Ronald Hensley, M.Ed.

Charles Hensley, Retired Driller

Agenda

Day (1)

08:30 am	Introduction and Pretest
09:00 am	Rig Equipment (Substructures, draw-works, Derrick, and Rig floor)
10:00 am	Break
10:15 am	Rig Equipment (Mud Pumps, BOP, Drill String, and Bits)
11:00 am	Rig and Site Personnel
12:00 pm	Lunch
01:00 pm	Rigging up, Making Connections, drilling surface, setting casing and cementing
02:00 pm	Break
02:15 pm	Functions of drilling mud
04:00 pm	Tripping pipe
04:30 pm	Adjourn

Day (2)

08:30 am	Review of Day (1)
08:45 am	Measurement While Drilling (MWD), Coring, and Well Logging
10:00 am	Break
10:15 am	Down hole problems
10:50 am	Post test
12:00pm	Adjourn

LEGEND

MAIN RIG

1. Crown Block
2. Mast Derrick
3. Drill Pipe Triple Stand
4. Monkey Board – Derrick Board
5. Gooseneck
6. Traveling Block
7. Tubing Board
8. Top Drive
9. Driller's Cabin (Top Doghouse)
10. Standpipe
11. Mud-Gas Separator
12. Mud Pit Cutting Containment
13. Flare Pipes
14. Wireline Spool
15. Pipe Racks
16. Catwalk with Pipe Skate
17. Pipe Ramp, "V" Door
18. Hydraulic Raising Cylinder
19. Substructure
20. Parts House
21. Accumulator Unit
22. Water Tank
23. Fuel Tank
24. Engine/Generator Sets
25. Variable Frequency Drive (VFD)

DOWNHOLE COMPONETS

48. Cellar
49. Casing Head
50. Cemented Conductor
51. Casing
52. Drill Pipe
53. Bottomhole Assembly
54. Drill Bit

RIG FLOOR

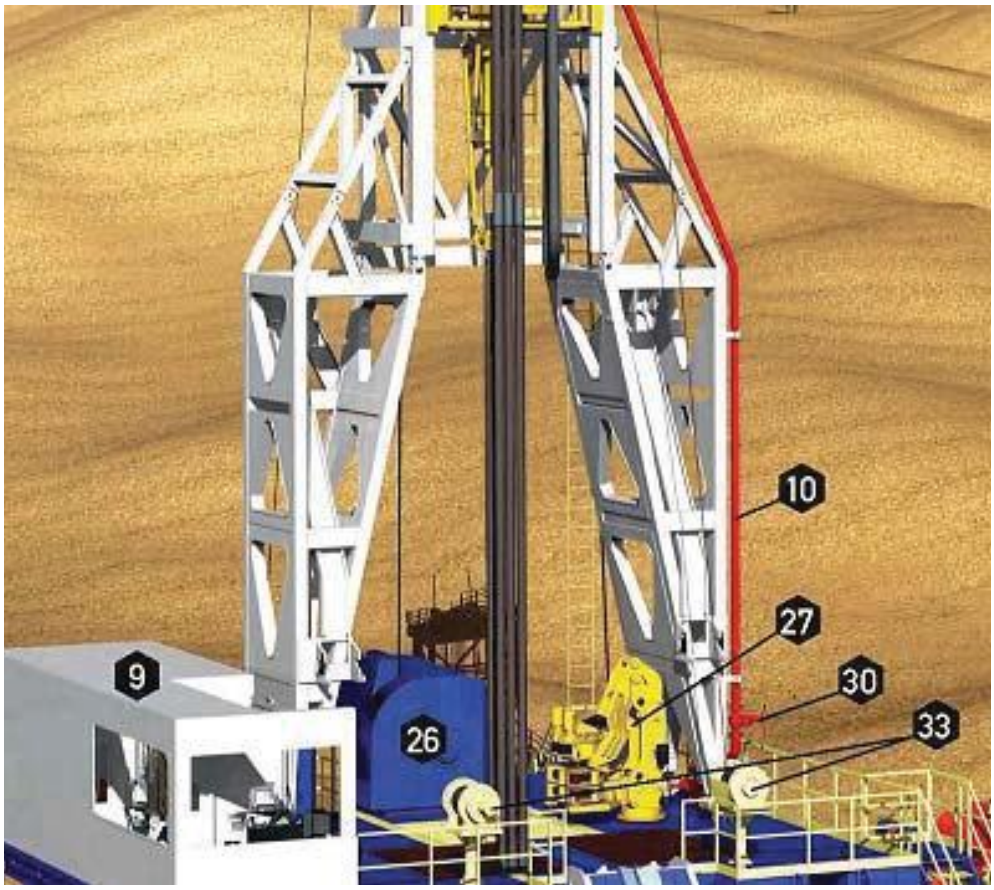
26. Drawworks
27. Iron Roughneck
28. Rotary Table
29. Mousehole Cover
30. Standpipe Manifold
31. Deadline Anchor
32. AC Motors
33. Winches

