings, and suspending the drill cuttings while drilling is paused and when the drilling assembly is brought in and out of the hole. The drilling fluid used for a particular job is selected to avoid formation damage and to limit corrosion.

9.2 DRILLING FLUIDS FUNCTIONS

9.2.1 Transport cuttings

- The well is drilled and cuttings are produced the must be removed from the well
- The drilling fluid is circulated down through the pipe and bit nozzles entraining the cuttings and carrying them up the annulus to surface.
- Cuttings removal is a function of cuttings size, shape, and density; rotation of the drill string and mud properties such as viscosity, density and annular velocity.

9.2.2 Release the cuttings at the surface

- Drilling fluid carries the rock excavated by the drill bit up to the surface.
- High concentrations of drill solids are detrimental to almost every aspect of the drilling operation, primarily drilling efficiency and ROP.
- Drill cuttings increase the mud weight and viscosity, which in turn increases maintenance costs and the need for dilution.

Figure 126 Shale Shakers

9.2.3 Suspend cuttings when circulating is interrupted

- Must suspend drill cuttings, weight materials and additives under a wide range of conditions.
- Drill cuttings that settle can causes bridges and fill, which can cause stuck-pipe and lost circulation.
- Weight material that settles is referred to as sag, this causes a wide variation in the density of well fluid, this more frequently occurs in high angle and hot wells.

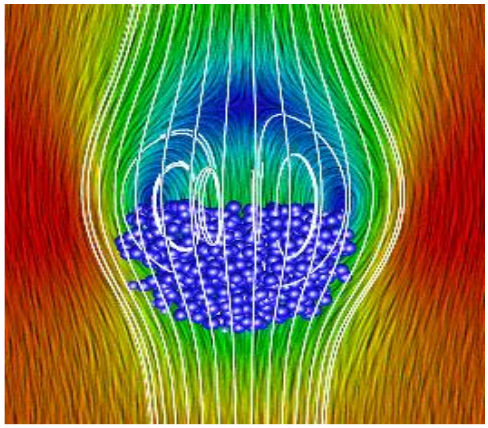


Figure 127 Sag often occur under dynamic conditions

9.2.4 Control formation pressures

- If formation pressure increases, mud density should also be increased to balance pressure and keep the wellbore stable. The most common weighting material is barite. Unbalanced formation pressures will cause an unexpected influx (also known as a kick) of formation fluids in the wellbore possibly leading to a blowout from pressured formation fluids.
- Hydrostatic pressure = density of drilling fluid × true vertical depth × acceleration of gravity. If hydrostatic pressure is greater than or equal to formation pressure, formation fluid will not flow into the wellbore.
- The well is considered under control when no formation fluids or gases are allowed into the wellbore.

Figure 128 Blowout due to loss of control of formation pressure

9.2.5 Cool and lubricate the bit and drilling assembly

- Considerable friction and heat by rotational and hydraulic forces of the bit and drill string
- Circulation of the fluid cools the drill string and bit distributing it throughout the wellbore.
- The drilling fluid also helps to cool down the bottom hole temperature.
- Drilling fluid also lubricates the BHA further reducing frictional heat. When required lubricating additives are put into the fluid to further mitigate the problem.

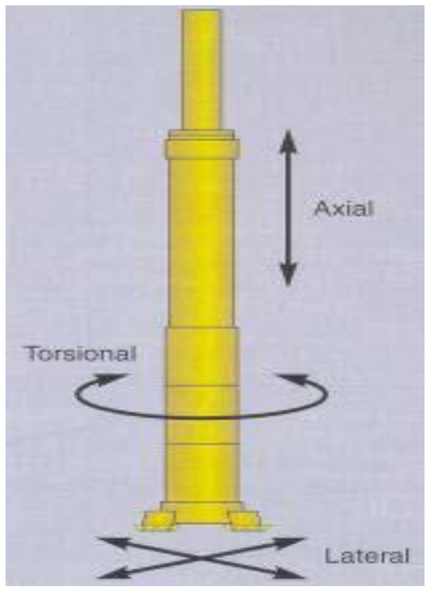


Figure 129 Heat caused by rotation and hydraulic forces at the bit

9.2.6 Maintain wellbore stability

- Borehole instability is most often identified by a sloughing formation, which causes tight hole conditions, bridges and fill on trips.
- This means the well must be reamed and cleaned and in extreme cases re drilled
- Borehole stability is greatest when the hole maintains its original size and cylindrical shape.
- Extremely water sensitive shales require an oil based or synthetic based fluid to drill successfully.

9.2.7 Provide Buoyancy for the Drill String

- The drilling fluid helps to support a portion of the drill string or casing string weight through buoyancy.
- If a drill string, liner or casing string is suspended in drilling fluid, it is buoyed by a force equal to the weight of the mud displaced, thereby reducing hook load on the derrick.
- Using buoyancy, it is possible to run casing strings whose weight exceeds a rig's hook load capacity.

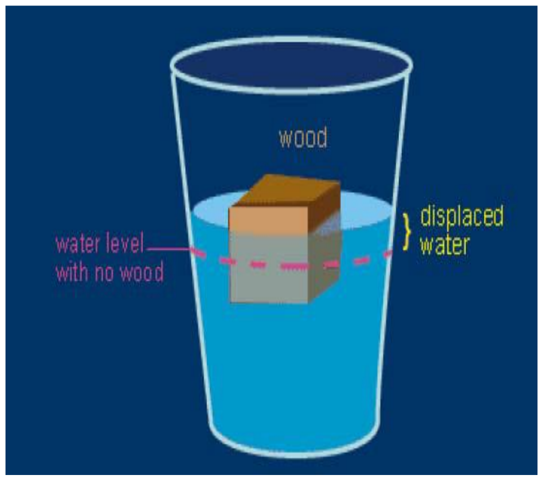


Figure 130 Buoyancy helps support drill string weight

9.2.8 Protect formation productivity

- Formation damage can happen as a result of solids plugging up the porosity or permeability or through chemical or mechanical interactions with the formation.
- Return permeability tests run with different fluids on cores will help to determine the best non-damaging fluids

9.2.9 Transmit hydraulic energy to tools and bit

- Special tools like MWD, LWD, and mud motors require an available pressure to function properly
- Proper hydraulics program can increase ROP, help minimize hole enlargement, help to clean the hole
- Hydraulic forces are limited to the available pump horsepower.
- All the pressure losses (pipe, bit, annular, tools etc) should be calculated beforehand to ensure adequate pressure is available for tools and hole cleaning.
- Density, plastic viscosity, BHA design all affect hydraulics

9.2.10 Ensure adequate formation evaluation

- Chemical and physical mud properties and wellbore conditions after drilling affect formation evaluation.
- Mud loggers examine cuttings for mineral composition, visual sign of hydrocarbons and recorded mud logs of lithology, ROP, gas detection or geological parameters.
- Wireline logging measure – electrical, sonic, nuclear and magnetic resonance.
- Oil-based mud, lubricants, asphalts will mask hydrocarbon indications.

9.3 DRILLING FLUIDS TYPES

Many types of drilling fluids are used on a day-to-day basis. Some wells require that different types be used at different parts in the hole, or that some types be used in combination with others. The various types of fluid generally fall into a few broad categories:

9.3.1 Air

Compressed air is pumped either down the bore hole's annular space or down the drill string itself.

9.3.2 Air/water

The same as above, with water added to increase viscosity, flush the hole, provide more cooling, and/or to control dust.

9.3.3 Air/polymer

A specially formulated chemical, most often referred to as a type of polymer, is added to the water & air mixture to create specific conditions. A foaming agent is a good example of a polymer.

9.3.4 Water

Water by itself is sometimes used. In offshore drilling sea water is typically used while drilling the top section of the hole.

9.3.5 Water-based mud (WBM)

Most basic water-based mud systems begin with water, then clays and other chemicals are incorporated into the water to create a homogeneous blend resembling something between chocolate milk and a malt (depending on viscosity). The most common of these is bentonite, frequently referred to in the oilfield as "gel".

9.3.6 Oil-based mud (OBM)

Oil-based mud is a mud where the base fluid is a petroleum product such as diesel fuel. Oil-based muds are used for many reasons, including increased lubricity, enhanced shale inhibition, and greater cleaning abilities with less viscosity.

9.3.7 Synthetic-based fluid (SBM)

(Otherwise known as Low Toxicity Oil Based Mud or LTOBM): Synthetic- based fluid is a mud where the base fluid is a synthetic oil. This is most often used on offshore rigs because it has the properties of an oil-based mud, but the toxicity of the fluid fumes are much less than an oil-based fluid.

On a drilling rig, mud is pumped from the mud pits through the drill string where it sprays out of nozzles on the drill bit, cleaning and cooling the drill bit in the process. The mud then carries the crushed or cut rock ("cuttings") up the annular space ("annulus") between the drill string and the sides of the hole being drilled, up through the surface casing, where it emerges back at the surface. Cuttings are then filtered out with either a shale shaker,, and the mud returns to the mud pits.

9.4 Properties of mud

9.4.1 Drilling fluids properties and testing equipment:

9.4.1.1 Density

It is the ratio of a substance's density divided by the density of pure water at a stated temperature, usually 4°C.

Drilling mud density is required to calculate the hydrostatic pressure that is being exerted by a column of drilling mud at any given depth.

Figure 131 Mud balance

9.4.1.2 Viscosity

Marsh Funnel viscosity is an indication of the overall viscosity of a drilling mud.

Figure 132 Marsh funnel viscometer

9.4.1.3 Rheology (Yield point-Gel strength)

Rheology is the study of deformation and flow, In the field, a rotational viscometer having an industry standardized bob and sleeve is used.

Yield Point: is the ability of the mud to **lift** the cutting while **circulation**

Gel strength: is the ability of the mud to **suspend** the cutting while pump **stopped**.

Figure 133 Rotational viscometer

9.4.1.4 Fluid loss

It is measured by the rate of fluid/filtrate lost from the mud in 30 minutes.

Collect the filtrate in the graduated cylinder for 30 minutes. At this time, remove the graduated cylinder, turn off and relieve the pressure on the test sample.

Figure 134 API (room temperature) Filter press

10. CASING COMPONENTS AND ACCESSORIES

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 hole has been drilled.

Once the open hole section is drilled, the hole has to be cased and the casings should be secured in place by cementing.

Casing is the major structural component of a well. Casing is needed to:

- Maintain borehole stability
- Prevent contamination of water aquifer
- Isolate water from producing formations
- Control well pressures during drilling, production, and workover operations

Casing provides base or connection for the installation of:

- Blowout preventers
- Wellhead equipment
- Production packers
- Production tubing

The cost of casing is a major part of the overall well cost, so selection of casing size, grade, connectors, and setting depth is a primary engineering and economic consideration.

10.1 CASING STRINGS

There are five basic types of casing strings

- Conductor Casing
- Surface Casing
- Intermediate Casing
- Production Casing
- Liner

10.1.1 CONDUCTOR CASING

Conductor casing is the first string to set. The conductor isolates unconsolidated formations and fresh water aquifer and protects against shallow gas. A well neck flange may be welded at top of the conductor to nipple up diverter or BOP stack. When cemented, this string is typically cemented to the surface.

10.1.2 SURFACE CASING

Surface casing is set to provide blowout protection, isolate water sands, and prevent lost circulation. It also often provides adequate shoe strength to drill into high-pressure transition zones. In deviated wells, the surface casing may cover the build section to prevent key seating of the formation during deeper drilling. This string is typically cemented to the surface.

10.1.3 INTERMEDIATE CASING

Intermediate casing is set to isolate:

- Unstable hole sections
- Lost-circulation zones
- Low-pressure zones
- Production zones

It is often set in the transition zone from normal to abnormal pressure. The casing cement top must isolate any hydrocarbon zones. Some wells require multiple intermediate strings. Some intermediate strings may also be production strings if a liner is run beneath them.

10.1.4 PRODUCTION CASING

Production casing is used to isolate production zones and contain formation pressures in the event of a tubing leak. It may also be exposed to:

- Injection pressures from fracture jobs
- Gas from the gas lift

A good primary cement job is very critical for this string.

10.1.5 LINER

Liner is a casing string that does not extend to the wellhead but it is hung on another casing string. Liners are used instead of full casing strings to:

- Reduce cost.
- Not represent a tension limitation for a rig.
- Save rig time.

Liners can be either an intermediate or a production string. Liners are typically cemented over their entire length

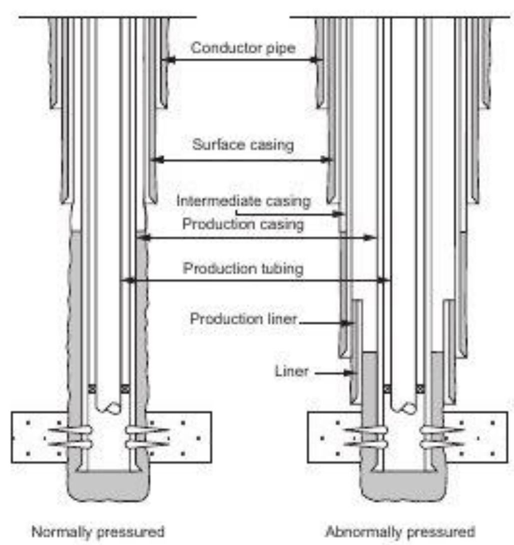


Figure 135 Casing String Terminology

10.2 CASING PROPERTIES

The American Petroleum Institute (API) grade of casing denotes the steel properties of the casing. The grade has a letter, which designates the grade, and a number, which designates the minimum yield strength in thousands of psi. A table of API

casing grades and properties are listed below

API STEEL GRADES				
API Grade	Yield Stress, psi Minimum	Yield Stress, psi Maximum	Minimum Ult. Tensile, psi	Minimum Elongation, %
H–40	40,000	80,000	60,000	29.5
J–55	55,000	80,000	75,000	24.0
K–55	55,000	80,000	95,000	19.5
N–80	80,000	110,000	100,000	18.5
L–80	80,000	95,000	95,000	19.5
C–90	90,000	105,000	100,000	18.5
C–95	95,000	110,000	105,000	18.5
T–95	95,000	110,000	105,000	18.0
P–110	110,000	140,000	125,000	15.0
Q–125	125,000	150,000	135,000	18.0

Figure 136 Casing String API Grades

Casing properties are defined as:

- **Yield Strength:** The tensile stress required to produce a total elongation of 0.5% per unit length
- **Collapse Strength:** The maximum external pressure or force required to collapse the casing joint
- **Burst Strength:** The maximum internal pressure required to cause a casing joint to yield

Casing dimensions are specified by its outside diameter (OD) and nominal wall thickness. Normal wellsite conventions specify casing by its OD and weight per foot. As stated earlier, one should specify which weight one is referring to, though most often it is the nominal weight

10.3 CASING COUPLINGS & THREADS

Couplings are short pieces of casing used to connect the individual joints.They are normally made of the same grade of steel as the casing. Through their strength can be different than the casing. The API has specifications for four types of couplings.

- Short round threads and couplings (CSG)
- Long round threads and couplings (LCSG)
- Buttress threads and couplings (BCSG)
- Extremeline threads (XCSG)

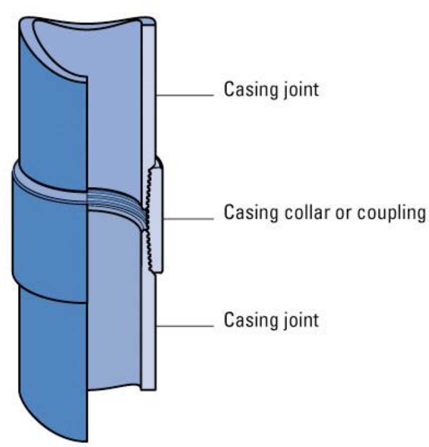


Figure 137 Cross Section of Casing Couplings

10.4 CASING ACCESSORIES

10.4.1 FLOAT (GUIDE) SHOE

A float shoe is a short and rounded shape component with non-return value inside which is installed at the end of the casing. The advantages of a float shoe are as follows;

- Prevent mud flowing back while running casing and prevent cement from outside U-tubing back into casing due to unbalanced conditions while performing cementing operation.
- Help running casing to the well. The round shape of a float shoe prevents a casing string from hanging up and guiding a string into a wellbore. Some float shoes are made of high strength drillable material and can be used to reciprocate and rotate to pass any obstructions in a wellbore.