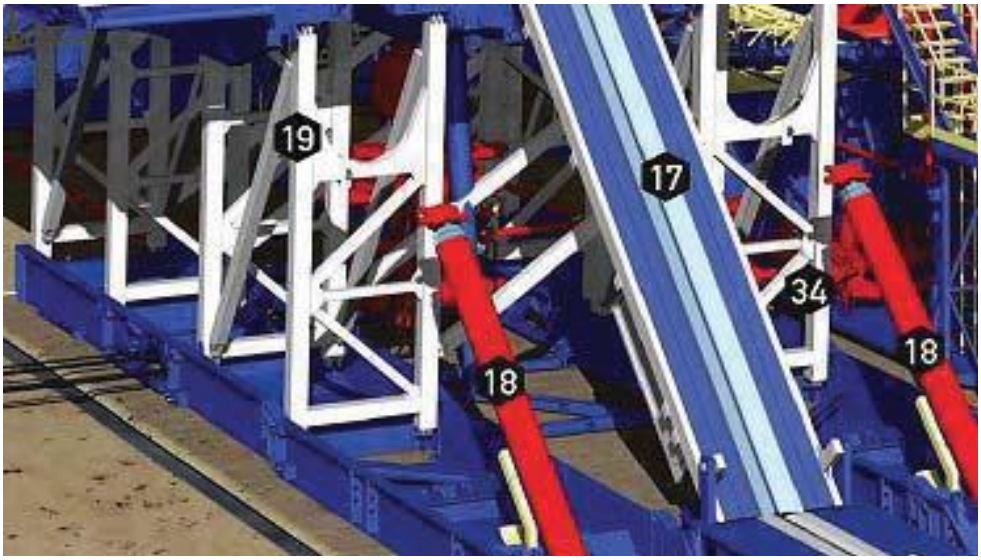
FLUID SYSTEM

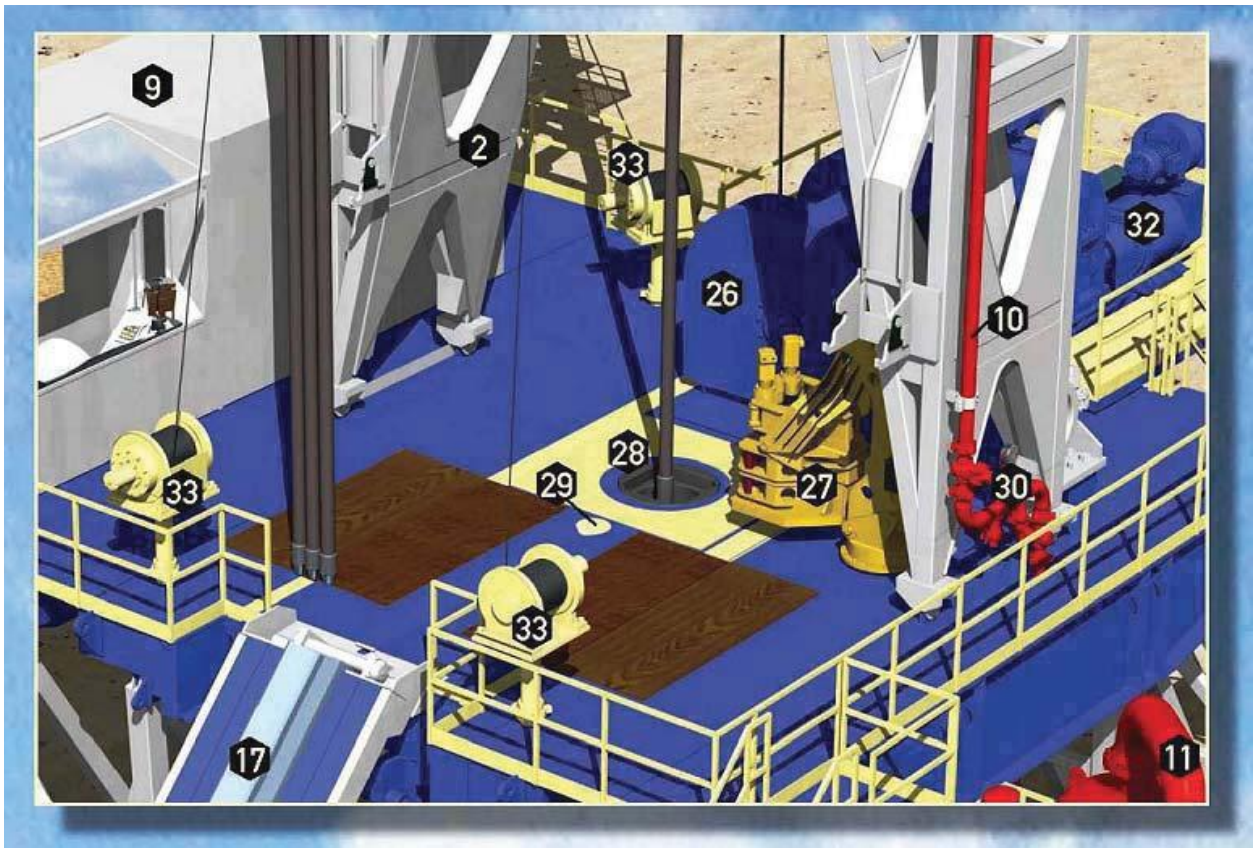
34. Choke Manifold
35. Mud Line Return
36. Mud Shale Shaker
37. Desander/Desilter, Mud Cleaner
38. Degasser
39. Tanks< Agitators
40. Mud Pumps

PRESSURE CONTROL SYSTEM

41. Annular Blowout Preventer
42. Pipe Rams
43. Blind Rams
44. Choke Line & Valves
45. Kill Lines & Valves
46. Drilling Spool
47. Pipe Rams



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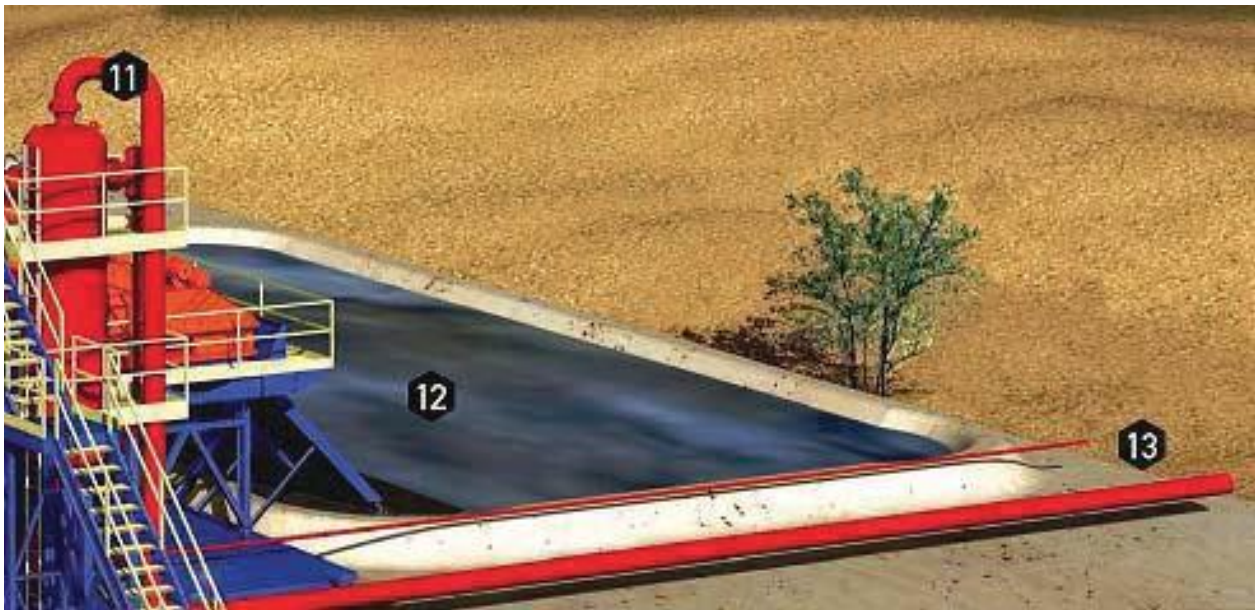

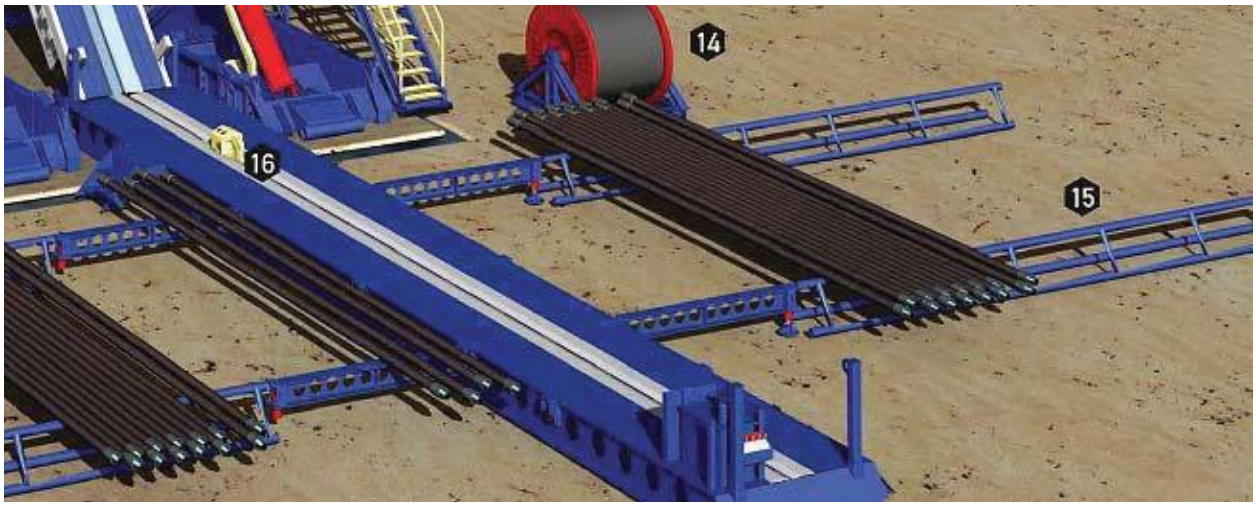

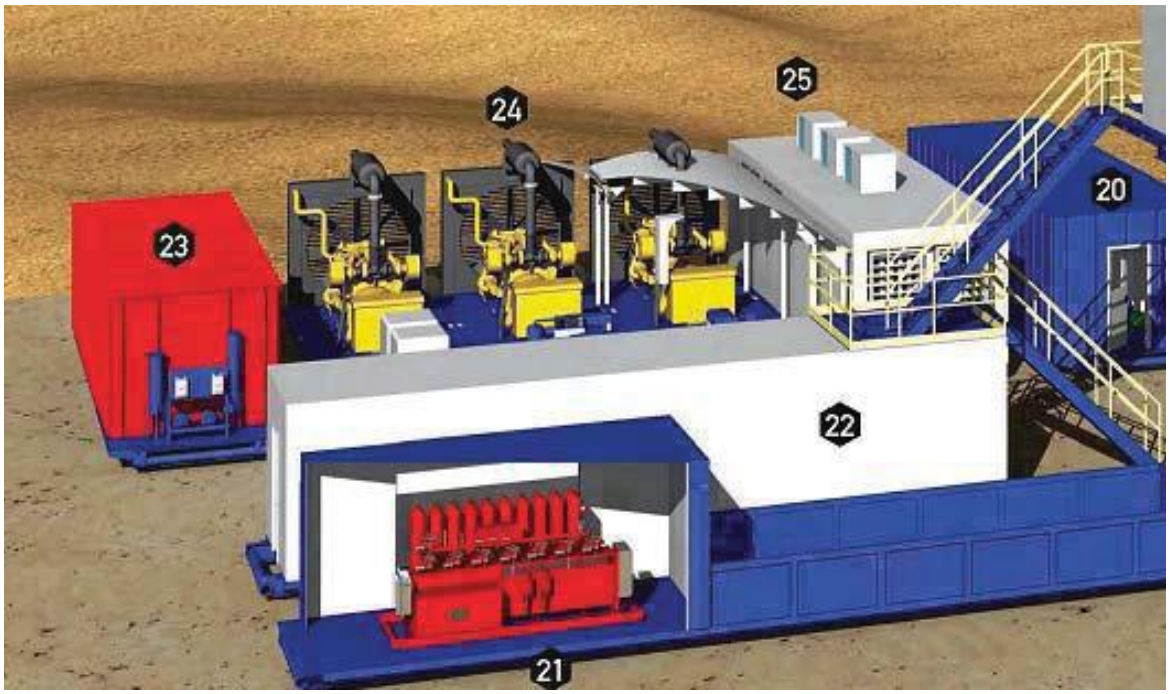

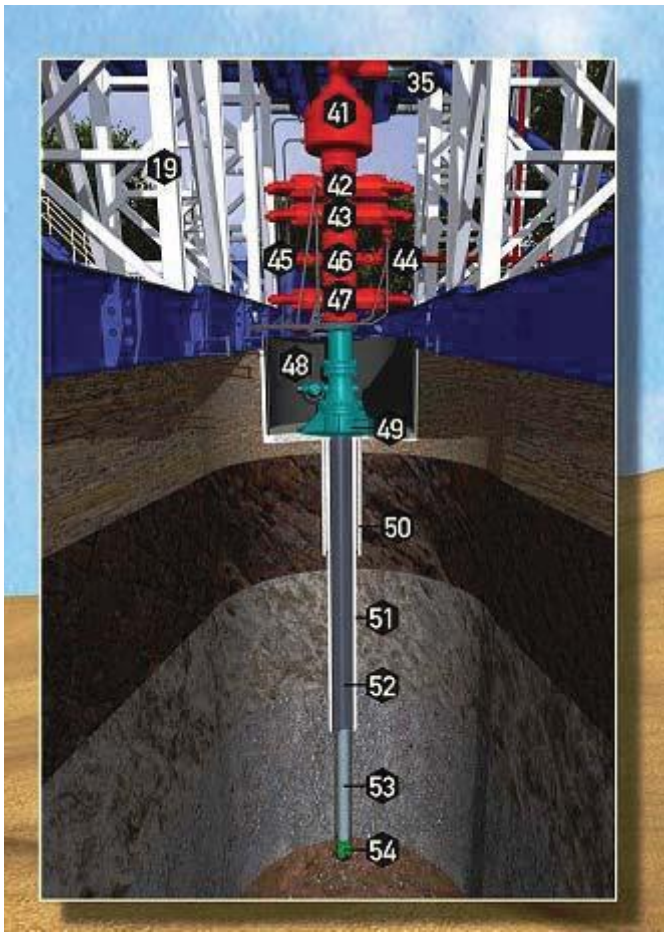

Why these course?

The Gulf Oil spill

Gas Drilling across the US

Pollution Associated with Drilling

Community Awareness (Gasland)

Environmental Regulations Sub Part OOOO

2

Do you know what these are?

Drawworks

Mud Pump

BOP

3

Course Objectives

Students will be able to recognize and identify the equipment used in the drilling rig operations.

Students will understand the personnel needed to operate a drilling rig. Each personnel function will be explained.

Students will understand how oil and gas wells are drilled. Straight, directional, and horizontal drilling will be explained.

4

Blow Out !

5	3	10/25/1979	GOLDKING PRODUCTION CO	Jackson		05084			1	Eaton (Wilcox) Wildcat	Colorado	N	N	0	0
6	1	10/24/1979	DILLEY PRODUCTION COMP	Las Vegas Ranch					6	Los Quatros	Maverick	Y	N	0	0
7	5	10/22/1979	GRACE PETROLEUM CORPO	K. S. Savage						Bear Grass (C. V.) Lime	Leon	N	Y	1	1
8	9	10/19/1979	BRIDWELL OIL COMPANY	Richards Ranch					2	Wildcat	Jack	N	N	0	0
9	7B	10/18/1979	WORLD PRODUCERS, INCOR	Clayton					1	N/A	Parker	N	N	0	0
0	**6**	**8/19/1979**	**MARSHALL EXPLORATION**	**W. B. Wiener**					**1**	**Wildcat**	**Panola**	**N**	**N**	**0**	**0**
1	6	8/19/1979	SEAGULL RESOURCES	Todd					1	Wildcat	Panola	N	N	0	0
2	1	8/4/1979	HILL PRODUCTION COMPAN	Rubin					1	Teeny Creek	Caldwell	Y	Y	1	1
3	4	8/3/1979	SUN OIL	L. Wiederkehr					191	Gov't. Wells N.	Duval	Y	N	0	0
4	8A	7/27/1979	BONNER, BOBBY	Turner					2	Wildcat	Borden	N	N	0	0
5	2	7/23/1979	MOBIL OIL CORPORATION	West Ranch "A"		03207			477	West Ranch	Jackson	N	N	0	0

8

Drilling Rig Count

- January 2014 1751
- January 2015 1811
- January 2016 664
- May 2016 404

9

The number of Drilling Rigs activity is dependent on several factors.

- Oil & Gas Prices
- Investments
- Permits
- Refinery Capacity

10

Drilling Rig Count (July 2022)

- The U.S. rig count peaked at 4,530 in 1981.
- US Rig Count, United States.
- Technology made previously uneconomical oil deposits viable.
- US Rig Count is at a current level of 750
- 470 one year ago (July 2021).
- Rig count in the Permian Basin 349

11

What A Barrel of Crude Oil Makes

Product	Gallons per barrel
Gasoline	18.90
Distillate Fuel Oil (includes both home heating oil and diesel)	12.14
Kerosene-Type Jet Fuel	3.95
Petroleum Coke	2.31
Still Gas	1.85
Liquefied Refinery/Petroleum Gases	1.68
Residual Fuel Oil	1.43
Asphalt and Road Oil	1.01

12

Five of the country's 30 best shale plays have been responsible for 80 percent of domestic shale gas production

- Barnett shale
- Eagle Ford
- Permian Basin
- Haynesville
- A few other smaller ones

13

14

While there have been instances when wells were drilled in as little as 15 days, a reasonable expectation for the time required to drill a well in the Eagle Ford is around one month. Based on a survey of operators in the region, drilling & completion cost per well are ranging from $5.5 to $9.5 million. The wide variation for drilling costs is dependent on such factors as the well's targeted depth, lateral lengths, number of laterals, and the number of frac stages deployed.

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Preparing The Site

Video

16

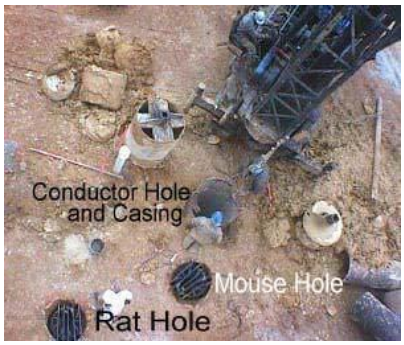
The "Reserve Pit" is where excess fluids and any other run off is stored. The cuttings from the well are deposited here.

Preparing The Site

17

The first part of the hole is larger and shallower than the main portion, and is lined with a large-diameter conductor pipe. Usually around 90 foot. A "Mouse hole" is a shallow bore hole under the rig floor, usually lined with pipe, in which joints of drill pipe are temporarily placed and readied to be placed into the drill string.Rigs with top drive units Have 2 mouseholes.
A "Rathole" is drilled to store the "Kelly" during removing the drill pipe (Tripping) from the borehole. Top drive units do not use a Kelly and therefore do not have a rat hole drilled.