Figure 138 Float (guide) shoe

10.4.2 FLOAT COLLAR

A float collar is also a non-return valve which normally installed one or three joints above a float shoe. The advantages of a float collar are as listed below;

- Prevent mud and cement from U-tubing back into a casing string and float casing if required. This is the same advantage as a float shoe, and this also serves as a backup check valve in the casing string. If the check valve in a float shoe fails, a check valve in a float collar still performs the same purpose.
- Land cement wiper plug. Some models of float collars have non-rotating profiles. A cement plug landed into the profile will have fewer tendencies to rotate while drilling out. This will minimize time to drill out cementing plug because a cement wiper plug will not be rotated.
- Contain contaminated cement. The space between a float shoe and float collar called a “shoe track” will contain any contaminated cement when the top plug wipes any residual mud inside the casing. This will prevent bad cement at a casing shoe and help operators to achieve good formation integrity test (FIT) or leak off test (LOT) of the next well section.

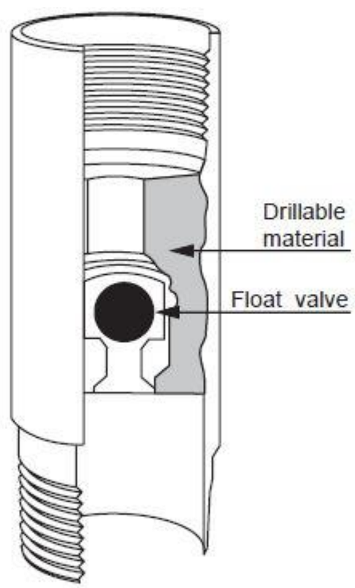


Figure 139 Float collar

10.4.3 DV TOOL

Stage-cementing tools, or differential valve (DV) tools, are used to cement multiple sections behind the same casing string, or to cement a critical long section in multistage. Stage cementing may reduce mud contamination and lessens the possibility of high filtrate loss or formation breakdown caused by high hydrostatic pressures, which is often a cause for lost circulation.

Stage tools are installed at a specific point in the casing string as casing is being run into the hole. The first (or bottom) cement stage is pumped through the tool to the end of the casing and up the annulus to the calculated-fill volume (height). When this stage is completed, a shutoff or bypass plug can be dropped or pumped in the casing to seal the stage tool. A free-falling plug or pumpdown dart is then used to hydraulically set the stage tool and open the side ports, allowing the second cement stage (top stage) to be displaced above the tool. A closing plug is used to close the sliding sleeve over the side ports at the end of the second stage and serves as a check valve to keep the cement from U-tubing above and back through the tool.

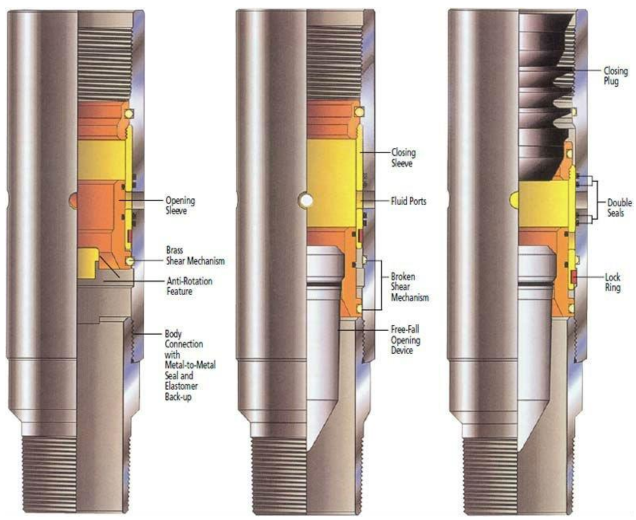


Figure 140 DV tool for stage cementing

10.4.4 CENTRALIZER/STOP COLLARS

A centralizer is a device to keep a casing string out of the well bore wall. The advantages of casing centralizers are listed below;

- ❖ Centralize casing string and minimize contact between casing string and wellbore
- ❖ Achieve proper cement around casing string and reduce cement channeling
- ❖ Minimize differential sticking and drag while running in hole.

Figure 141 Centralizers

10.5 CASING RUNNING TOOLS

10.5.1 ELEVATORS

Elevators must be securely latched onto the elevator links. The bails must also be safely secured to the hook or top drive. Hand injuries are the most common type of injuries to personnel using the elevators. To avoid hand injury, do not place your hands between the elevators and the tubular. Use the handles on the elevators for handling them and operating the latch. Wait until the elevators have stopped moving before handling them.

Figure 142 Casing elevator

The elevators must be maintained in good condition and inspected before use (Figure 137). Report any defects you notice to your supervisor.

10.5.2 POWER TONGS

Rig men use power tongs to tighten pipe connections up to final torque and break out torqued pipe connections. Some models of power tongs require backup tongs. Others require no backup tongs because they include a self-contained back-up device. Some models have a spinning wrench included. Power tongs can be powered hydraulically or pneumatically.

One main advantage of power tongs over conventional ones is that you can adjust and preset the amount of torque needed to make up a particular joint properly. This allows the tong to repeat a required torque automatically on each tool joint.

Figure 143 Power Tong

10.5.3 SPIDER SLIP

Slip action (Figure 139) is controlled by a conveniently positioned pneumatic control valve, or in the case of the 200-ton tools, by simple manual operation.

All pneumatically controlled units operated by utilizing the rig air supply. For maximum crew safety, the system may be manually operated if rig air pressure is temporarily lost. Further safety is insured by a positive locking mechanism, which locks slips in the set position.

Figure 144 Spider Slip

A number of components are fitted together to make up casing strings. These components enable casings to be cemented in place. In order to successfully cement each casing string, casing accessories should be installed. The necessary components are listed below;

10.6 CASING MILLING/CLEANING TOOLS

10.6.1 STRING MILL OR WATERMELON MILL

Watermelon Mill was made to run in tandem with other mills designed and dressed in such a way that it can mill up or down. The watermelon mill is also designed to grind up casing internally into a fine metal powder instead of metal shavings.

Figure 145 String Mill

10.6.2 SCRAPERS

Casing scraper is designed to mechanically assist in cleaning wellbore casings by scoring and removing mud film and other restrictive material from the inner casing wall diameters.

Figure 146 Casing scraper

10.1 PREPARING CASINGS

Before running the casing, the first job is to remove the casing/thread protectors, inspect the pipe for physical damage to the tubular body and ends. Look for any damage to determine if the joint is suitable for downhole use. Check the thread to see if they have any damages.

Drift the tubulars before cleaning the threads. The rabbit can pull dirt and other objects through the end of the pipe.

Drifting the casing is to check that the internal diameter of the casing meets the specified tolerance. A tool called a drift or rabbit 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.

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 or damage in the casing.

Drifting tubulars (drill pipes, drill collars, tubing, and casing) is to pull a known diameter plug, or rabbit, through them. Drifting tubulars ensures that they are free of obstacles or dents that could cause a blockage. It also checks the minimum diameter along the length of a tubular.

The internal diameter of all pipe needs to be checked so that plugs tools, or other equipment, can pass through them.

Drifting also helps to ensure that the pipe is free of objects or dirt that can block the bit nozzles when drilling. Different sizes of rabbit are available, made from metal or plastic.

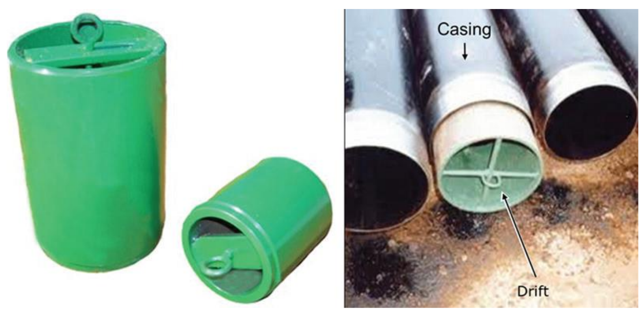


Figure 147 Drifts


Figure 148 Drifting Casings

11. CEMENTING OPERATIONS

Cementing operations are carried out for two purposes in oil and gas well.

- ❖ Primary cementing
- ❖ Remedial cementing

The first and by far the most popular one is called the primary cementing operation. It is mainly performed to secure casings in the hole. The second one is called remedial cementing and it is performed to repair or modify inadequate primary cementing jobs. Remedial cementing is divided into two categories; one is called squeeze cementing which is performed to repair an inadequate primary cementing job, and the other is called plug back cementing and it is used for various purposes, such as well abandonment, side tracking etc.

11.1 PRIMARY CEMENTING

Casings and liners are cemented from top to bottom using Class 'G' cement. The drilling engineer should perform the following tasks to aid in the planning of a successful cementing job:

- ❖ Determine the static bottom hole temperature and hydrostatic pressure at the casing depth.
- ❖ Estimate the bottom hole circulating temperature at the casing depth.
- ❖ Calculate the density of the cement slurry required that is less than the fracturing pressures of formations above casing shoe and greater than the formations pore pressures.
- ❖ Provide the amount of mix water and slurry yield per sack.
- ❖ Decide whether the cementing job is to be performed in single stage or multiple stages. Locate the position and type of DV tool to be used.
- ❖ Calculate the density of cement to be used for the second stage. • Calculate the required cement slurry and thickening time.
- ❖ Consult with the lab and decide what other additives are needed to achieve the required density, thickening time, strength retrogression, fluid loss, potential gas migration, and free water. • Determine the composition of the mix water. Is there a need to add bactericide (biocide)?
- ❖ Calculate the cement volumes for the first and second stage. Use excess volumes based on current practices used in offset wells.
- ❖ Select the cement placement method (conventional or inner string).
- ❖ Select the type and amount of spacers ahead and behind the cement.
- ❖ Select mixing method (batch mixing or recirculating mixer).
- ❖ Specify compressive strength of cement required prior to drilling out shoe and waiting time (WOC)required for the cement to achieve that strength.

Decide whether there is a need to perform confirmation lab tests on rig cement samples before the cement job is performed. The rig sends two samples to the lab prior to pumping the cement. The first sample consists of dry cement sample, mix water sample (with no additives mixed in the water) and samples of cement additives available on the rig. The sample is sent few days before the cementing job is performed. The second sample is sent after the additives are mixed in the mix water and the rig is preparing for the cement job. The second sample consists of a dry cement sample and a sample of the mix fluid (with the additives mixed in the water). The lab will conduct tests on both samples to measure thickening time, fluid loss, free water content, density and rheology to make sure they meet the cement properties specified in the drilling program. If the properties do not meet the requirements in the program, the lab will modify the concentrations and types of additives.

11.1.1 Cementing Procedure:

Include in the drilling program a short cementing procedure for each cementing stage. The procedure should include the following:

- Type of cement, number of sacks, and concentrations of all additives. Amount of excess cement used in per cent or height of cement rise above DV or liner hanger.
- Slurry density and yield
- Mix water volume per sack
- Thickening time
- Bottom hole static temperature and circulating temperature
- Free water and fluid loss
- Compressive strength in psi and waiting time (WOC).
- Number of hole volumes to be circulated to condition the mud.
- Volume, weight, and type of spacers ahead and behind the cement.
- Volume, type, and weight of displacing fluid.
- Maximum pumping pressure.
- Operation of the DV tool (circulation of excess cement from first stage, packer inflation, opening of circulating ports, closing DV ports).

11.1.2 Cementing Equipment:

For every section of casing, a cementing crew arrives on location with the cement unit (Figure 144).

Figure 149 Cement Unit

The cement unit is a large mixing unit and pump. High pressure lines are installed from the cement unit to the top of the casing cement head. The casing cement head screws into the top of the casing. The cement unit mixes dry cement powder, water and chemicals to make a batch of cement, called "slurry".

Figure 150 Casing Cement Heads

The cement head holds plugs that are released ahead and behind cement being pumped; bottom and top plugs, respectively. The top plug is pumped down/ displaced with water or drilling fluid. This prevents the cement from coming back up the casing. The plug is pumped down to the bottom of the casing, so that the rest of the casing has no remaining cement.

Figure 151 Cement Head Plug

11.1.3 Cementing Operation:

The process in (Figure 147) shows that the cement slurry is pumped out through the shoe at the bottom of the casing. The cement then fills the space between the casing and the formation all the way to surface.

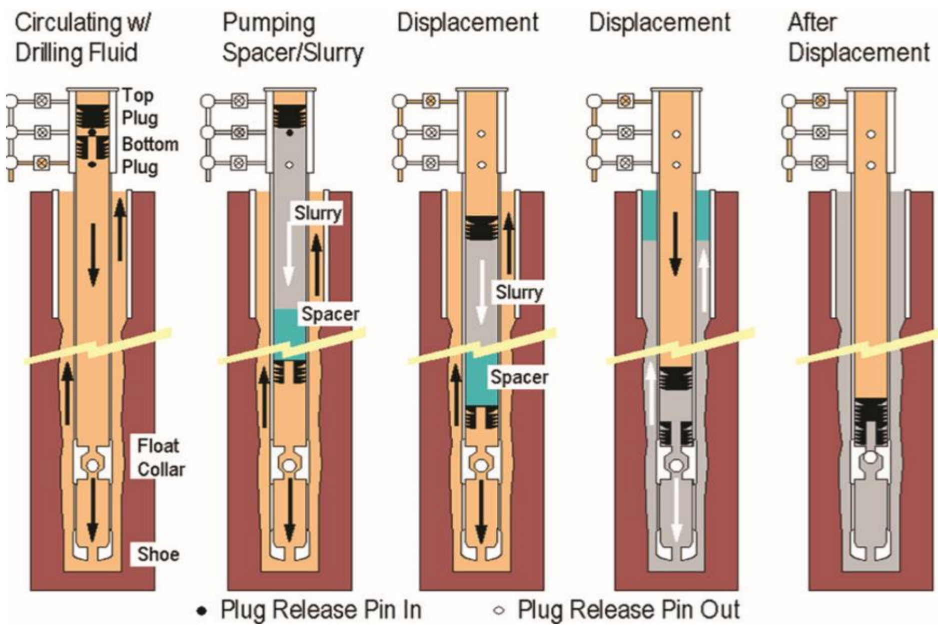


Figure 152 Cementing Process

After the cement hardens, it makes a seal between the casing and the rock formation. This prevents formation fluids from entering the well. The next section of the well can then be drilled. The smaller diameter hole is drilled through the bottom of the casing shoe.

11.2 SQUEEZE CEMENTING

Squeeze cementing is defined as the process of forcing a cement slurry, under pressure, through holes or splits in the casing/wellbore annular space. When the slurry is forced against a permeable formation, the solid particles filter out on the formation face as the aqueous phase (cement filtrate) enters the formation matrix. A properly designed squeeze job causes the resulting cement filter cake to fill the opening(s) between the formation and the casing.

Upon curing, the cake forms a nearly impenetrable solid. In cases where the slurry is placed into a fractured interval, the cement solids must develop a filter cake on the fracture face and/or bridge the fracture.

A special squeeze packer is used for this operation.

Figure 153 EZ Drill® SVB Squeeze Packer

11.3 PLUG BACK CEMENTING

Cement plugs and their applications are used for various reasons, including:

11.3.1 Well or zone abandonment:

- Seal a dry hole;
- Seal depleted zones;
- Seal non-commercial zones or wellbores;

11.3.2 Temporary well or zone abandonment. Zonal isolation or well stability:

- Isolate one pressure zone from another;
- Prevent zonal fluid communication;
- Stop lost circulation events;

11.3.3 Enable drilling through fracture or weak formations. Directional drilling (kick-off plugs):

- Support controlled changes in well trajectory (whipstock operations);
- Sidetrack operators around a "fish".

It is essential to these operations that a competent cement plug is placed the first time. Properly placing the designed cement plug helps reduce nonproductive rig time, minimize wasted material, and mitigate the need for additional cementing services.

Plugging oil or gas wells is a very common operation.

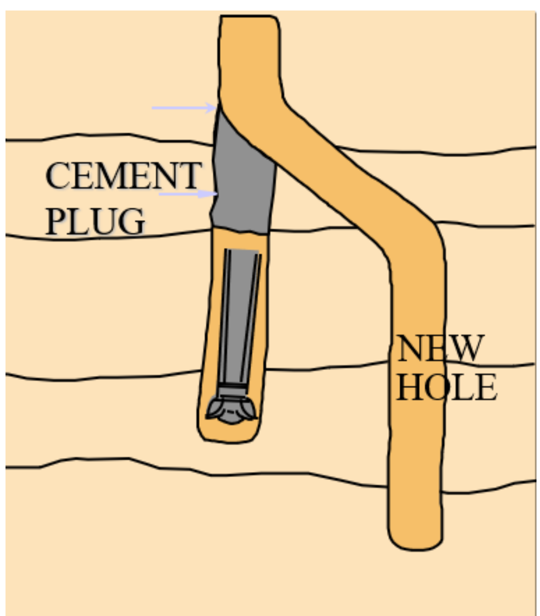


Figure 154 Cement Plug for side tracking

Thus, the challenge is placing a relatively small amount of cement slurry above a larger volume of wellbore fluid. As a result, a sound engineering design that addresses the major factors affecting plug success is necessary. Factors include the density and rheology of both the cement and the wellbore fluid as well as hole size and hole angle including vertical, deviated and horizontal well orientations Setting a Hi-Vis pill may be required to effectively spot the plug.

12. WELL HEAD

The wellhead equipment is used as a connection base for the BOP, casing or tubing strings, and for the production tree. A production tree controls the flow of fluids from the well after the rig has moved. The well can also be shut in by using the production tree.

12.1 EQUIPMENT

The wellhead equipment includes:

- Landing base
- Casing hanger
- Casing spools
- Tubing spools
- Tubing Hanger
- Production tree

12.1.1 Landing Base

The landing base is the first connection between surface casing and any BOP equipment or wellhead equipment. The landing base is also called a casing head. As shown in Figure 155, the top of the landing base is a flanged connection. The bottom of the landing base is welded (it can also be threaded) on to the surface casing. There is usually a threaded side outlet on the landing base. This threaded side outlet is for draining the BOP after it is installed.

Figure 155 Landing base

12.1.2 Casing Hanger

A casing hanger (Figure 156) is a two-piece slip and seal assembly inserted into a landing base. A casing hanger is also installed into every casing spool.

The slips suspend the casing so that the top of the casing can be cut above the slips. The seal then installs onto the top of the slips. The seal part of the casing hanger prevents wellbore pressure from reaching the space below the seal. It seals between the outside of the casing, and the inside profile of the landing base or casing spool.

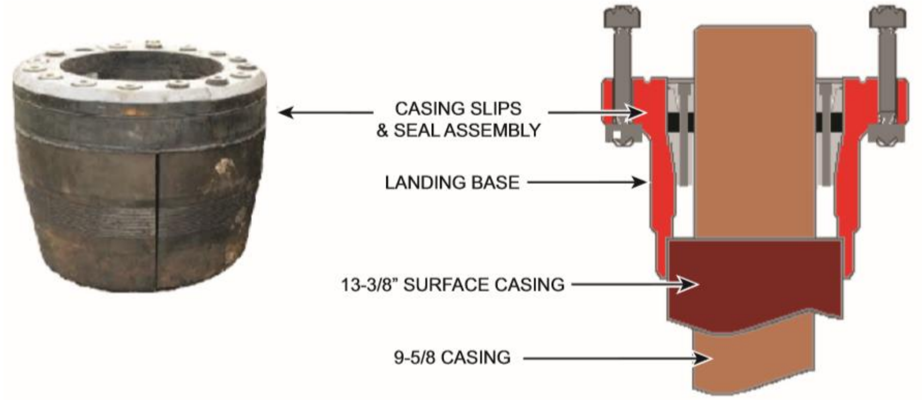


Figure 156 Casing Hanger

12.1.3 Casing Spools

A casing spool (Figure 157) is similar in design to a landing base. The casing spool has flanged connections instead of a welded connection. It is bolted to the top of the landing base after a string of casing has been run and cemented into the wellbore.

Figure 157 Casing spool

12.1.4 Tubing Spools

Tubing is run after the last casing string. The hydrocarbons flow up through the tubing to the surface when the well is ready to produce. The tubing spool is similar in design to the casing spool. It has lockdown screws for the tubing hanger in the upper flange, as shown in Figure 158. The tubing spool receives and locks the tubing hanger that supports the weight of the tubing. The production tree attaches to the top of the tubing spool. The tubing hanger has a seal that seals off against the tubing spool and tubing. This isolates the annulus below the tubing hanger. The side outlets on the tubing spool allow access to this annulus. The tubing hanger screws onto the tubing.

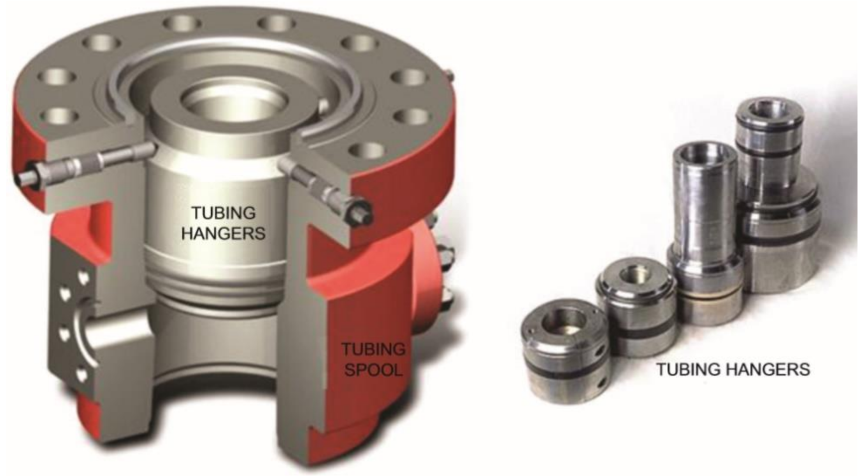


Figure 158 Tubing spool

12.1.5 Tubing Hanger

12.1.6 Production Tree

The production tree (also called Christmas tree or Xmas tree) uses heavy duty valves to control the flow of oil or gas out of the well (Figure 159). It also has an access point for equipment to service the well [28].

Figure 159 X-mass tree or Production tree

12.2 INSTALLING A LANDING BASE ON A LANDRIG

After the surface casing has been cemented into the wellbore, the landing base is installed onto the casing. The landing base is the first connection between the casing and the BOP. The procedure for installing a landing base includes [29]:

- Cut the casing
- Position the landing base
- Weld the landing base
- Pressure test the weld

12.3 INSTALLING A CASING SPOOL

After the intermediate string of casing is run and cemented into the wellbore, the next step is to install a casing spool on top of the landing base. To do this, the BOP has to be removed from the landing base. The detailed procedure for installing a casing spool includes:

- Nipple down BOP
- Set casing hanger/slips
- Cut the casing
- Nipple up casing spool
- Nipple up BOP

12.3.1 Nipple Down BOP

Nipple down means to remove all the bolts on a flanged connection. When the bolts are removed, the BOP is lifted with the BOP hoist to access the inside of the landing base.

12.3.2 Set Casing Hanger/Slips

Once the BOP is lifted, a pressure washer is used to clean the inside of the landing base around the casing hanger profile as shown in Figure 160. Casing hangers/Slips are set and the casings are landed as per the manufacturer's recommendations.

Figure 160 Casing Hanger

12.3.3 Cut the Casing

Once the slips are set and the casing is suspended by the hanger in the landing base, then a welder cut the casing that is sticking up as in Figure 161.

Figure 161 Cutting Casings

12.3.4 Nipple Up the Casing Spool

Nipple up means making up all the bolts on a flanged connection. The casing spool attaches to the landing base with a flanged connection. The casing spool is lowered into place by using the bolt and chain sling and a hoist line through the rig floor. The seal areas of the casing spool and landing base have to be cleaned thoroughly and a new seal ring installed. The bolts are tightened and the sling removed. The casing spool is tested as followings: The casing spool has a port on the side of the flange. The port allows the seals between the casing spool, hanger and the landing base to be pressure tested with hydraulic oil.

12.3.5 Pressure Test the Casing Spool

The casing spool has a port on the side of the flange. The port allows the seals between the casing spool, hanger and the landing base to be pressure tested with hydraulic oil.

12.3.6 Nipple Up the BOP

The BOP needs to be flanged to the top of the casing spool. Once the BOP has been tightened to the casing spool, the flanged connections are pressure tested before drilling operations can begin [30].

12.4 INSTALLING BOPs

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 (Figure 162) after the surface section has been drilled and cased.

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.

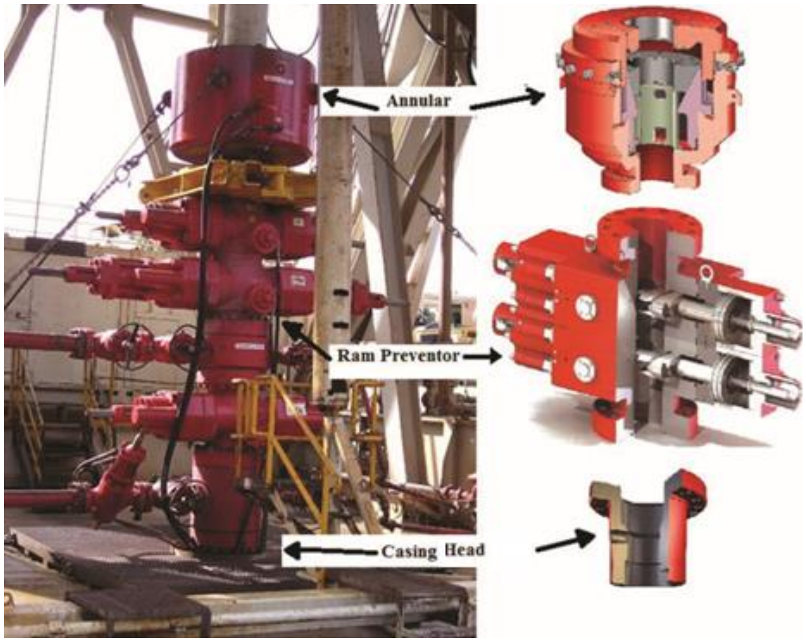


Figure 162 Installing BOP

13. EXERCISE SET-II

Select the correct answer.

1. What is the name of the heavy pipes and tools that also include the drill bit?
   a) DP
   b) BHA
   c) Casings
   d) Tool Joints

2. What is the first section of the well that is drilled by the drilling rig?
   a) Production Section
   b) Intermediate Section
   c) Cross Section
   e) Surface Section

3. What is the purpose of a wellbore survey?
   a) To determine how to drive to the rig site
   f) To determine if the hole is deviating
   b) To determine how many people on the rig
   c) To determine how many rigs are available

4. Why do the crew drift casing?
   a) To check casing outside diameter
   g) To check casing inside diameter
   b) To determine coupling sizes
   c) To make sure casings fit in hole

5. The purpose of drilling a well is to extract ___________.
   a) drilling fluid
   b) formation water
   c) formation samples
   d) hydrocarbons

6. When the rig arrives at the well location, it must be ___________ before drilling can begin.
   a) painted
   b) rigged down
   c) rigged up
   d) cased

7. The ___________ is normally run in the hole before any surface casing.
   a) conductor pipe
   b) surface casing
   c) production casing
   d) intermediate casing

8. When the bit first starts to drill the ground, it is called ___________ the well.
   a) swabbing
   b) spudding
   c) surging
   d) surveying

9. A ___________ is used to measure if the hole is vertical.
   a) rabbit
   b) trip
   c) spud
   d) survey

10. A ___________ is used to check the internal diameter of the casing.
    a) Rabbit (drift)
    b) trip
    c) spud
    d) survey

11. After every hole section is drilled, ___________ is run to line the hole.
    a) a survey
    b) casing
    c) drilling fluid
    d) a rabbit

12. A ___________ is installed after casing the surface section, to prevent high pressure fluids from exiting the casing at surface.
    a) BOP
    b) BHA
    c) rabbit
    d) TD

13. The rig is rigged down after ___________.
    a) the surface section
    b) spudding the well
    c) the intermediate section
    d) completing the well

14. Pulling the drill string out of the hole is known as ___________.
    a) RIH
    b) ROP
    c) POH
    d) BOP

15. Before the drill string is pulled out, the hole is ___________.
    a) opened, and mouse hole closed
    b) closed, and mouse hole opened
    c) cleaned by circulation
    d) opened, and rathole closed

16. The kelly is stored in the ___________ during tripping operations.
    a) fingerboard
    b) monkeyboard
    c) mouse hole
    d) rathole

17. The ___________ breakout holds the top drill pipe when breaking out a connection.
    a) table
    b) kelly
    c) slips
    d) tong

18. A ___________ is used to direct mud from the drill pipe back to the tanks when breaking connections.
    a) mud bucket
    b) mud pump
    c) mud gun
    d) fingerboard

19. When a connection is broken, the drill pipe stand is racked in the ___________.
    a) fingerboard
    b) elevators
    c) c. rathole
    d) d. mouse hole

20. To pull a stand of drill pipe out of the hole, the crew will latch the ___________ onto the top of the drill pipe.
    a) tongs
    b) elevators
    c) pipe spinner
    d) traveling block

21. BHA components require a ___________ than the drill pipe when making up connections.
    a) lower torque
    b) higher torque
    c) taller derrick
    d) smaller derrick

22. The ___________ puts pipe into the elevators when tripping in the hole.
    a) pipe spinner
    b) mud can
    c) air hoist
    d) derrickman

23. After tripping in the hole, the ___________ must be installed to start drilling.
    a) kelly
    b) rig tongs
    c) pipe spinner
    d) elevators

24. Primary cementing is used to ___________.
    a) deviate from vertical
    b) fix previous cement troubles
    c) secure casings in the hole
    d) inject cement mixture into the formation

25. Before any cement job the hole has to be ___________.
    a) cleaned of drilling fluid and made it empty
    b) cleaned of cuttings by circulation
    c) replaced with oil
    d) enlarged

26. Squeeze cementing is used to ___________.
    a) deviate from vertical
    b) fix previous cement troubles
    c) secure casings in the hole
    d) inject cement mixture into the formation

27. In case we have a long casing strings we may use ___________.
    a) Squeeze cementing
    b) Remedial cementing
    c) Multi stage cementing
    d) Plug back cementing

28. Identify the cementing equipment below.
    a) Cement head
    b) Wiper plug
    c) Float collar
    d) Guide Shoe

29. Identify the cementing equipment below.

a) Cement head
b) Wiper plug
c) Float collar
d) Guide Shoe

30. Identify the equipment below.

a) Rabbit (for drifting casings)
b) Wiper plug
c) Float collar
d) Guide Shoe

31. Identify the equipment below.

a) Elevator
b) Centralizer
c) Float collar
d) Guide Shoe

32. Identify the equipment below.

a) Elevator
b) Power tong
c) Float collar
d) Stabilizer

33. Identify the casing equipment below.

a) Float collar
b) Power tong
c) Float (guide) shoe
d) Stabilizer

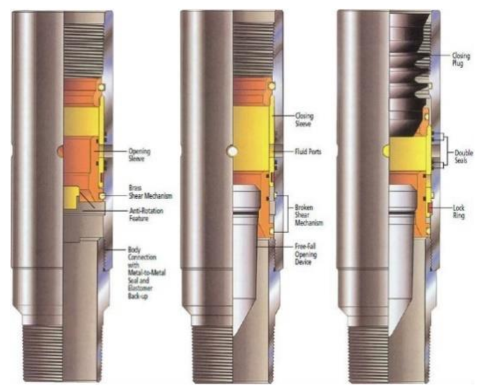
34. Identify the casing equipment below.

a) Elevator
b) Centraliser
c) Float collar
d) Guide Shoe

35. Identify the casing equipment below.

a) Elevator
b) Centraliser
c) Float collar
d) Casing scraper

36. Identify the casing equipment below.



a) Float collar
b) Power tong
c) Differential Valve (DV tool) or multi stage tool
d) Stabilizer

37. The ____________ is the first connection between the surface casing and any other wellhead equipment.

a) blowout preventer
b) production tree
c) landing base
d) tubing hanger

38. A ____________ is bolted to the top of the landing base after the casing has been run and cemented.
a) casing spool
b) lockdown screw
c) back pressure valve
d) tubing hanger

39. The ___________ uses heavy duty valves to control the flow of oil or gas out of the well.
    a) casing spool
    b) tubing hanger
    c) landing base
    d) production tree (X-mass tree)

40. The casing needs to be ___________ before the landing base can be installed.
    a) removed
    b) cut
    c) painted
    d) filled

41. The ___________ must be removed from the landing base before the casing spool can be installed.
    a) welds
    b) casing
    c) BOP
    d) flange

14. DIRECTIONAL DRILLING

14.1 DEFINITION

Directional drilling can generally be defined as the science of directing a wellbore along a predetermined trajectory to intersect a designated subsurface target.

14.2 APPLICATIONS

14.2.1 Multiple wells from offshore structures

The most common application of directional drilling techniques is in offshore drilling. Many oil and gas deposits are situated well beyond the reach of land-based rigs. Drilling a large number of vertical wells from individual platforms is both impractical and uneconomical. The obvious approach for a large oilfield is to install a fixed platform on the seabed, from which many directional boreholes can be drilled. The bottom hole locations of these wells are carefully spaced for optimum recovery.

In conventional development, wells cannot be drilled until the platform has been constructed and installed. This can mean a delay of several years before production begins. Such delay scan be considerably reduced by predrilling some of the wells through a subsea template while the platform is being constructed. These wells are directionally drilled from a semisubmersible rig and tied back to the platform once it has been installed.