Preparing The Site



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Cellar

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A circular pit, called a cellar, is dug around the location of the actual drilling hole. This is where the "Blow-out Preventer or BOP" will be positioned after surface is drilled.

Flow Line

20

The large-diameter metal pipe that connects the bell nipple under the rotary table to the possum belly at the mud tanks. A "Possum belly", is a metal container at the head of the shale shaker.

Flow Line

21

The Flow line is positioned at a downward angle from the conductor pipe to the mud tanks.

Water Source

22

All drilling rigs need a water source, even those that are drilled with "Air". It could be a creek, lake, or pond. Sometimes water is trucked in or a water well is drilled.

Equipment Overview

23

Substructures

24

25

They come in all shapes and sizes.
The larger the sub the greater the size of the Derrick it can support and the farther down that can be drilled. Large substructures can support a greater BOP stack.
Smaller substructures are more cost efficient to move.

26

Substructures are connected together with large pins. Separation is required for moving.

27

The Derrick

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The Crown

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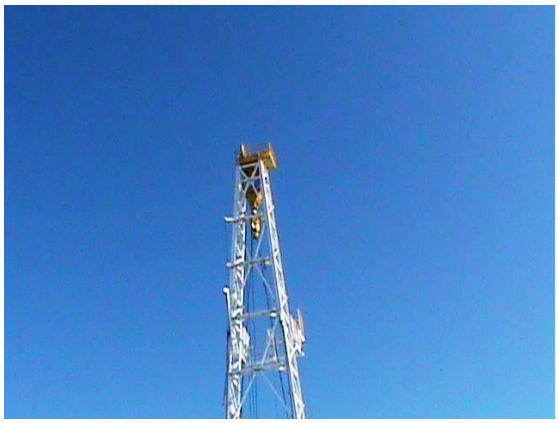
The Crown is the stationary section of a block and tackle that contains a set of pulleys or sheaves through which the drill line (wire rope) is threaded or reeved and is opposite and above the traveling block.



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The line exits the last sheave on the crown block and is fastened to a derrick leg on the other side of the rig floor. This section of drilling line is called the "dead line".

32

Mast

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The section between the Crown and the Derrick board.

Derrick

34

They can vary in shapes and sizes. The one here is a "triple". When pipe is removed, this derrick can support 3 drill pipes.

The Derrick Board

35

This is where the Derrickman stands when "Tripping" pipe. It is also sometimes called the "Monkey Board".

Climbing belt with counter weight

36

37

This view shows the derrick fingers or slots where the pipe is racked during pipe removal.

38

Safety Belt

39

Emergency Exit

Video

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The "A frame" is the section on the rig floor that the derrick is pinned to when raised.

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The welded angle iron on to the A frame is used for workers to climb on to drive the derrick pins in.

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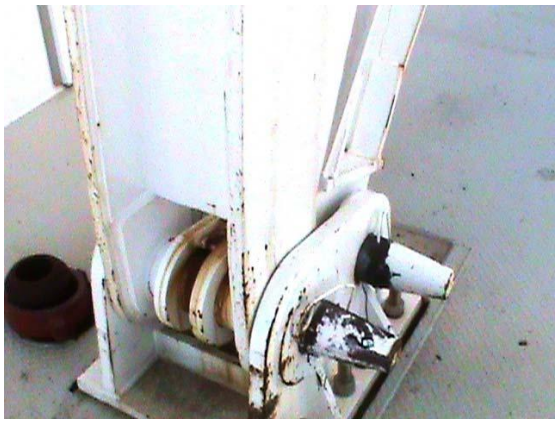

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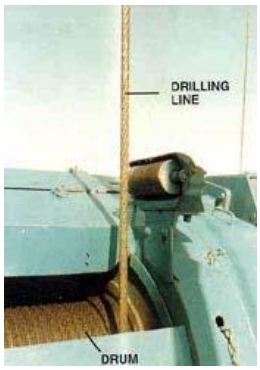
The Drawworks

46

A draw-works is the primary hoisting machinery that is a component of a drilling rig. Its main function is to provide a means of raising and lowering the traveling blocks. The wire-rope drilling line winds on the draw-works drum and extends to the crown block and traveling blocks, allowing the drill string to be moved up and down as the drum turns. The segment of drilling line from the draw-works to the crown block is called the "fast line". The drilling line then enters the sheaves of the crown block and is makes several passes between the crown block and traveling block pulleys.

The Drawworks



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As drilling line is spooled on and off the Draw-works during the course of drilling a well the line becomes worn & must be replaced at regular intervals. The greatest area of wear is where the line is constantly spooled over the drum. The figures that determine when the Drilling Line is cut are kept by the Rig Manager and are determined by "Ton/Miles" of accumulated wear. Although Ton/Miles usually determine when a cut is made it is very important to examine the line on made, the drum regularly for any broken wires. A visual inspection of damage always supersedes Ton/Miles figures when determining when to cut the Drilling Line.

48

Draw-works come in different sizes and different shapes.

Draw-works runs the rig floor and controls the "traveling block" The brake handle stops the block and levers control the cable for the tongs. The Derrick is also raised and lowered using the Draw-works.

THE BASIC OF A DRAWWORKS

The drawwork is a winch and is part of the hoisting system. It can also be used to drive the rotary. The one you see here is a National Oilwell 1625 DE with an input horse power of 3000 (2238Kw) and is rated at drilling depths from 16000 ft (4877m) to 25000 ft (7620m).

It is driven by 2 or 3 electric DC motors that offers four hoisting speeds and two rotary speeds. This model uses a 42 in. double plate clutch for low drum drive and a 46 in. x 10 in. Dy-A-Flex air clutch for high drum drive. The clutches drive a 36 in. dia. x 61 1 /4 in. integral, spiralled two- step grooving long main drum.

Older modules were furnished with the standard band brake system that are now being replaced with a hydraulically controlled disc brake system. It provides improved performance over conventional band brakes

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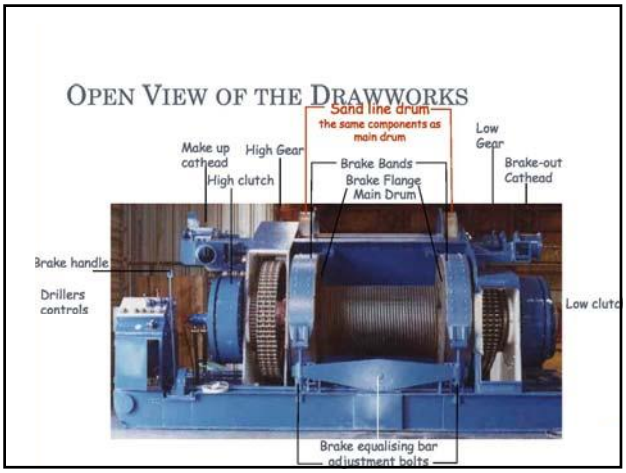

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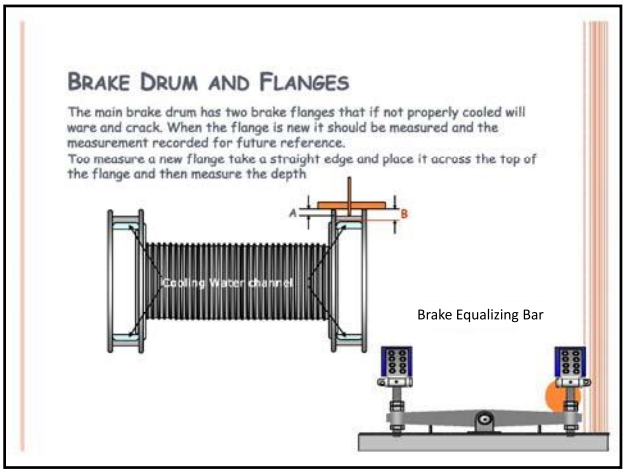
The drum is grooved to create a path for the line to spool properly.