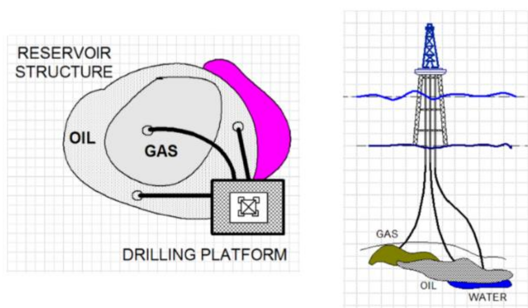


Figure 163 Multiple wells from offshore structures

14.2.2 Relief Wells

Directional techniques are used to drill relief wells in order to “kill” blowouts Relief wells are deviated to pass as close as possible to the uncontrolled well. Heavy mud is pumped into the reservoir to overcome the pressure and bring the wild well under control.

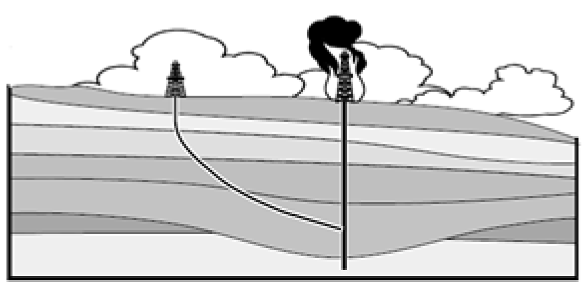


Figure 164 Relief Well

14.2.3 Controlling Vertical Wells

Directional techniques are used to “straighten crooked holes”. When deviation occurs in a well which is supposed to be vertical, various techniques can be used to bring the well back to vertical. This was one of the earliest applications of directional drilling.

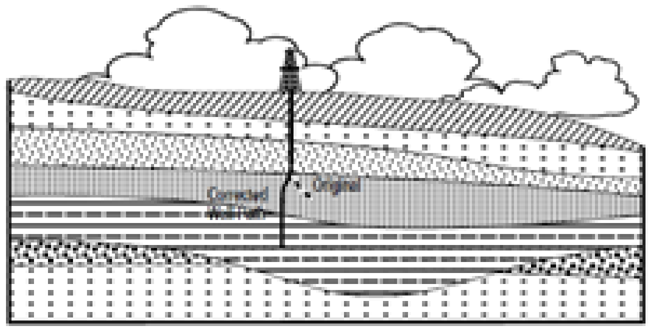


Figure 165 Controlling Vertical Wells

14.2.4 Sidetracking

Sidetracking out of an existing wellbore is another application of directional drilling. This is done to bypass an obstruction (“fish”) in the original wellbore, to explore the extent of a producing zone in a certain sector of a field, or to sidetrack a dry hole to a more promising target Wells are also sidetracked to access more reservoir by drilling a horizontal hole section from the existing well bore.

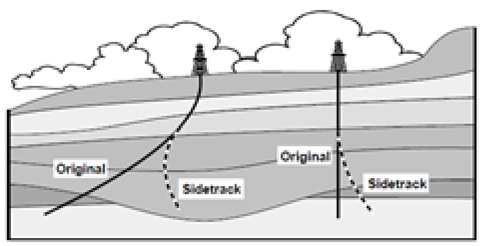


Figure 166 Side Tracking

14.2.5 Sidetracking Into Multiple Sands From A Single Wellbore

A very profitable application of directional drilling pertains to the intersection of multiple sands from a single wellbore.

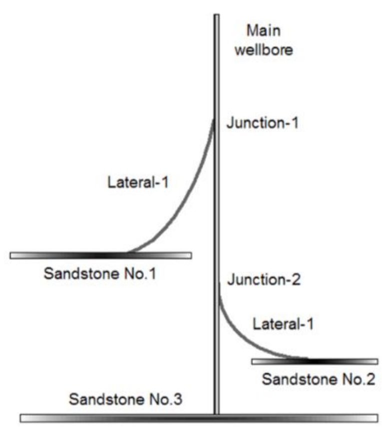


Figure 167 Accessing multiple sands with side track laterals from a main wellbore

14.2.6 Inaccessible locations

Directional wells are often drilled because the surface location directly above the reservoir is inaccessible, either because of natural or man-made obstacles

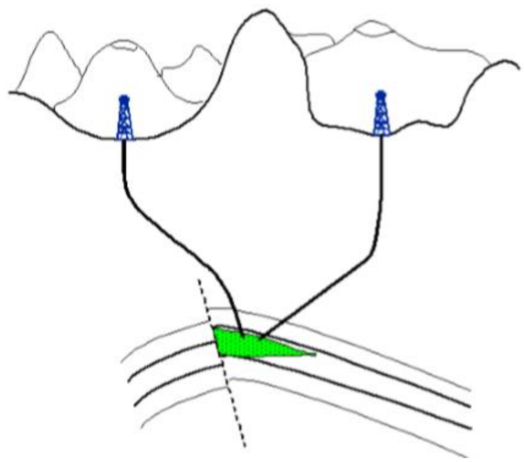


Figure 168 Drilling directional wells beneath natural surface obstructions

14.2.7 Fault Drilling

Directional wells are also drilled to avoid drilling a vertical well through a steeply inclined fault plane which could slip and shear the casing.

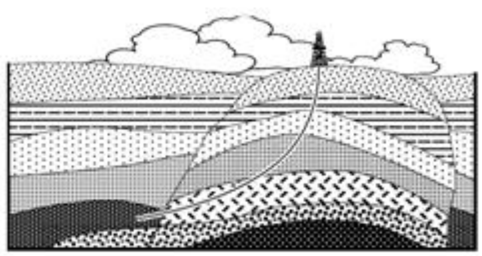


Figure 169 Fault Drilling

14.2.8 Salt Dome Drilling

Directional drilling programs are sometimes used to overcome the problems of drilling near salt domes. Instead of drilling through the salt, the well is drilled at one side of the dome and is then deviated around and underneath the overhanging cap.

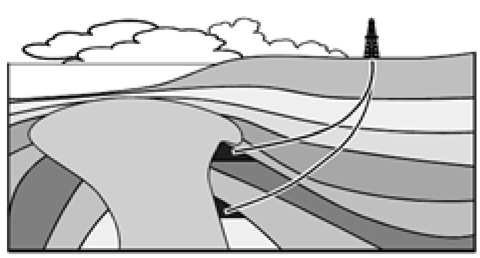


Figure 170 Salt Dome Drilling

14.2.9 Shoreline Drilling

In the case where a reservoir lies offshore but quite close to land, the most economical way to exploit the reservoir may be to drill directional wells from a land rig on the coast.

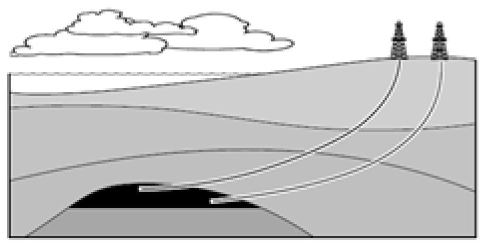


Figure 171 Shore Drilling

These are only some of the many applications of directional drilling. Although it is not a new concept, one type of directional drilling, horizontal drilling, is the fastest growing branch of drilling, with major advances occurring in tools and techniques. As with directional drilling, there are numerous specific applications for horizontal drilling.

14.3 EQUIPMENT

14.3.1 Downhole Motors

The downhole motors turn the bit without needing to turn the entire drill string. However not rotating the entire drill string has certain disadvantages (hole cleaning, differential sticking). The technology, called rotary steerable systems (RSS) is superior to the old system as it allows steering while rotating the entire drill string.

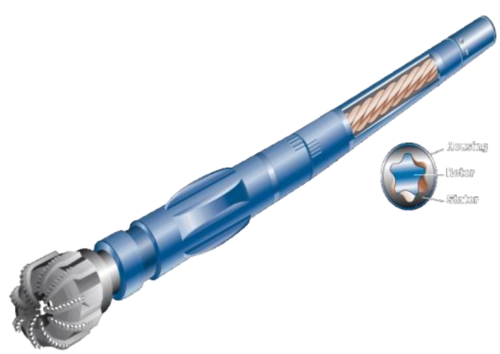


Figure 172 Downhole Motor (Schlumberger Power Pack)

14.3.2 Stabilizers

Stabilized BHA can be designed to build, hold or drop inclination.

Figure 173 Stabilized BHA for directional drilling

14.3.3 Bend Sub

The direction where the bends are pointing is called toolface direction (TF). The bent sub is used on top of a straight mud motor or straight turbine to initiate deviation.

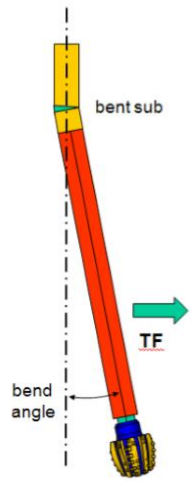


Figure 174 Bent Sub to initiate directional drilling

14.3.4 Whipstock

Whipstock is also used to start deviation in a vertical hole or to side track from the well just in case if pipe is left in the hole.

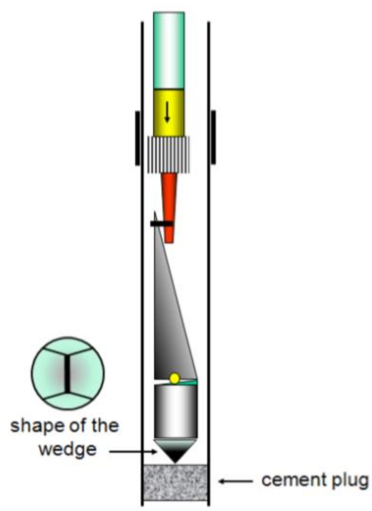


Figure 175 Whipstock to initiate directional drilling

14.4 SURVEYING

The direction and angle of the drilled hole have to be measured by proper tools. This process is called surveying. The tools used for this purpose are called the survey tools.

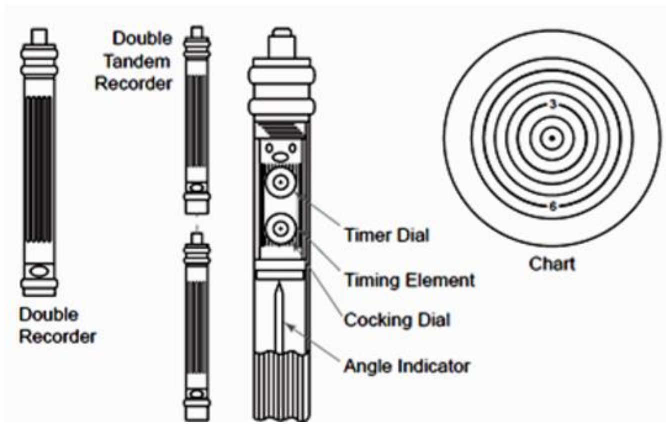


Figure 176 TOTCO inclinometer (The device to measure the hole inclination)

14.4.1 MWD

The evaluation of physical properties, usually including pressure, temperature and wellbore trajectory in three-dimensional space, while extending a wellbore. 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. Data transmission methods vary from company to company, but usually involve digitally encoding data and transmitting to the surface as pressure pulses in the mud system. These pressures may be positive, negative or continuous sine waves. 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. MWD tools that measure formation parameters (resistivity, porosity, sonic velocity, gamma ray) are referred to as logging-while-drilling (LWD) tools. LWD tools use similar data storage and transmission systems, with some having more solid-state memory to provide higher resolution logs after the tool is tripped out than is possible with the relatively low bandwidth, mud-pulse data transmission system

14.4.2 LWD

Logging While Drilling is a fairly recent technology in directional drilling and formation evaluation. It allows simultaneous surveying while drilling.

LWD has following benefits:

- It allows to determine formation tops
- It also allows to drill tjhru the productive sections of the reservoir

There are many tools available depending on what you want to measure, such as: resistivity surveying, porosity surveying, etc.

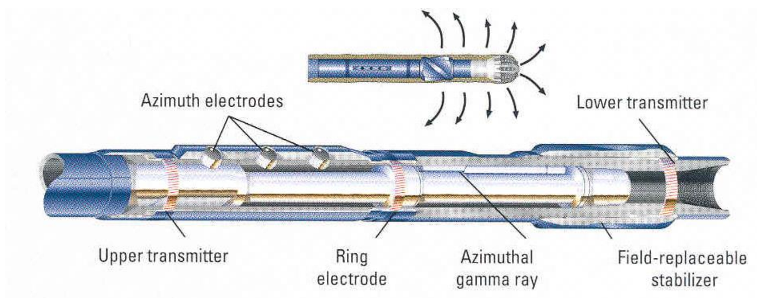


Figure 177 LWD with GR and Resistivity Sondes

15. SLICKLINE AND WIRELINE

In the oil and gas industry, the term wireline usually refers to a cabling technology used by operators of oil and gas wells to lower equipment or measurement devices into the well for the purposes of well intervention, reservoir evaluation, and pipe recovery.

Tools inserted into the well for both workover and logging efforts, wirelines and slicklines are very similar devices. While a slickline is a thin cable introduced into a well to deliver and retrieve tools downhole, a wireline is an electrical cable used to lower tools into and transmit data about the conditions of the wellbore called wireline logs. Usually consisting of braided cables, wirelines are used to perform wireline logging, as well.

15.1 SLICKLINE

Used to place and recover wellbore equipment, such as plugs, gauges and valves, slicklines are single-strand non-electric cables lowered into oil and gas wells from the surface. Slicklines can also be used to adjust valves and sleeves located downhole, as well as repair tubing within the wellbore.

Wrapped around a drum on the back of a truck, the slickline is raised and lowered in the well by reeling in and out the wire hydraulically.

On the other hand, wirelines are electric cables that transmit data about the well. Consisting of single strands or multi-strands, the wireline is used for both well intervention and formation evaluation operations. In other words, wirelines are useful in gathering data about the well in logging activities, as well as in workover jobs that require data transmittal.

Figure 178 Slick line Truck

15.2 WIRELINE LOGGING

Well logging, also known as borehole logging is the practice of making a detailed record (a well log) of the geologic formations penetrated by a borehole. The log may be based either on visual inspection of samples brought to the surface (geological logs) or on physical measurements made by instruments lowered into the hole (geophysical logs). Some types of geophysical well logs can be done during any phase of a well's history: drilling, completing, producing, or abandoning. Well logging is performed in boreholes drilled for the oil and gas, groundwater, mineral and geothermal exploration, as well as part of environmental and geotechnical studies..

A sample log track and logging tools of various kinds are given below

Figure 179 Logging Truck

15.3 WELL LOGGING METHODS

The logging tool, also called a sonde, is located at the bottom of the wireline. They are brought to the site with a dedicated company truck.

The measurements are taken by lowering the wireline to the prescribed depth and then raising it out of the well. The measurements are taken continuously on the way up, in an effort to sustain tension on the line.

- Spontaneous potential
- Gamma Ray
- Resistivity
- Density
- Sonic
- Caliper

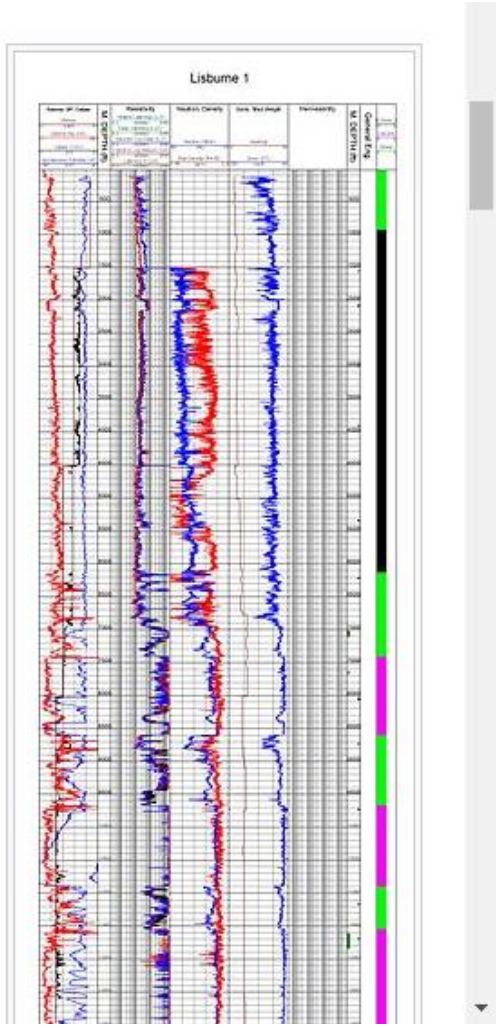


Figure 180 A Sample Log

Figure 181 Logging tools (sonde) of various type

16. COILED TUBING

16.1 OVERVIEW

In the oil and gas industries, coiled tubing refers to a very long metal pipe, normally 1 to 3.25 in (25 to 83 mm) in diameter which is supplied spooled on a large reel. It is used for interventions in oil and gas wells and sometimes as production tubing in depleted gas wells. Coil tubing has also been used as a cheaper version of work-over operations. Coiled tubing is often used to carry out operations similar to wire lining.

The main benefits over wireline are the ability to pump chemicals through the coil and the ability to push it into the hole rather than relying on gravity.

The tool string at the bottom of the coil is often called the bottom hole assembly (BHA). It can range from something as simple as a jetting nozzle, for jobs involving pumping chemicals or cement through the coil, to a larger string of logging tools, depending on the operations.

Coil tubing can perform almost any operation for oil well operations if used correctly.

16.2 APPLICATIONS

16.2.1 Circulation

The most typical use for CT is circulation. By running coiled tubing into the bottom of the hole and pumping in the gas, the kill fluid can be forced out to production. Circulating can also be used to clean out light debris, which may have accumulated in the hole.

16.2.2 Pumping

In many cases, the use of coiled tubing to deploy a complex pump can greatly reduce the cost of deployment by eliminating the number of units on site during the deploy.

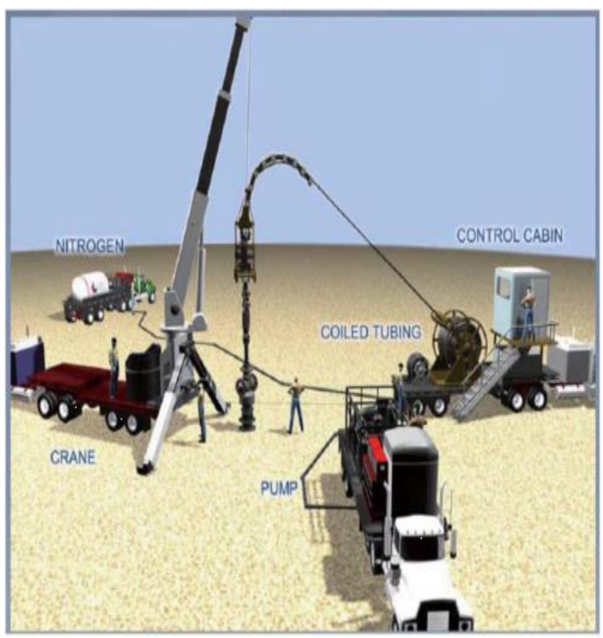


Figure 182 CT Pumping and Circulation Application

16.2.3 Coiled Tubing Drilling

A relatively modern drilling technique involves using coiled tubing instead of conventional drill pipe. This has the advantage of requiring less effort to trip in and out of the well (the coil can simply be run in and pulled out while drill pipe must be assembled and dismantled joint by joint while tripping in and out).

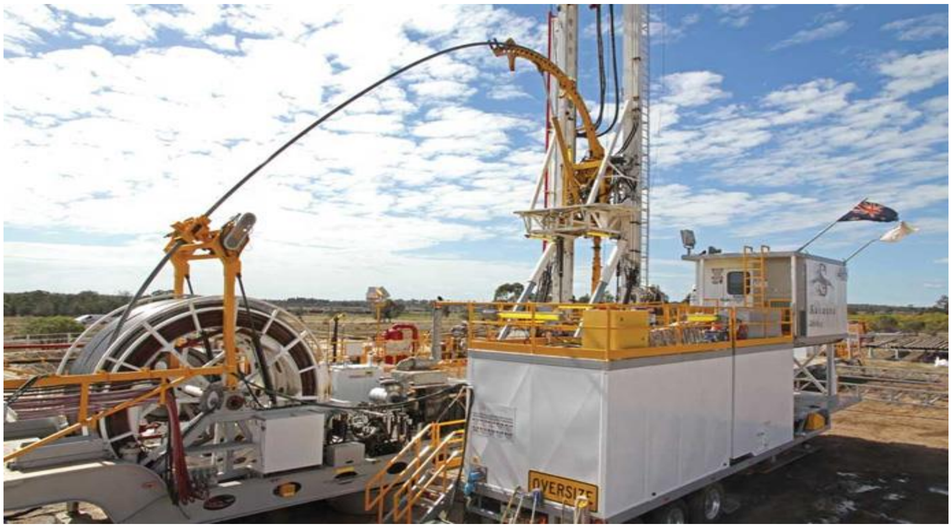


Figure 183 CT Drilling Unit

16.2.4 Logging and perforating

These tasks are by default the area of wire line. Because CT is rigid, it can be pushed into the well from the surface. This is an advantage over wire line.

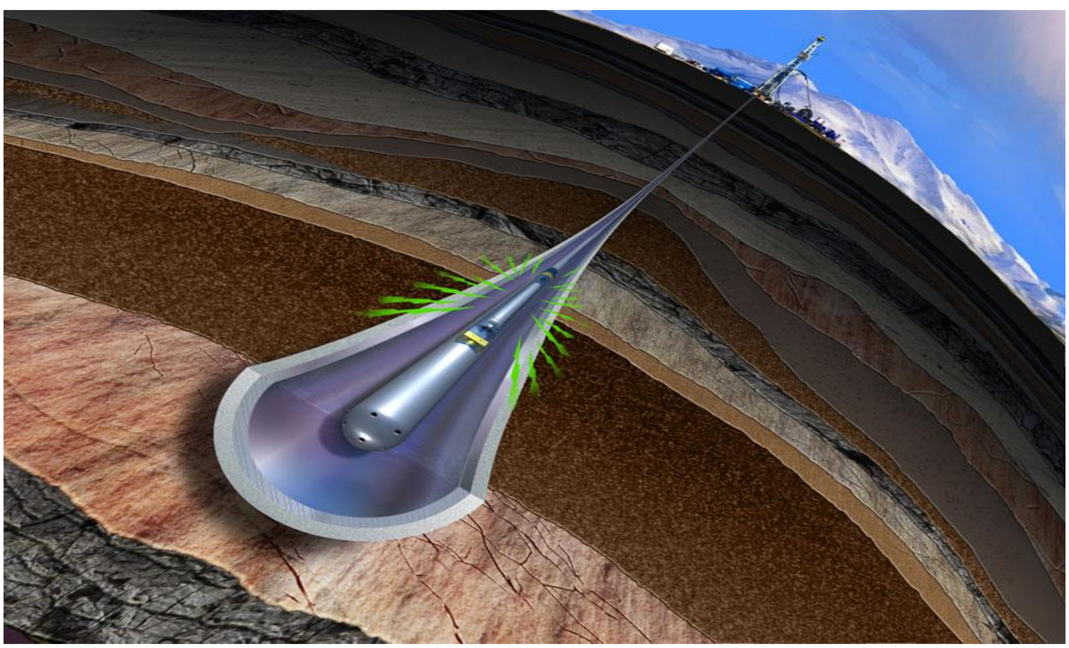


Figure 184 CT Logging and perforation

16.2.5 Production

CT is often used as a production string in shallow gas wells that produce some water. The narrow internal diameter results in a much higher velocity than would occur inside conventional tubing or inside the casing. This higher velocity assists in lifting liquids to surface.

Figure 185 CT Unit

16.3 MAIN PARTS OF A CT SYSTEM

The basic components of a coiled tubing unit are as follows:

1- Tubing Injector Assembly.

2- Tubing Guide Arch

3- Service Reel.

4- Power Supply / Prime Mover.

5- Control Console and Monitoring Equipment.

6- Well Control Equipment.

Figure 186 Main parts of CT System

16.3.1 Tubing Injector Assembly

The injector assembly is designed to control the rate of lowering the tubing into the well under various well conditions.

Figure 187 Tubing Injector Assembly

16.3.2 Tubing Guide Arch

The tubing arch supports the tubing through the 90 °bending radius and guides the C.T. from the reel into the injector chains.

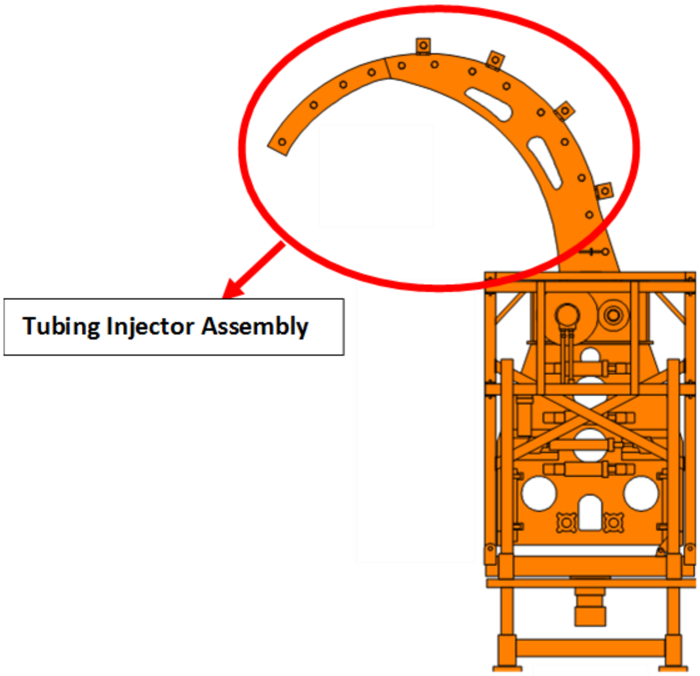


Figure 188 Tubing Guide Arch

16.3.3 Service Reel

The services reel serves as the C.T. storage mechanism during transport and as the spooling device during C.T. operations.
The rotation of the service reel is controlled by a hydraulic motor.

Figure 189 Service Reel

16.3.4 Power Supply / Prime Mover.

the prime mover packages are equipped with diesel engines and multi-stage hydraulic pumps which are typically rated for pressures of 3,000 psig to 5,000 psig. And in addition, the accumulator package for well control equipment.

The basic functions of the CTU power pack and control cabin is providing hydraulic power required by the CTU (engine and hydraulic pumps)

Figure 190 Service Reel

16.3.5 Control Console and Monitoring Equipment.

The control unit contains all of the necessary controls for operating a coiled tubing unit from this location. Typically, a control unit is located behind a coiled tubing reel.

Figure 191 Control Console and Monitoring Equipment

16.4 <u>Well Control Equipment</u>

In order to safely operate in a live well, coiled tubing units must have pressure control systems in place for well control.

Figure 192 Well Control

16.5 SUMMARY

Coil tubing has also been used as a cheaper version of work-over operations. It is used to perform open hole drilling and milling operations.

Common coiled tubing steels have yield strengths ranging from 55,000 PSI to 120,000 PSI so it can also be used to fracture the reservoir, a process where fluid is pressurised to thousands of psi on a specific point in a well to break the rock apart and allow the flow of product.

Coil tubing can perform almost any operation for oil well operations if used correctly.

17. WELL COMPLETION

17.1 DEFINITION

Completion is the process of making a well ready for production (or injection). This principally involves preparing the bottom of the hole to the required specifications, running in the production tubing and its associated down hole tools as well as perforating and stimulating as required.

17.2 How Does Well Completion Work?

Well completion incorporates the steps taken to transform a drilled well into a producing one. These steps include casing, cementing, perforating, gravel packing and installing a production tree.

A typical well completion includes the following subcomponents:

- A wellhead assembly which seals and controls well pressure and flows at the surface (valves, spools and flanges).
- A casing and tubing arrangement to provide zonal isolation and allow fluids to flow from the producing zone to the surface.
- A bottom-hole completion assembly which seals and provides control over the producing zone.

17.3 COMPLETION TYPES

17.3.1 Open hole

This designation refers to a range of completions where no casing or liner is cemented in place across the production zone. In competent formations, the zone might be left entirely bare.

Open hole completions have become increasingly popular in recent years, and there are many configurations.

17.3.2 Liner

In this case the casing is set above the primary zone. An un-cemented screen and liner assembly is installed across the producing zone. It also makes cleanout easy. Perforating expense is also low to non-existent. (

B).

17.3.3 Cased Hole

This involves running casing or a liner down through the production zone, and cementing it in place. Connection between the well bore and the formation is made by perforating. Because perforation intervals can be precisely positioned, this type of completion affords good control of fluid flow (

C).

Before running a completion assembly inside of the casings has to be scraped and cleaned out. The 9-5/8” and 7” scrapers are used to scrape any scale, cement or dirt adhering to the casing. The polish mill is used to polish the bore of the tie back receptacle of the 7” liner hanger. The magnet is run to pick up any metal debris in the mud.

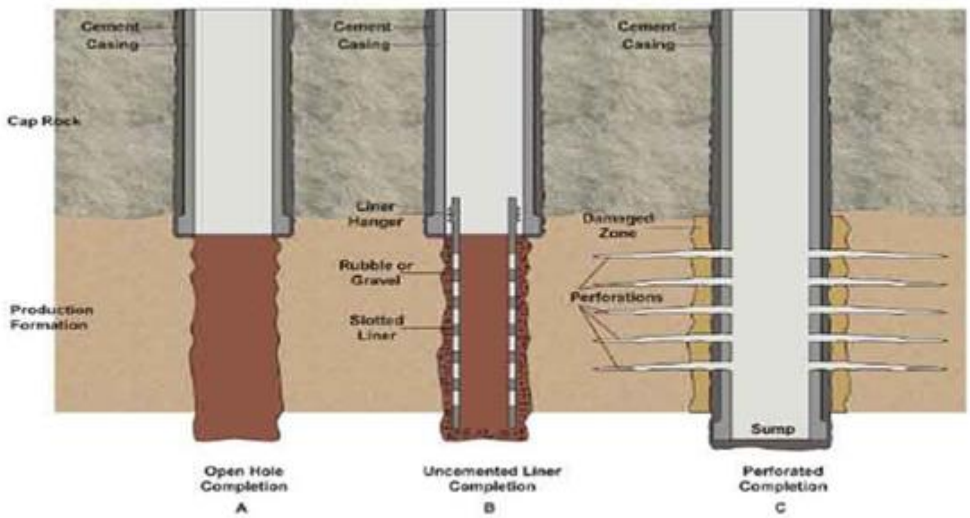


Figure 193 Types of completions

17.4 PRODUCTION EQUIPMENT

17.4.1 PRODUCTION TUBING

When selecting production tubing, the following data has to be specified:

1. The grade of steel selected for the manufacture of the tubing ,e.g. N80 , L-8o etc . Will be dependent on a number of factors such as the strength requirements for the string and, the possible presence of corrosive components such as CO_2 or H_2S.

2. The wall thickness of the tubing has to be specified based on the difference between internal and external pressures.

3. The threaded coupling is an important part of the design specification as it defines both the tensile strength and the hydraulic integrity of the completion string, threads commonly selected for production tubing are EUE , VAM , VAM-TOB etc.

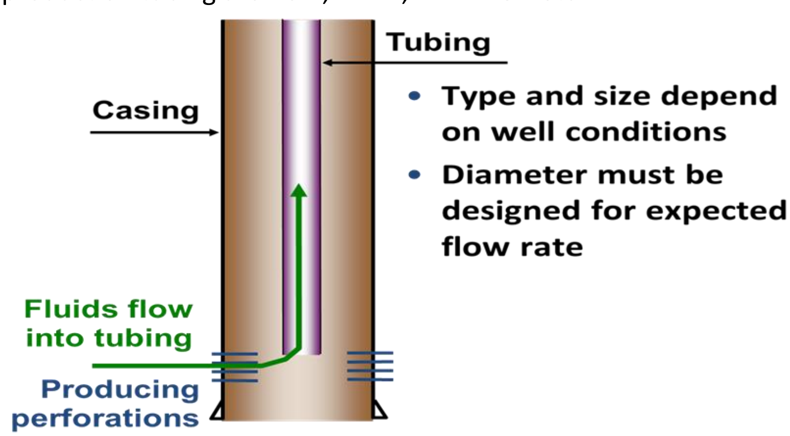


Figure 194 Production tubing

17.4.2 PRODUCTION PACKER

The function of the production PKR is to seal the flow in the tubing/CSG annuals, and use for one of the following reasons:

1. To improve flow stability and production control

2. To provide the facility to select or isolate various zones during stimulation or production, e.g. to isolate two producing zones having different fluid properties, GOR, pressure or permeability (especially relevant for injection) or to stimulate or pressure maintenance.