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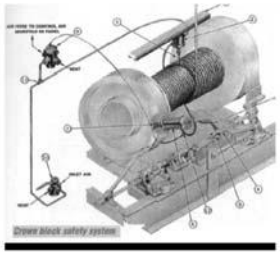
There is a crown safety device on the drum.

52

DRAWWORKS

Crownblock protecting device

Is air operating device which have to prevent collision of the traveling block with the crown block. When traveling block is within a preset distance from zthe crown block, it disengaged the clutch and simultaneously applies the brakes to the drawworks.



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As a safety device, all derricks are equipped with a crown protection device.

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Draw-works are rated by the amount of weight that can be supported.

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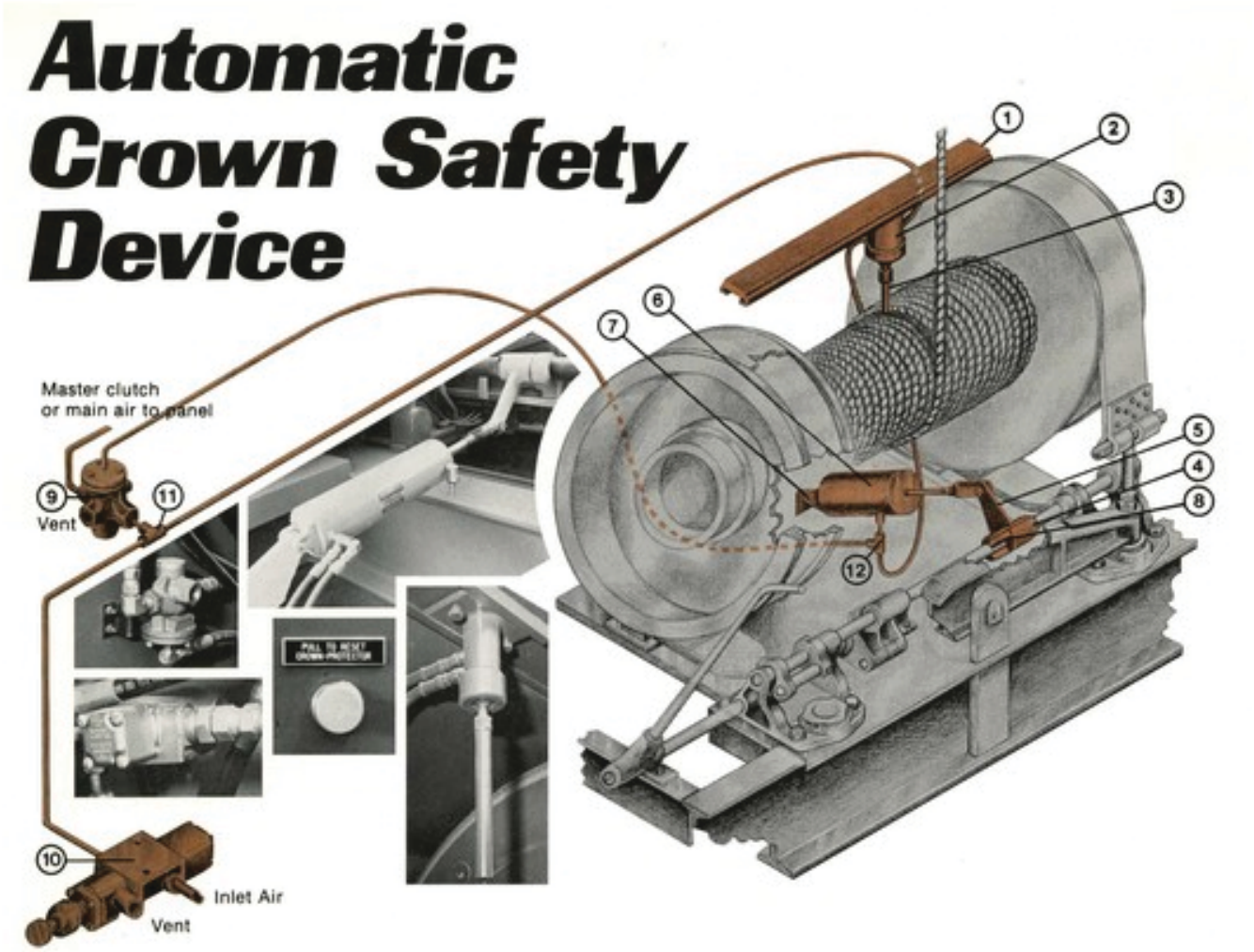
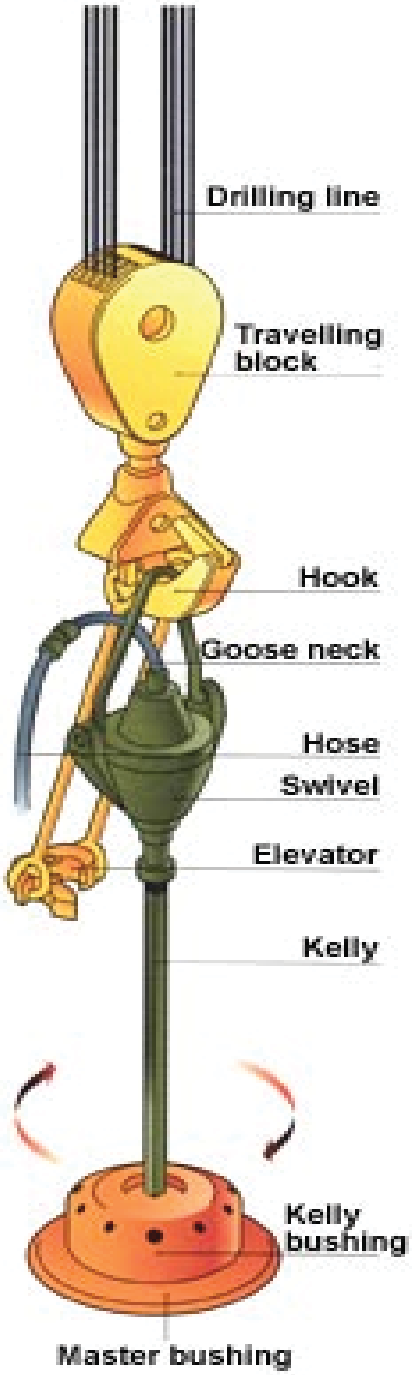
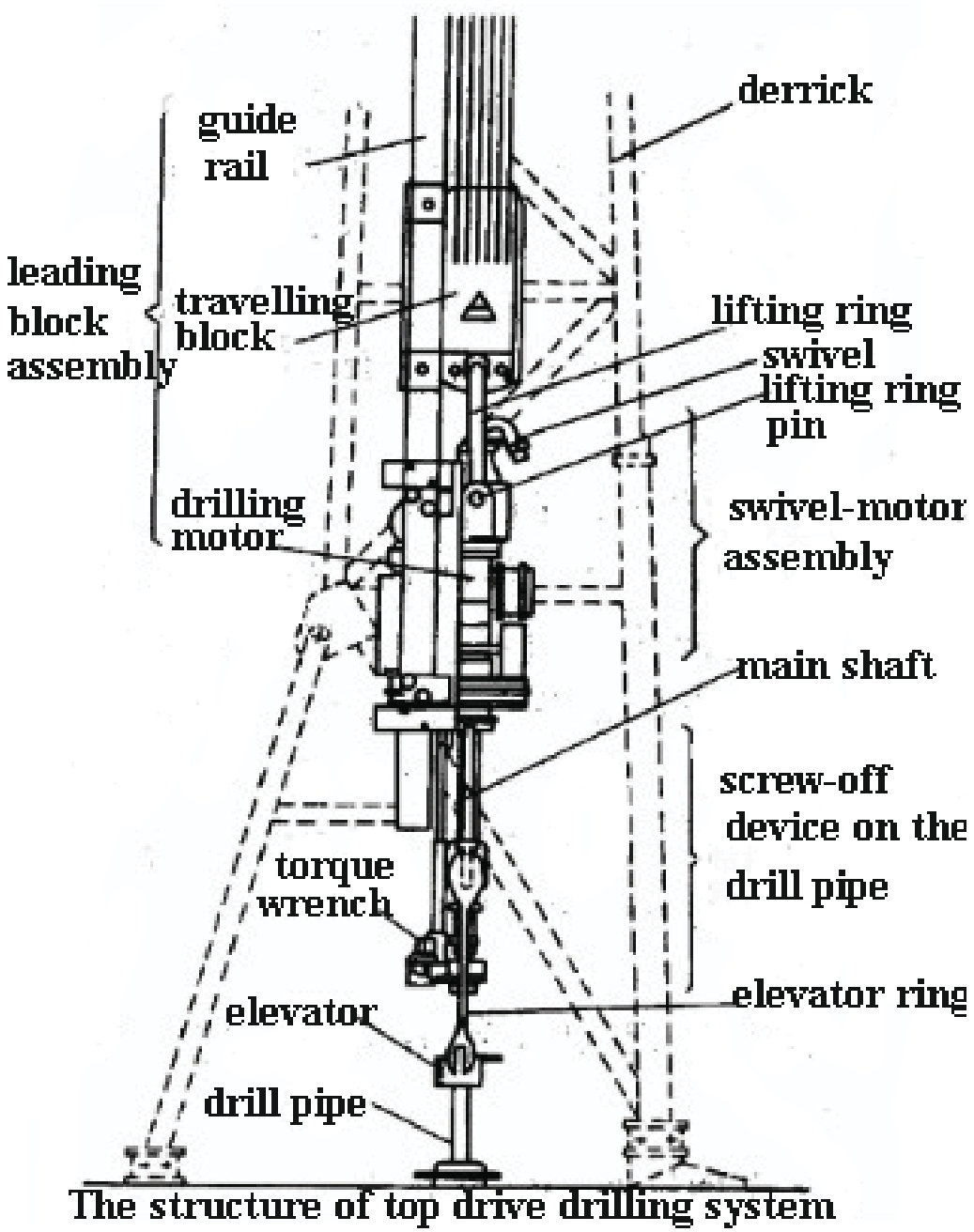
Crown-O-Matic Safety Device