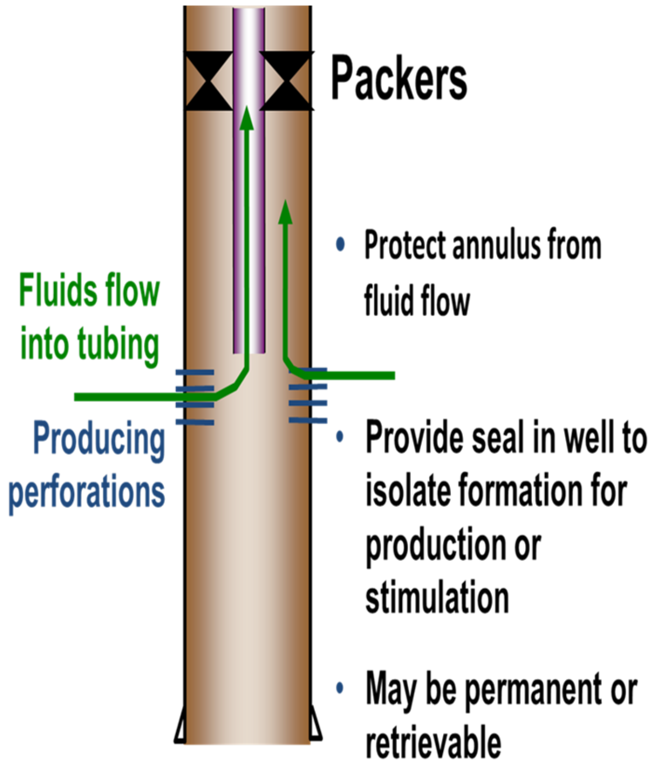


Figure 195 Production Packer

17.5 Horizontal well Completion

The completion that can be run through a given radius of curvature will depend on :-

- the radial clearance between the completion item and hole(liner size).
- the length and flexibility of the completion.
- the rating of the connection

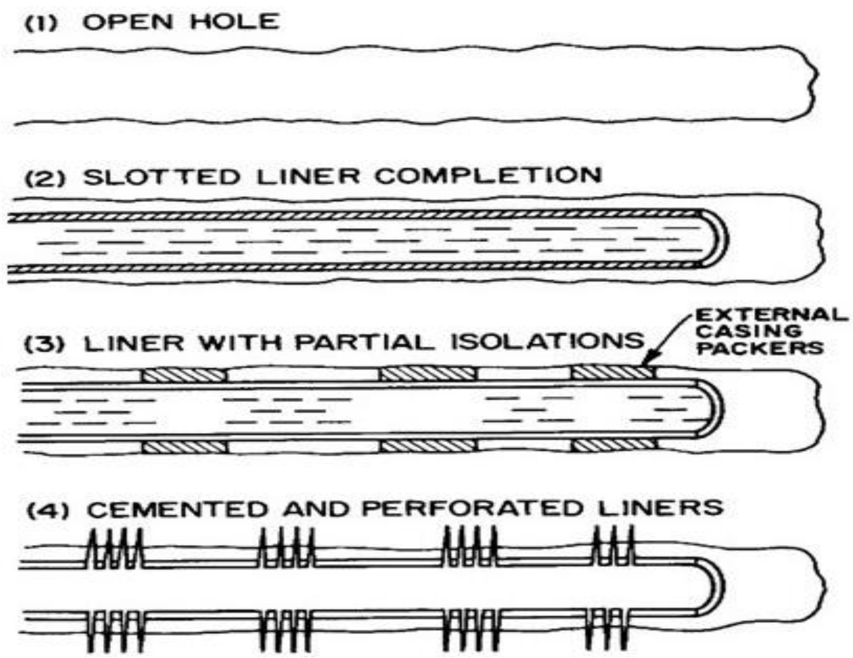


Figure 196 Horizontal well completion

17.6 Multilateral well Completion type

A multilateral well is a well with two or more laterals (horizontal, vertical, or deviated) drilled from a main mother well.

This allows one well to produce from several reservoirs. Multilateral wells are suitable for complex geology where drilling more new wells to penetrate to those reservoirs is not economical. Lateral sections may be used to produce from a separated section in depleted, faulted, layered and heavy oil reservoirs.

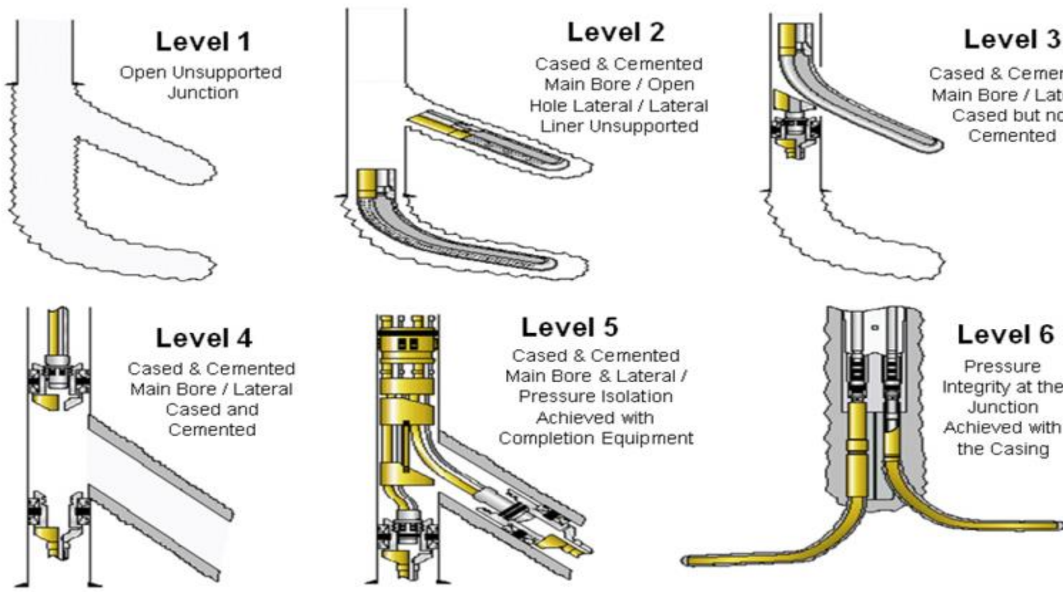


Figure 197 Multilateral well completion types

17.7 SUMMARY

Oil and Gas well drilling from spud to TD involves in a number of common operations. As some of these operations are being performed by drilling contractors, some others are being performed by different service companies. There is a logical sequence for these operations.

The rig personnel are expected to:

- be familiar with common drilling operations;
- be familiar with all the preparation procedures for the upcoming operation;
- know the sequence of the operations and understand the need for them and
- know what tools and equipment are being used to perform them.

18. DRILLING INDUSTRY PERSONNEL AND CAREER PROGRESSION

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. The rig requires specialized people to help manage and operate the various systems found on the rig. Key personnel on the rig include:

18.1 OPERATOR COMPANY JOB PROFILE

18.1.1 Rig Foreman (Company man)

Description

- ❖ The rig foreman is in charge of the rig with a great understanding of the drilling process and provides the rig with the drilling program.

Job duties

- ❖ Responsible for the well and all operations on the location.
- ❖ Will organize the casing, equipment and other services to support the drilling operations.
- ❖ Makes decisions based on his experience, training and office support.
- ❖ Gives instructions to the drill crew on drilling the well. If there is a problem with the well, he gives instructions to fix the problem.

18.1.2 Assistant Rig Foreman (if available)

Description

- ❖ The assistant rig foreman is usually less experienced than the rig foreman. He is a rig foreman in training.

Job duties

- ❖ He has the same responsibilities as the rig foreman, but he usually works on the night-shift.

18.2 DRILLING CONTRACTOR JOB PROFILES

18.2.1 Roustabout

Description:

- ❖ Perform general labor and maintenance on the rig site

Job duties:

- ❖ Clean, scrape and paint the deck, equipment and work areas
- ❖ Offload supplies from trucks and move them to storage areas
- ❖ Mix and condition the drilling mud
- ❖ Walk continually and stand for several hours in a day regardless of weather conditions
- ❖ Handle tools with sharp edges and supplies that may contain hazardous materials

18.2.2 Floorman/Roughneck

Description

- ❖ Work on the rig floor to execute duties required for the drilling operation being carried out

Job duties

- ❖ Handle tubular and drill tools using drill floor equipment
- ❖ Assist the well operator in rigging up and rigging down
- ❖ Pull/lay down rods, tubing, casing, and other functions
- ❖ Clean and maintain the drilling equipment and clean the drilling area on the rig floor
- ❖ Work the derrick if/when needed
- ❖ Set up, maintain, disassemble and transport equipment
- ❖ Move and transfer pipes and drill stems

18.2.3 Derrickman

Description

- ❖ Work above the rig floor, guiding tubing, instruments and tools in and out of the well

Job duties

- ❖ Load and unload boats and trucks safely
- ❖ Perform routine maintenance on rig floor and handle tubular goods
- ❖ Operate and maintain solids control equipment
- ❖ Perform maintenance and fluid repairs on mud pumps
- ❖ Perform pump house operation and assist in repairing and maintaining it
- ❖ Under supervision, perform minor electrical work, heavy carpentry, metal cutting, pipe fitting and machine maintenance
- ❖ Service BOP
- ❖ Work the derrick

18.2.4 Assistant Driller

Description

- ❖ Support the driller's duties when necessary

Job duties

- ❖ Monitor the repair of high pressure pumps and associated valves
- ❖ Inspect safety equipment related to the derrick and mixing drilling fluids and chemicals
- ❖ Monitor mud properties and perform calculations, and recognize warning signs of kicks
- ❖ Understand BOP equipments in nippling them up and down
- ❖ Perform as a driller when required and inform driller on needed operating supplies

18.2.5 Driller

Description

- ❖ Responsible for operations during the drilling process

Job duties

- ❖ Supervise the repair of pressure pump associated with valve aligned mud systems
- ❖ Inspect all safety equipment
- ❖ Monitor mud properties and perform calculations to recognize warning signs of kicks
- ❖ Identify priorities of work, direct and coordinate crew members and storage of hand and power tools

18.2.6 Tool pusher

Description

- ❖ Managing the entire rig crew and all mechanical operational systems

Job duties

- ❖ Assist in operation and maintenance of rotatory oil well
- ❖ Perform managerial functions common to the segment level
- ❖ Provides leadership, plan and coordinate overall logistics for rig operations
- ❖ Arrange representative of necessary service organization to be available to perform jobs
- ❖ Follow accident report procedures

18.2.7 Mud Engineer

Description

- ❖ The mud engineer is in charge of the drilling fluid on the rig and in the hole.

Job duties

- ❖ Coordinates with the rig foreman to plan a recipe of mud to drill the well.
- ❖ Orders all the chemicals required for the mud.
- ❖ Directs the rig man or derrick man to which chemicals to mix into the mud system.
- ❖ Regularly tests the mud to determine whether additional chemicals are needed to be added.

18.2.8 Barge Engineer (offshore rigs)

Description

- ❖ Responsible for all mechanical and operational systems

Job duties

- ❖ Direct mechanics and electricians to operate and maintain systems
- ❖ Maintain and operate jacking system (where applicable)
- ❖ Assist rig move master during rig moves
- ❖ Perform load calculations, and supervise loading and offloading of materials
- ❖ Maintain equipment inventory
- ❖ Supervise deck crew performing all operations

18.2.9 Rig Mechanic

Description

- ❖ Daily inspection and maintenance to any mechanical equipment on board

Job duties

- ❖ Assess condition of mechanical components, maintain records and schedule preventative maintenance.
- ❖ Diagnose and supervise repairs.
- ❖ Conduct safety and housekeeping checks.
- ❖ Advise tool pusher and crew members on proper care of equipment
- ❖ Closely supervise training activities and evaluate performance
- ❖ Initiate spare parts and third-party repair requests

18.2.10 Mechanic helper

Description

- ❖ Assist mechanic duties and conduct maintenance as necessary

Requirements upon entry

- ❖ 2 years of training and experience in mechanical field
- ❖ High school diploma

Job duties

- ❖ Shadow the mechanic for maintenance inspection and making daily reports
- ❖ Perform the general maintenance and overhaul of equipment as needed for repair or in accordance with preventative maintenance
- ❖ Assist the Mechanic with the maintenance, repairs and installation of all rig associated mechanical equipment

Job competencies

- ❖ Ability to work under supervision of and understand how to repair diesel and gasoline engines
- ❖ Proficient knowledge in how purchase orders and storage of equipment and supplies are done
- ❖ Proficiency in performing equipment inspection, maintenance and tests
- ❖ Ability to understand drawing or sketches on equipment needing repairs

18.2.11 Rig Electrician

Description

- Daily inspection and maintenance to any electrical equipment on board

Job duties

- Teach, train and supervise electrical maintenance staff
- Liaise with Rig foreman, tool pusher, barge captain, mechanic and drill crew
- Perform inspections, preventative maintenance and troubleshooting repairs
- Complete on-site work permits and pre- and post-job checks
- Order material and supplies
- Complete all required reporting and distribution

18.2.12 Electrician Helper

Description

- Assist electrician duties and conduct maintenance as necessary

Job duties

- Shadow the electrician for maintenance inspection and making daily reports
- Ensure that all electrical systems and related equipment are maintained, serviced, tested, and installed in accordance with the applicable rules and regulations
- Assist the Electrician with the installation, maintenance and repairs of all rig associated electrical equipment

18.2.13 Crane operator

Description

- Operate crane activities supporting the rig setup, drilling and rig down operations

Job duties

- Perform daily crane inspection and maintenance
- Operate crane including unloading and loading within safe working limits
- Attend to all housekeeping functions assigned to crane
- Assist in on the job training of other operators
- Provide and log lift plan for critical, Tandem, or pick and carry lifts

18.2.14 Rig Welder

Description

- Support maintenance activities requiring welding

Job duties

- Join or cut metals in beams, girders, vessels, piping and other metal components
- Select type and size of pipe, and other equipment according to specifications
- Operate manual and semiautomatic welding equipment to trouble shoot, repair and manufacture equipment
- Install, assemble, fabricate, maintain and repair mechanical piping systems
- Ability to know which welding process is best used on various pipes and metal sheets and other raw material

18.2.15 Safety Advisor

Description

- Responsible for execution and compliance of all drilling safety standards

Job duties

- Plan and facilitate weekly HSE meetings
- Communicate all safety alerts with crew members
- Ensure all incidents are reported in a timely manner
- Coordinate on-site inspections to audit work conditions
- Mitigate hazardous conditions as required

18.3 SERVICE COMPANY JOB PROFILES

These people visit drilling rigs from time to time to perform a specific task or operation. They are not the permeant members of the rig. They leave the rig upon successfully completing their assigned tasks.

18.3.1 Wireline Junior Operator

Description

- Assist and help operators with all wireline operations and equipment

Job duties

- Rig up and down all wireline equipment under supervision
- Redress, clean and maintain all various wireline related tools and equipment
- Assist driving trucks and cranes on loading and unloading wireline unit
- Assist in the wireline lab/workshop
- Assist in the repair and maintenance of equipment
- Assist in assembly and preparation of equipment for installation and service
- Assist in the running of a job and in the clean-up, repair, and preparation for the next job

18.3.2 Wireline Operator

Description

- Rig-up and rig-down wireline logging equipment on work locations for the purpose of recording information wellbore condition and reservoir formation

Requirements upon entry

- High school diploma
- Relevant years of experience
- Requires entry level drilling education

Job duties

- Assemble different wireline tool strings and perforation guns
- Preparation and calibration of wireline unit and reel
- Run wireline tools
- Provide on-site training to junior operators
- Maintain, clean and perform preventative maintenance on equipment

18.3.3 Slickline Junior Operator

Description

- Assist and help operators with all phases of slickline operations and equipment

Job duties

- Preparation and maintenance of slickline unit and reel
- Rig up and down all slickline equipment under supervision
- Redress, clean and maintain all various equipment and tools
- Assist with pre-job service equipment preparation (assembly, test, mobilization
- Assists with post-job demobilization, clean up and repair of service equipment and products.

18.3.4 Slickline Operator

Description

- Assists the Service Supervisor during all phases of providing slickline services

Job duties

- Assemble different slickline tool strings
- Run the slickline unit tripping in/out the well
- Provide on-site training to junior operators
- Repair/redress well pressure control equipment in preparation for the next job
- Assist with process documentation

18.3.5 Coil Tubing Junior Operator

Description

- Assist and help with all coil tubing operations and equipment

Job duties

- Prepare and maintain coil tubing unit, pump etc.
- Rig up and down all coil tubing equipment under supervision
- Assist driving trucks and cranes
- Perform pre/post job coil tubing equipment inspections
- Perform and complete preventative maintenance procedures
- Maintain support equipment (i.e., pumps, flowback lines etc.)

18.3.6 Coil Tubing Operator

Description

- Assemble different coil tubing tool strings

Job duties

- Assemble and prepare equipment for installation and service
- Maintain general housekeeping, and perform pre/post job coiled tubing equipment inspections
- Responsible for safe crane and rigging operations
- Operate High Pressure fluid pump and coil tubing support equipment (flow back package)
- Perform hydrostatic testing on Blow Out Prevention Equipment (BOPE) and reels
- Mentor and train junior operators

18.3.7 Stimulation Junior Operator

Description

- ❖ Assist and help operators with all stimulation operations and equipment

Job duties

- ❖ Rig up and down all stimulation equipment under supervision
- ❖ Assist driving trucks and cranes
- ❖ Assist in monitoring fluid production and recording all different tank levels
- ❖ Perform pre/post job equipment inspections
- ❖ Perform and complete preventative maintenance procedures
- ❖ Maintain support equipment

18.3.8 Stimulation Operator

Description

- ❖ Responsible for fracture acid fluids quality during the delivery of services

Job duties

- ❖ Prepare and maintain all equipment and pumps
- ❖ Manage and monitor fluid production, recording all different tank levels
- ❖ Provide on-site training to junior operators
- ❖ Complete all required paperwork (Pre-job/Post-job Trip Tickets, load tickets, etc.)

18.3.9 Cementing Junior Operator

Description

- ❖ Assist cementing operator during rigging up and down of cementing service equipment

Job duties

- ❖ Rig up and down all cementing equipment under supervision
- ❖ Assist in the proper performance of pre-trip and post-trip vehicle inspections and associated paperwork/reports

18.3.10 Cementing Operator

Description

- ❖ Operate cement pump and mixing equipment, maintain equipment and machine operations

Job duties

- ❖ Rig up and down cementing service equipment on work locations to include spotting of cement storage vessels, pre-mixing of spacer fluids, identifying additives to be mixed on the-fly, rigging-up appropriate data monitoring equipment, planning emergency backup equipment and contingencies
- ❖ Handle cement bulk and other chemicals
- ❖ Train operator assistants in cement pumping and mixed equipment, blenders, pumps, data systems, and storage systems

18.3.11 Casing/Tubular Junior Operator

Description

- Assist and help operators with all casing and tubular operations and equipment

Job duties

- Rig up and down all handling and power equipment
- Assist in monitoring and maintaining all equipment
- Assist in completing and maintaining logs and job reports during operations
- Assist in carrying out stabber duties (including pipe alignment stabbing, signaling Driller, and operating handling tools)

18.3.12 Casing/Tubular Operator

Description

- Operate casing/tubular handling power equipment

Job duties

- Operate handling tubing running tools and power equipment
- Monitor and maintain all equipment
- Supervise crews and junior operators
- Complete and maintain logs and job reports during operations
- Carry out stabber duties (including pipe alignment stabbing, signaling Driller, and operating handling tools)

18.3.13 Liner Hanger Junior Operator

Description

- Assist with running different liner hangers with various sizes

Job duties

- Assist in monitoring and maintaining tools on rig-site
- Assist with ensuring supplied equipment is compatible with all other equipment used for the job
- Assist with completing all paper work prior to or upon job completion

18.3.14 Liner Hanger Operator

Description

- Run different liner hangers with various sizes

Job duties

- Monitor and maintain liner hanger tools on rig-site
- Ensure supplied equipment is compatible with all other equipment used for the job
- Provide front-line support with customer
- Complete all paper work accurately prior to or upon job completion
- Conduct on the job training for junior operators

18.3.15 Well Testing Junior Operator

Description

- ❖ Under supervision; maintain and oversee all Well Testing equipment during the rig up to ensure the equipment is working properly and safely

Requirements upon entry

- ❖ High school diploma
- ❖ Requires ongoing drilling activity specific training

Job duties

- ❖ Assist during the rig up and rig down of well testing service line equipment
- ❖ Assist during well testing operations
- ❖ Assist in installation of unit or system to be tested

18.3.16 Well Testing Operator

Description

- ❖ Assemble and set up well testing equipment and service unit

Job duties

- ❖ Unload and assemble the equipment to be used, set up the service unit, and initiate the rig up
- ❖ Perform routing readings of equipment during rigging
- ❖ Provide training of well testing equipment to junior operators

---

18.3.17 Completion Tools Junior Operator

Description

- ❖ Assist operator in assembling, preparing, and operating down-hole completion tools

Job duties

- ❖ Assist with pre-job product, service equipment preparation, and mobilization
- ❖ Assist with product installation at the well site
- ❖ Assist with post-job demobilization, clean up, and repair

18.3.18 Completion Tools Operator

Description

- ❖ Assemble, prepare and operate tools down-hole completion

Job duties

- ❖ Install product at the well site
- ❖ Work on post-job demobilization, clean-up, and repair
- ❖ Complete all well site and post-job paperwork

18.3.19 Mud Logging Operator

Description

- Execute and retrieve mud sampling

Job duties

- Perform the collection of cutting samples
- Wash and screen samples
- Assist in core recovery and packaging as required
- Assist in performing regular and frequent calibration checks of instruments
- Assist in routine maintenance of sensors and other equipment
- Assist with rig-up procedures

18.3.20 Workshop Assistant Technician-Mechanic

Description

- Assist mechanic duties and conduct maintenance as necessary

Job duties

- Shadow the mechanic for maintenance inspection and making daily reports
- Perform the general maintenance and overhaul of service line equipment as needed for repair
- Assist the Mechanic with maintenance, repairs, and installation of all service line associated mechanical equipment

18.3.21 Workshop Assistant Technician- Electrician

Description

- Assist electrician duties and conduct maintenance as necessary

Job duties

- Shadow the Electrician for maintenance inspection and making daily reports
- Ensure that all electrical systems related to service line equipment are maintained, serviced, tested, and installed in accordance with the applicable rules and regulations
- Assist the Electrician with the installation, maintenance, and repairs of all service line associated electrical equipment

18.4 RIG ORGANISATION CHART

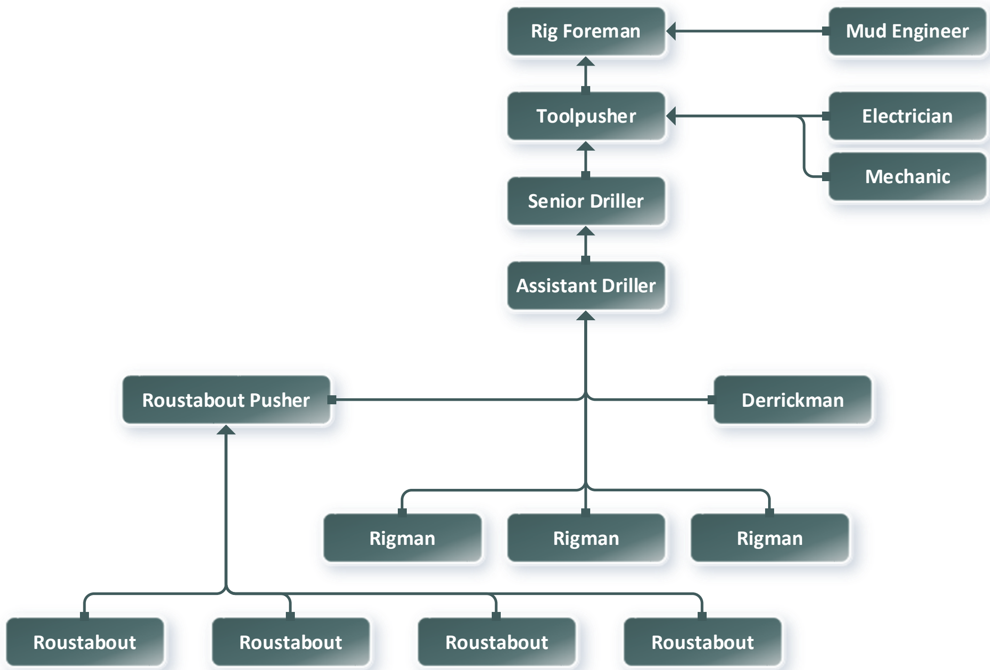


Figure 198 Rig Crew Reporting Structure

The reporting structure for the day shift on a rig is illustrated in the organization chart above. The night shift will have the same personnel, but normally supervised by an assistant rig foreman.

18.5 SUMMARY

Drilling of an oil and gas well is a complicated task that requires a good number of personnel from the operator company, to the drilling contractor and other 3rd party service companies. There are a number of job titles and job descriptions commonly being used. It is very important that rig personnel know the duties and responsibilities under these titles. Presented by the organization chart, the rig personnel have a reporting structure that allows creating an effective working environment as well as slick coordination amongst them.

19. COMMUNICATION SKILLS

There are specific things to do that can improve your communication skills. However please note that communicating effectively is a teachable skill, therefore following a few of the tips outlined below, will enable you to hone up on your communication skills.

19.1 LISTEN, LISTEN, AND LISTEN.

People want to know that they are being heard. Really listen to what the other person is saying, instead of formulating your response. Ask for clarification to avoid misunderstandings. At that moment, the person speaking to you should be the most important person in your life. Another important point is to have one conversation at a time. This means that if you are speaking to someone on the phone, do not respond to an email, or send a text at the same time. The other person will know that she doesn't have your undivided attention.

19.2 WHO YOU ARE TALKING TO MATTERS.

Use proper language at work and avoid slang language.

19.3 BODY LANGUAGE MATTERS.

This is important for face-to-face meetings and video conferencing. Make sure that you appear accessible, so have open body language. This means that you should not cross your arms. And keep eye contact so that the other person knows that you are paying attention.

19.4 ASK QUESTIONS

If you are not sure that you understood, don't be shy of asking questions.

19.5 BE BRIEF, YET SPECIFIC.

For written and verbal communication, practice being brief yet specific and clear, that you provide enough information for the other person to understand what you are trying to say. And if you are responding to an email, make sure that you read the entire email before crafting your response. With enough practice, you will learn not to ramble, or give way too much information.

19.6 WRITE THINGS DOWN.

Take notes while you are talking to another person or when you are in a meeting, and do not rely on your memory. Send a follow-up email to make sure that you understand what was being said during the conversation.

19.7 SOMETIMES IT'S BETTER TO PICK UP THE PHONE.

If you find that you have a lot to say, instead of sending an email, call the person instead. Email is great, but sometimes it is easier to communicate what you have to say verbally.

19.8 THINK BEFORE YOU SPEAK.

Always pause before you speak, not saying the first thing that comes to mind. Take a moment and pay close attention to what you say and how you say it. This one habit will allow you to avoid embarrassments.

19.9 TREAT EVERYONE EQUALLY.

Do not talk down to anyone, treating everyone with respect. Treat others as your equal.

19.10 MAINTAIN A POSITIVE ATTITUDE AND SMILE.

Even when you are speaking on the phone, smile because your positive attitude will shine through and the other person will know it. When you smile often and exude a positive attitude, people will respond positively to you.

19.11 SUMMARIZE

Summarize what you understood. Make sure that you have got the right message.

20. UNIT CONVERSIONS

MULTIPLY	BY	TO OBTAIN
Acre	43,560	square feet
	4,047	square meters
	0.4087	hectacre
Acre foot	7,758	barrels
	43,560	cubic feet
	1,233.49	cubic meters
Atmosphere	33.95	feet of water (39.1°F)
	29.92	inches of mercury (32°F)
	760	millimeters of mercury (32°F)
Barrel (bbl)	158.97	liters
	9,702	cubic inches
	5.6146	cubic feet
	42	gallons
Barrel of water (39.1°F)	349.88	pounds
Barrel (36° API)	0.1342	metric tons
Centimeter	0.3937	inch
Centimeter of Mercury	0.1934	psi
Cubic centimeter (cc)	0.06102	cubic inch
	0.033814	ounce (fluid U.S.)
Cubic foot (cu.ft.)	0.1781	barrel
	7.4805	gallons (U.S.)
	0.02832	cubic meter
	1,728	cubic inches
	28.317	liters
Cubic foot of water (68°F)	62.316	pounds
Cubic inch (cu.in.)	16.387	cubic centimeters
Cubic inch of water (68°F)	0.03606	pound
Cubic meter (cu.m or m^3)	6.2897	barrels
	35.3147	cubic feet
	264.173	gallons (U.S.)
Foot (ft.)	30.48	centimeters
	0.3048	meters
Foot of water (39.1°F)	0.4335	pounds per square inch
	0.88265	inch of mercury (32°F)
Gallon (U.S.)	0.2381	barrel
	0.1337	cubic feet
	231.0000	cubic inches
	3.785	liters
	0.8327	gallon (Imperial)
Gallon of water (68°F)	8.3304	pound

21. GLOSSARY OF DRILLING REPORT ABBREVIATIONS

The following letter abbreviations are commonly found in drilling reports.

ABD, ABND	Abandoned
BFPH	Barrels of fluid per hour
BHA	Bottomhole assembly: includes the bit, stabilizers, drill collars, and other tools used below the drillpipe
BHP	Bottomhole pressure; usually measured with a pressure bomb on wireline
BLD	Bailed; refers to the practice of removing debris from the hole with a cylindrical container on wireline
BO	Barrels of oil
BOP	Blowout preventer(s)
BOPD	Barrels of oil per day
BPH	Barrels per hour
BPD, B/D	Barrels per day
BPV	Backpressure valve; a valve that allows fluid to flow through it in only one direction and therefore will maintain pressure (backpressure) on the downstream side
BU	Bottoms up; when circulation has displaced the mud from the bottom of the hole to the surface
BW	Barrels of water
BWPD	Barrels of water per day
BWPH	Barrels of water per hour
CBL	Cement bond log; an acoustic device for determining the condition of the bond between cement and hole, and cement and casing.
CFG	Cubic feet of gas
CFGPD	Cubic feet of gas per day
CHK	Choke; a restriction in a flowline or system, usually referring to a production choke during a test or to the choke in the well control system
CIRC	Circulate
CMT	Cement
CNL	Compensated neutron log; a radioactivity log for measuring porosity
COMP	Completed

CP	Casing pressure; pressure on the annulus between tubing and casing: this is measured at the surface
CRD	Cored
CSG	Casing
DC	Drill collar
DF	Drill floor or derrick floor
DIL	Dual induction laterolog; an electrical log for measuring resistivity
DP	Drillpipe
DRLG	Drilling
DST	Drillstem test
FDC	Compensated formation density log; a log that uses radioactivity to measure porosity
FP	Flowing pressure; usually refers to flowing tubing pressure
FTP	Flowing tubing pressure; pressure measured at the Christmas tree, while the well is flowing
GCM	Gas cut mud; mud containing quantities of gas from subsurface formations
GIH	Go in hole or going in hole; usually relating to the drillstring, a casing string,or a wireline device that is being lowered into the hole
GL	Ground level
GOR	Gas-oil ratio; ratio of gas to oil production during a test (SCF/bbl or m3/m3)
GR	Gamma ray log; a radioactivity log indicating lithology
HGR	Hanger; a piece of equipment used for hanging casing or tubing at the surface
IES	Induction electrical survey log; an electrical log for measuring resistivity
IP	Initial production; usually describing an initial production test
ISF	Induction spherically focused log; an elec trical log for measuring resistivity
JTS	Joints; as in joints of drillpipe or tubing
KB	Kelly bushing
KBE	Kelly bushing elevation
KO	Kicked off; deviated
KOP	Kick-off point; the depth at which a directional hole is deviated from vertical
L/D	Lay down; as in "lay down drillpipe," meaning that the equipment is placed horizontally on a pipe rack
L/S	Long string; relating to the longest of two or more strings of tubing in a well with a multiple completion; the longest string of casing

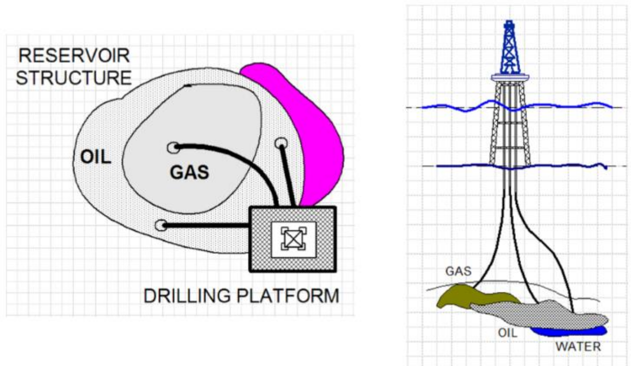
LCM	Lost circulation material; material added to the drilling mud to correct lost circulation by plugging off fractures in the rock
LOC	Location; wellsite
LSE	Lease; refers to the property on which the well is being drilled
M/U	Make up; to assemble parts to form a complete unit; to screw together; to mix or blend
MCF	Thousand cubic feet of gas
MIR	Moving in rig
MIRT	Moving in rotary tools (see MIR)
MOR	Moving out rig
MW	Mud weight; the density of the drilling fluid, usually given in pounds per gallon
N/D	Nipple down; the reverse of nipple up (N/U)
N/U	Nipple up; to bolt together valves or fittings, as in "nipple up BOP stack"
OCM	Oil cut mud; mud containing quantities of oil from subsurface formations
OH	Openhole: interval of hole without casing
P/U	Pick up; as in "pick up drillpipe," meaning that the pipe is picked up and assembled from a horizontal position, rather than having been stacked vertically
P&A	Plug and abandon; to plug the well with cement and remove surface equipment
PBTD	Plug back total depth: the depth of a well after it has been drilled and then partially plugged back to a shallower depth
PERF	Perforate
PKR	Packer: the anchoring and sealing device that blocks off the annular space between tubing and casing
PL	Pipeline
POOH	Pull out of hole; retrieve drillstring, tubing string, or wireline equipment from the hole
POP	Putting on pump: installing a pumping unit on a well
RDRT	Rigging down rotary tools
REC	Recover: usually pertains to an item lost or left in the hole
RFT	Repeat formation tester; electric wireline device for taking samples of formation fluids and pressures from multiple points in the hole
RIH	Running in hole or ran in hole, see GIH
RMG	Reaming: enlarging an under gauged drilled hole a previously drilled hole