Kelly Drill String

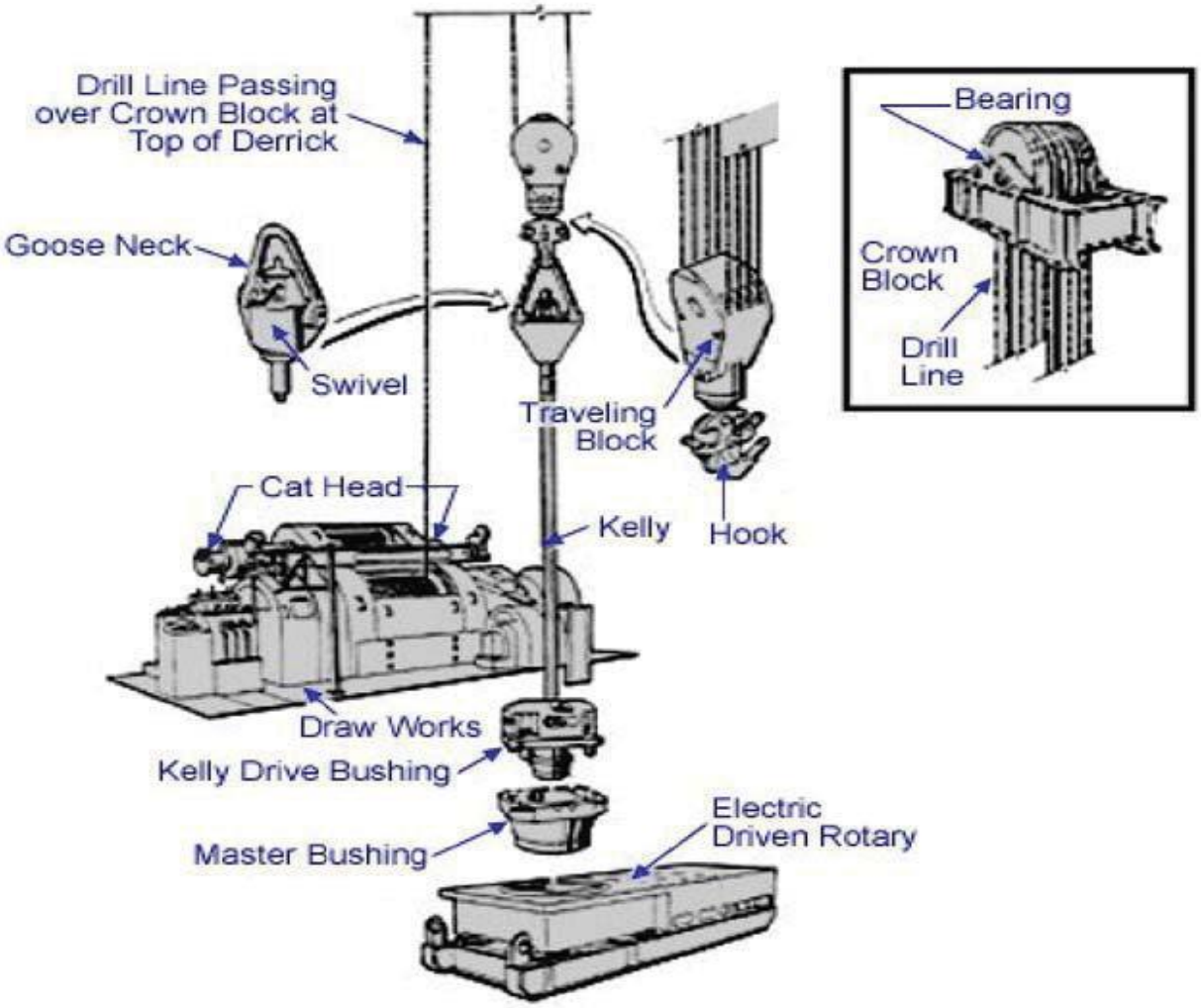


Top Drive System



The structure of top drive drilling system

Drill String



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Traveling Block

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Spool

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The spool can either be out front of the rig or sometimes housed in the substructure.

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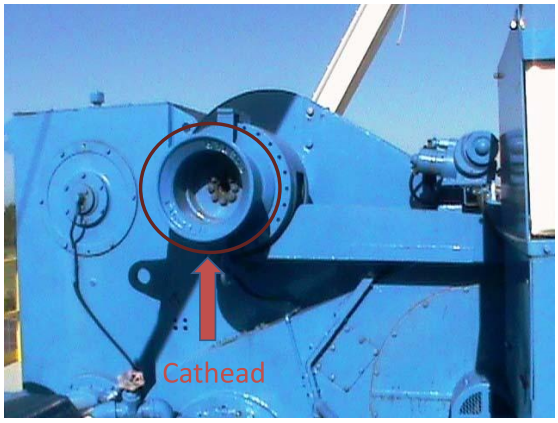
The Cat-head constantly rotates. A rope that is has a sheave in the derrick can be looped to lift equipment.



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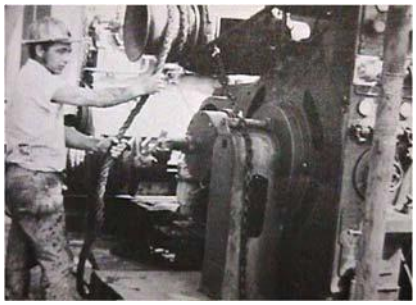


Video

62

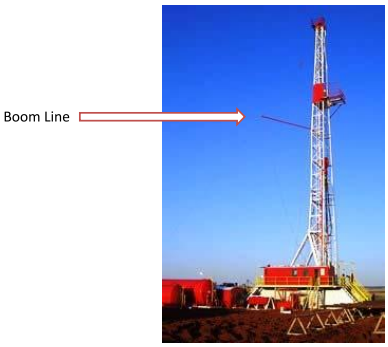
The rope shown wraps around the "cat-head". The left side is normally used for the cat-line.They can also be used for a "boom-line". They are used to lift equipment and to put pipe in the V-Door or mouse hole.
Most rigs have an "Air Hoists" which are much safer than the use of a cat-line.

63

The crown section. Notice the small sheave at the right. Cat-line or Air Hoist lines go from the device through the sheave to the floor.

64

The boom pole is used to pick up equipment further out on the drilling location. Some rigs have two boom poles.



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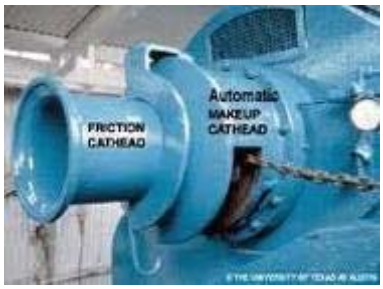

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The driller control the Automatic Makeup cat-head. This has a chain that connects to the rig floor tongs.
They can also be used to pull on a spinning chain.

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Air Hoist

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The "Air Hoist" is used to move equipment on the rig. Rigs can have more than one.

Air Hoist

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The Drilling String

Swivel

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It's a Dirty and Dangerous Job!

Video

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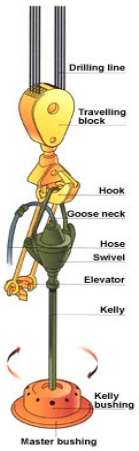
Drill String



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The Drill String. Notice the Kelly Hose and the Elevators. The green section is set into the Rat hole during drill pipe removal.

The Drilling String

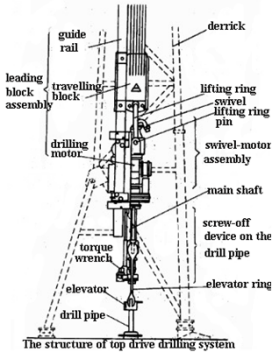
Top Drive

74

The latest technology, "Top Drive". It houses an electric motor that turns the drill pipe. The Top drive unit stays attached during pipe removal.

Because there is no Kelly to set back during the drill pipe removal,a "Rat" hole is not needed.

Top Drive System



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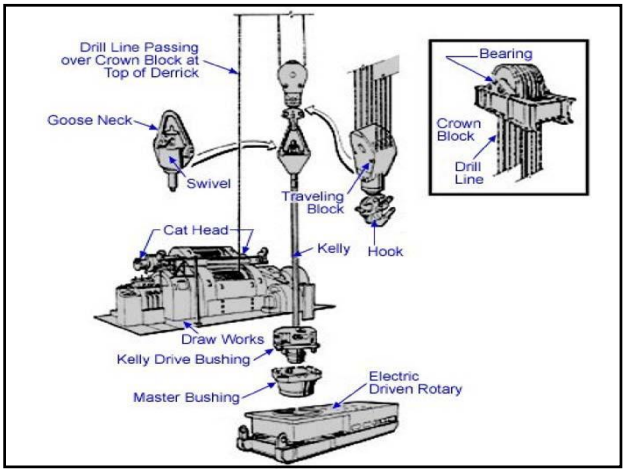

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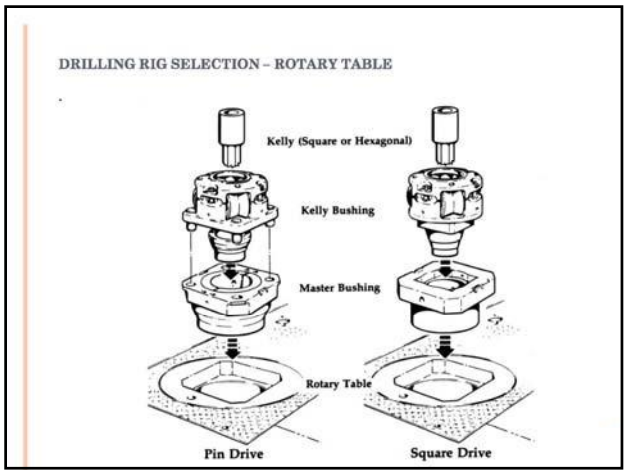
A different view of a drill string (Kelly rig). The Electric Driven Rotary table (Diesel Electric rigs)provides the method for the drill pipe to turn. But it requires a bushing to be inserted into the rotary table.

Some Kelly rigs have chain driven rotary tables. The chain is connected from the Draw-works to a sprocket on the rotary table.



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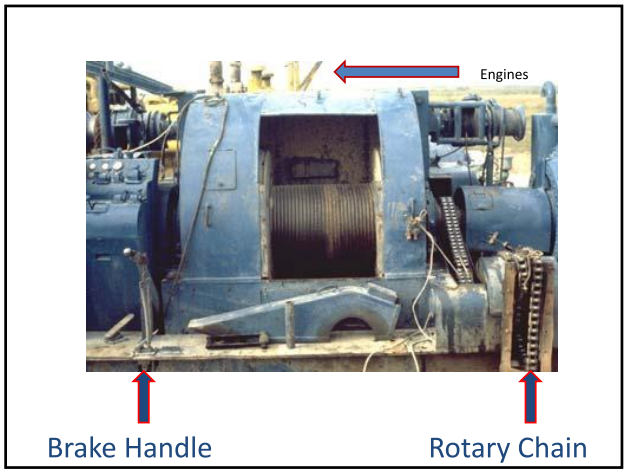
There are two different types of bushings. One has pins and the other just has the square base that sets into the Master Bushing. Bushing are only used in Kelly rigs. When the rotary table rotates, the bushing is turned,which turns the pipe and drill bit.



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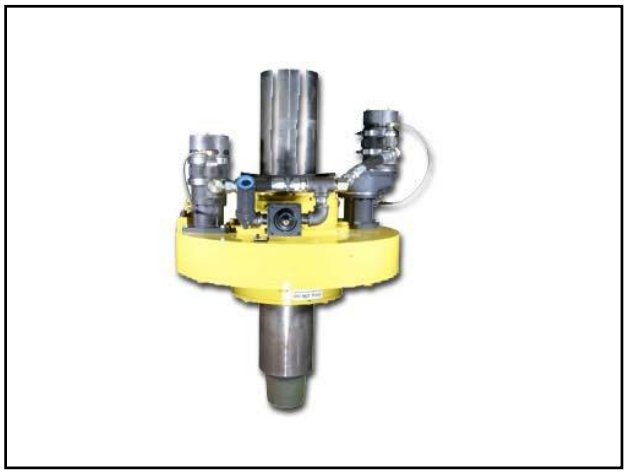
Notice the chain to the right. This chain will be attached to the rotary table sprocket. The engines at the back run the draw-works.



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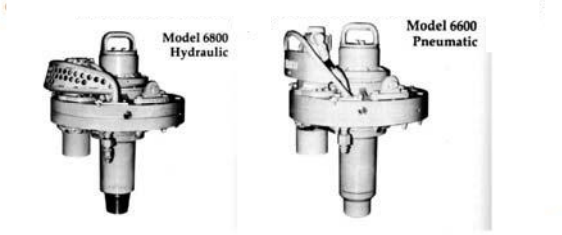
"Kelly Spinners" are used screw the pipe up during connections.

DRILLING RIG SELECTION – HANDLING EQUIPMENT

KELLY SPINNER



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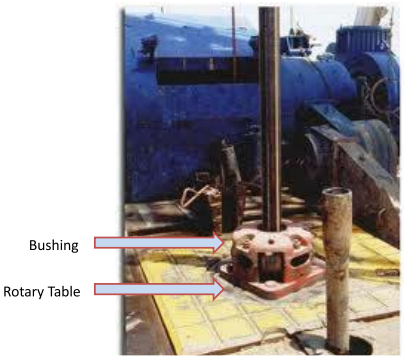
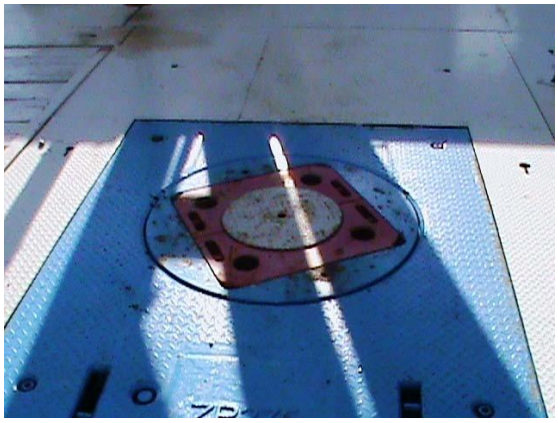


81

The Rotary table is flush with the floor and the Bushings set on top.