RTTS	Retrievable test treat squeeze packer: a retrievable packer designed for use in performing operations in the hole, but not usually left in the well as part of the permanent completion equipment
R/U	Rig up; assemble and prepare for action; relates to the drilling rig itself or any other equipment
S/S	Short string; relating to the shortest of two or more strings of tubing in a well with a multiple completion
SD, SS	Sandstone
SDO	Shut down waiting on orders: waiting for instructions from management before proceeding with any activity
SG	Show of gas: gas in mud or cuttings
SI	Shut in
SIBHP	Shut in bottomhole pressure: bottomhole pressure measured after the well has been shut in for a significant period of time, usually 24 to 48 hrs or more
SICP	Shut-in casing pressure: casing pressure measured when the well is shut in
SIDPP	Shut-in drillpipe pressure; drillpipe pressure measured at the surface with well shut in, usually referred to during kick-killing procedures
SIP	Shut-in pressure: any shut-in rather than flowing pressure
SITP	Shut-in tubing pressure
SLM	Steel line measurement; measured with a steel measuring tape
SP	Self potential log: an electrical log for indicating lithology
SPD	Spudded; began drilling first part of hole
SQ, SQU	Squeeze: as in "cement squeeze," where casing is selectively perforated and cement pumped into the perforations
STDS	Stands: as in "stands of pipe," meaning two or three joint sections stacked in the derrick
SUR, SURV	Survey: usually refers to a magnetic survey done to determine position of hole relative to the surface location
SW	Saltwater
SWBD	Swabbed: refers to the suction of fluids into the well, purposefully or inadvertently
SX	Sacks; as in sacks of cement; one sack of cement produces about 1.2 ft3 (.034 m3) of cement when mixed with water
TBG	Tubing
TD	Total depth
TIH	Trip in hole: to lower into the hole, same as "go in hole"
TOOH	Trip out of hole: opposite of TIH

TOF	Top of fish: relating to the depth of the uppermost part of a section of pipe lost in the hole
TP	Tubing pressure
VIS	Viscosity: usually refers to mud viscosity and is reported in units of "seconds"; obtained from a Marsh funnel test
W/C	Water cushion: water placed in drillpipe during a DST to lessen pressure differential between formation and drillpipe
WC	Wildcat: well drilled in totally unexplored territory
WL, WIL	Wireline
WLM	Wireline measurement; as opposed to a tubing or drillpipe measurement of hole depth
WO/O	Waiting on orders: waiting for instructions from management
WOC	Waiting on cement: time spent waiting for cement to set
WOW	Waiting on weather: time spent waiting for weather conditions to permit operations to continue

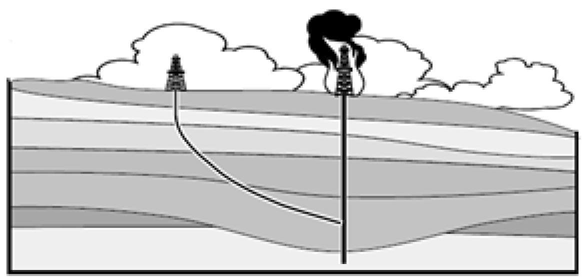
22. EXERCISE SET-III

1. The directional drilling application in the figure below is which one of the followings?



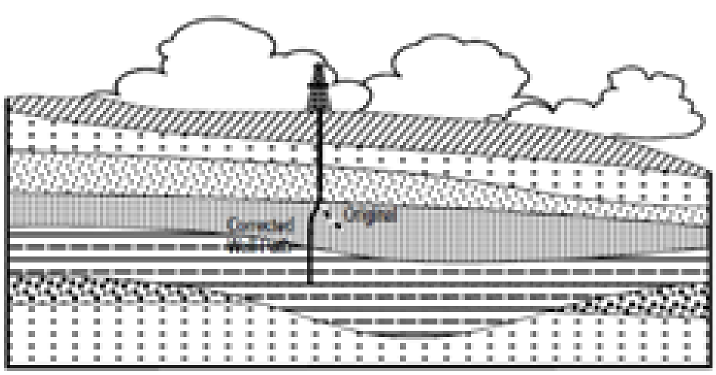
   d) Relief wells
   e) Controlling vertical wells
   f) Side tracking
   g) Multiple wells from offshore structures

2. The directional drilling application in the figure below is which one of the followings?



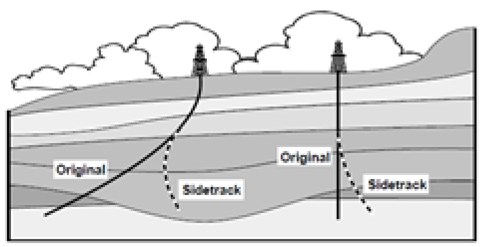
   a) Relief wells
   b) Controlling vertical wells
   c) Side tracking
   d) Multiple wells from offshore structures

3. The directional drilling application in the figure below is which one of the followings?



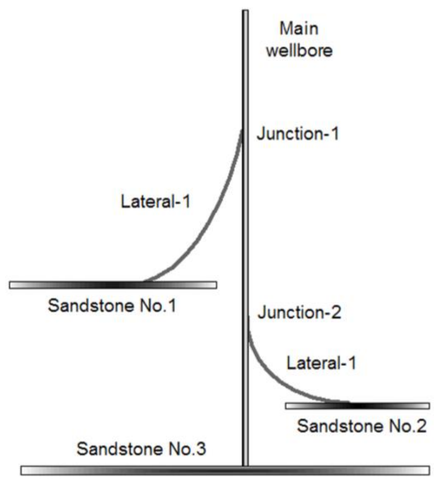
d) Relief wells
e) Controlling vertical wells
f) Side tracking
g) Multiple wells from offshore structures

4. The directional drilling application in the figure below is which one of the followings?



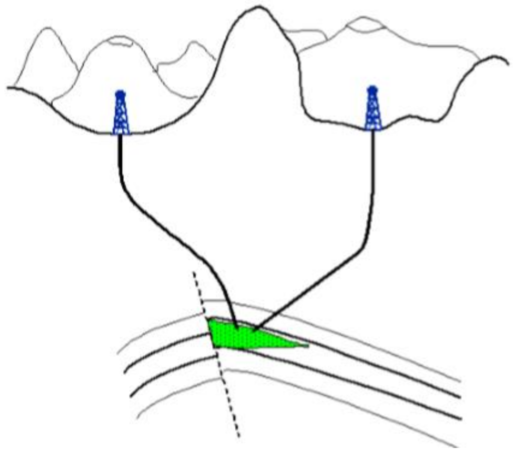
e) Relief wells
f) Controlling vertical wells
g) Multiple wells from offshore structures
h) Side tracking

5. The directional drilling application in the figure below is which one of the followings?



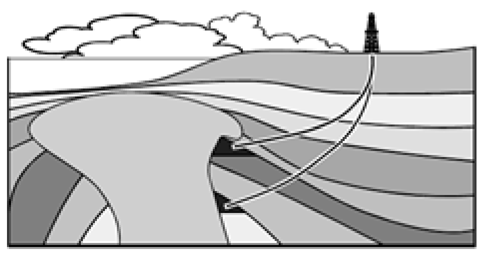
e) Relief wells
f) Controlling vertical wells
g) Sidetracking into multiple sands from a single wellbore
h) Multiple wells from offshore structures

6. The directional drilling application in the figure below is which one of the followings?



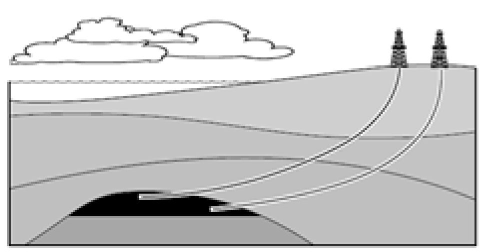
e) Inaccessible locations
f) Relief wells
g) Controlling vertical wells
h) Multiple wells from offshore structures

7. The directional drilling application in the figure below is which one of the followings?



e) Relief wells
f) Salt Dome drilling
g) Controlling vertical wells
h) Multiple wells from offshore structures

8. The directional drilling application in the figure below is which one of the followings?

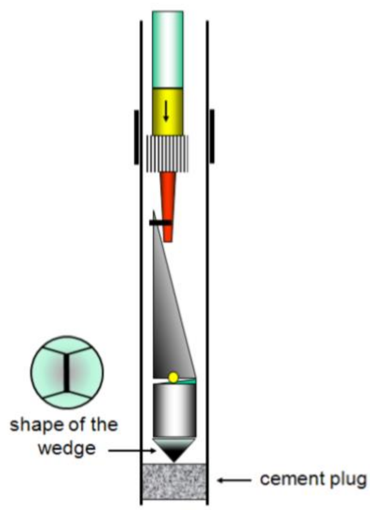


e) Controlling vertical wells
f) Multiple wells from offshore structures
g) Salt dome drilling
h) Shoreline drilling

9. The equipment in the below figure is used in directional drilling and it is called……

a) Positive Displacement Motor
b) Stabilized BHA
c) Whipstock
d) Downhole motor

10. The equipment in the below figure is used in directional drilling and it is called ___________.

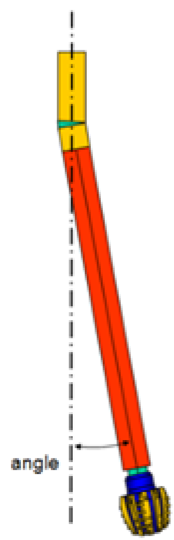


a) Bent Sub
b) Stabilized BHA
c) Whipstock
d) Downhole motor

11. The equipment in the below figure is used in directional drilling and it is called ___________.

a) Positive Displacement Motor
b) Stabilized BHA
c) Whipstock
d) Downhole motor

12. The equipment in the below figure is used in directional drilling and it is called ___________.



a) Bent Sub
b) Stabilized BHA
c) Whipstock
d) Downhole motor

13. ___________ can generally be defined as the science of drilling a wellbore along a determined path
h) Cementing
i) Directional Drilling
j) Surveying
k) Completion

14. The process of inclination and azimuth measurement of a drilled hole is called ___________.
a) Cementing
b) Directional Drilling
c) Surveying
d) Completion

15. The term ___________ usually refers to a cabling technology used by operators of oil and gas wells to lower equipment or measurement devices.
a) Deadline
b) Wireline
c) Fastline
d) Drilling line

16. Which one of the followings cannot be performed by CT?
    a) Rigging up
    b) Circulation
    c) Pumping
    d) Production

17. The tool called ___________ is normally located at the bottom of the wireline logging.
    a) bit
    b) casing shoe
    c) landing base
    d) sonde

18. Which one of the followings is not considered as one of the well completion types?
    a) open hole
    b) BOP
    c) liner
    d) cased hole

19. Inside diameter of the (9 5/8'' 40 lb/ft K55) casing is 8.835 ''. What is the inside volume of a 200 ft casing section?
    *Hint: (d^2/1029) *length.*
    a) 20,20
    b) 15,17
    c) 17,15
    d) 77,51

20. ___________ is the abbreviation used in oilfield terminology for casings.
    a) MW
    b) CSG
    c) POOH
    d) GIH

21. ___________ is the abbreviation used in oilfield terminology for wait on cement.
    a) VIS
    b) RIH
    c) WOC
    d) GIH

22. When you ___________ often and show a positive attitude, people will respond positively to you.
    a) insert
    b) smile
    c) laugh
    d) cry

23. A slickline is a thin cable introduced into a well to deliver and retrieve tools downhole
    a) True
    b) False

24. A wireline logs is an electrical cable used to lower tools into and transmit data about the conditions of the wellbore
    a) True
    b) False

25. Spontaneous Potential, Gamma Ray, Resistivity, Density, Sonic and Calliper are the ___________.

    a) Completion types
    b) Logging tool types
    c) Directional drilling tool types
    d) Cementing equipment types

26. In the oil and gas industries, coiled tubing refers to a very long metal pipe, normally 1 to 3.25 in (25 to 83 mm) in diameter which is supplied spooled on a large reel
    a) True
    b) False

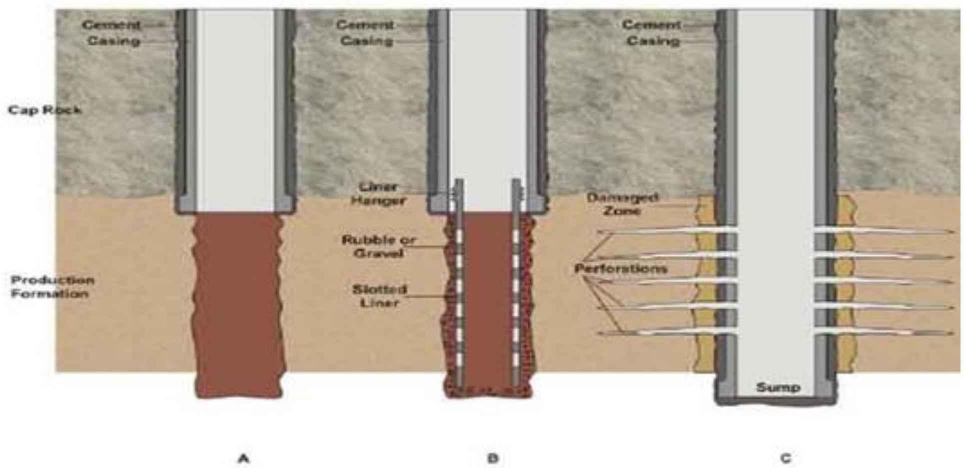
27. The main benefits of coiled tubing over wireline are the ability to pump chemicals through the coil
    a) True
    b) False

28. Circulation, Pumping, Drilling, Logging, Perforating and Production are some of the operation we can perform with ___________.
    a) Well Logging equipment
    b) Coiled Tubing
    c) Rig hoisting system
    d) Cementing equipment

29. The equipment in the below figure is called ___________.

    a) CT unit
    b) Cement truck
    c) Logging truck
    d) Mud Pump

30. The completion type A in the below figure is called a/an ___________.



a) Open hole completion
b) Cased hole completion
c) Liner completion
d) Multiple completion

31. The completion type B in the above figure is called a/an ___________.
a) Open hole completion
b) Cased hole completion
c) Liner completion
d) Multiple completion

32. The completion type C in the below figure is called a/an ___________.
a) Open hole completion
b) Cased hole completion
c) Liner completion
d) Multiple completion

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العربية شركة الحفر
Arabian Drilling Co.

SAIPEM

SANAD
Saudi Aramco Nabors Drilling

ENSCO

HALLIBURTON

Schlumberger

SINOPEC

Rawabi روابي
Oil & Gas للنفط والغاز

ARO DRILLING
أرامكو روان للحفر

NOBLE

BAKER HUGHES
a GE company

المؤسسة العامة للتدريب التقني والمهني
Technical and Vocational Training Corporation

DPS

شركة زي بي العربية للحفر المحدودة
ZP ARABIA DRILLING COMPANY LTD

SHELF DRILLING

WDI
A WEATHERFORD COMPANY

NPS
الشركة الوطنية للخدمات البترولية
National Petroleum Services

ADES
ADVANCED ENERGY SYSTEMS

Weatherford

CAMERON
A Schlumberger Company

Seadrill

Grey Wolf
Grey Wolf International

TESCO

المنصوري
ALMANSOORI

DALMA ENERGY

NOV

Sanjel

جسكو
JESCO

SAPESCO
SAHARA PETROLEUM SERVICES

TANAJIB
FOR GENERAL CONTRACTING COMPANY LTD.

Scientific Drilling

Abdel Hadi Abdullah Al-Qahtani & Sons Co.
Tariq Abdel Hadi Al-Qahtani & Brothers
Dammam, Saudi Arabia

PIPE & WELL SERVICES CO.
DAMMAM
PWS
SAUDI ARABIA

NEFT ENERGIES
طاقات النفط

NEFT ENERGIES
طاقات النفط

صدى
SADA