82

83

"Elevators" are used to hold on to the drill pipe during drill pipe removal.

84

The Kelly hose is where fluids are pumped through the Kelly and down the well bore.

The Rig Floor

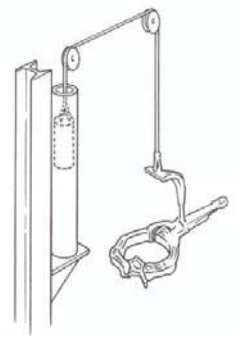
85

Tongs

86

Tongs act like giant pliers. When pushed out with the left and hand and pulled back on the right the tong will bite.

Counter Weight (Weight Bucket)



87

Tongs are heavy and cannot be picked up by one person. There is a line through a sheave to a counter weight (Weight Bucket) to balance the tongs.

Tongs

88

Pipe Slips

89

Pipe slips hold the drill pipe while a connection is being made. The slips will hold the entire weight of the drill pipe, collars, and any other tools in the well bore.

Iron Roughneck

90

The Iron Roughneck replaces tongs for screwing and tightening drill pipes.

Tongs

Video

91

The Spinning Chain

92

If a rig does not have a "Kelly Spinner" or some other screwing device,like a iron roughneck, a"Spinning Chain" will be used. Many power rigs still use spinning chains.

Video

93

It is easy to get hurt. Distractions kill.

Casing Tongs

94

Pictured is a casing tong. They are used during the running casing (steel pipe that seal the well bore). Casing Tongs are a powered tong used to screw up both large and small casing.

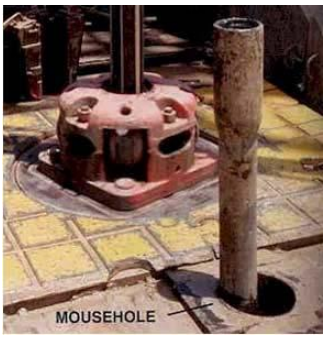
Casing Tongs

95

Mouse Hole

96

Mouse Hole



97

98

Kelly in “Rat Hole”

On “Power” rigs the “Kelly” is set off into the Rat hole to store it while tripping or running casings in and out of the well bore hole. Some rigs have the Rat hole on the left side and others on the right side.

99

Kelly in “Rat Hole”

100

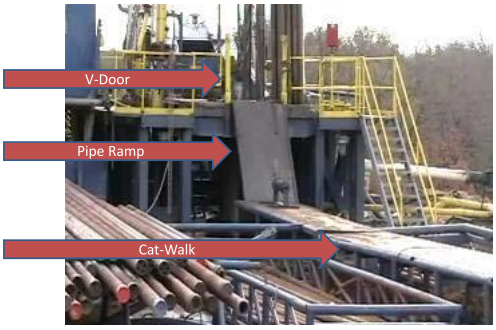
Kelly in “Rat Hole”

101

Kelly in “Rat Hole”

102

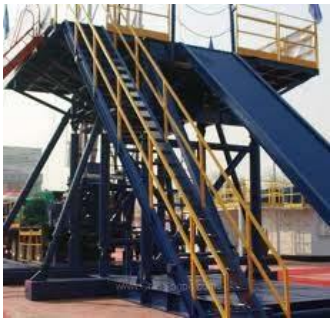
The bushing also is set off into the rat hole. This is used only for "Kelly Rigs"



103

Not all V-Doors look the same. This is the most common look

“V-Door”



104

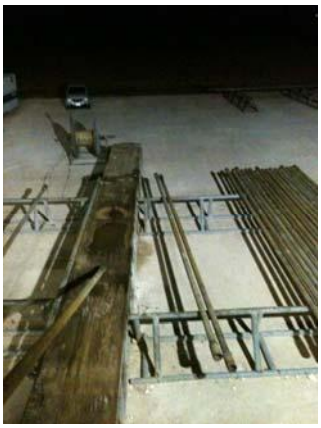
“Catwalk”

105

“V-Door” with pipe in it.

106

Floor hands will drag pipes up from the catwalk and set them into the V-door. Later after a connection, the one pipe is hoisted and placed into the mouse hole.



107

Pipe Racks

108

Pipe Racks with pipe

109

Rig Mud Pumps

Duplex

Triplex

110

Duplex and Triplex mud pumps. They pump drilling fluids from the mud tanks through the drill pipe and out the drill bit and back into the mud tanks.

111

112

This is a dangerous area to be in. Several thousand pounds of pressure is traveling through the pipes. Circled is a "pop-off" value. It is a safety device that provides pressure relief to the mud pumping system.

113

Drilling rigs that are Diesel Electric will have the pumps powered by electric motors. But some small power rigs will have a Diesel engine to power the pumps.

Mud Pump with Engine

Video

114

RIG PUMPS

Triplex Single Action stroke cycle

There are two drilling fluid circulating system involved in oil well drilling, the low pressure mixing system and the high pressure circulating system. For the rig to operate effectively good high pressure mud pumps is needed.

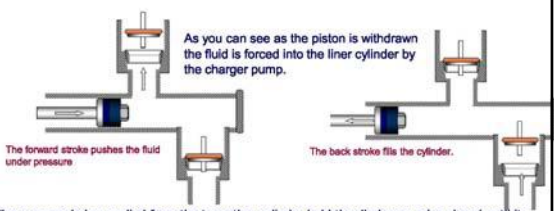
Wells are getting deeper by the day and circulating pressures are climbing. 20 years go circulating with 3000 psi was high pressure, today drilling pressure in excess of 4200 psi are not uncommon and so the need for a reliable circulating system arises.

The National-Oilwell model 12-P-160 Triplex mud pumps offers the rig a wide range of pressures and volumes for maximum operational flexibility. The Pump is equipped with a maintenance free suction and discharge pulsation dampener that is designed reduce hydraulic noise and improve detection of MWD signals that are transported from the tools to surface via the drilling fluid.

115

Rig Pumps

Due to the speed the triplex can run at it is force feed by a charger pump. Normally a 11" centrifugal pump powered by a 75 horse power electric motor. By changing the liner and piston the pump pressure can be regulated between 0 and 7500 psi. As the name triplex indicates, there are three liners and all there have to make a complete cycle to complete one the stroke.



The pressure being applied from the two other cylinder hold the discharge valve closed until it starts it's forward stroke. The suction valve then closes and the drilling fluid is forced up into the main stream circulation system. Quick release caps and heads make them an extremely easy pump to work on when changing out the liners

116

Pump Valves

117

Pump Parts

Pump Rods

118

RIG PUMPS

Triplex Single Action stroke cycle

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Rig Pumps

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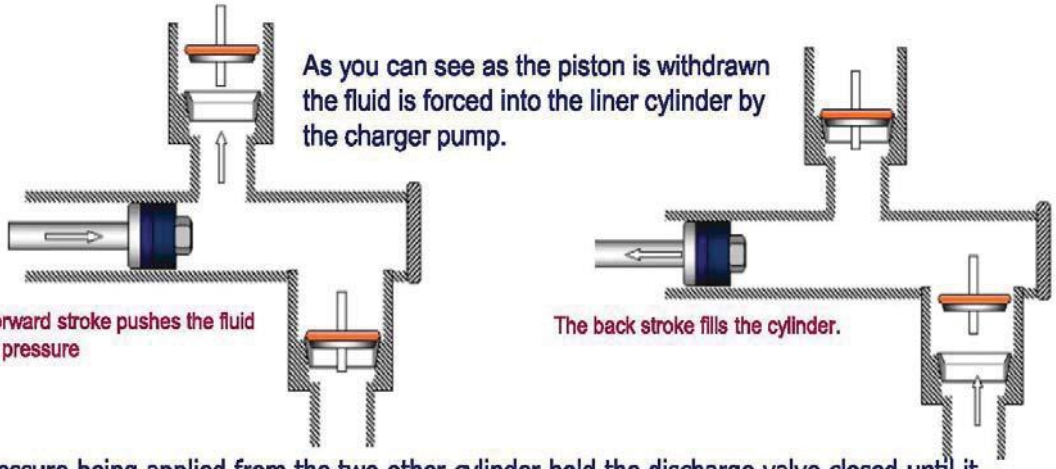

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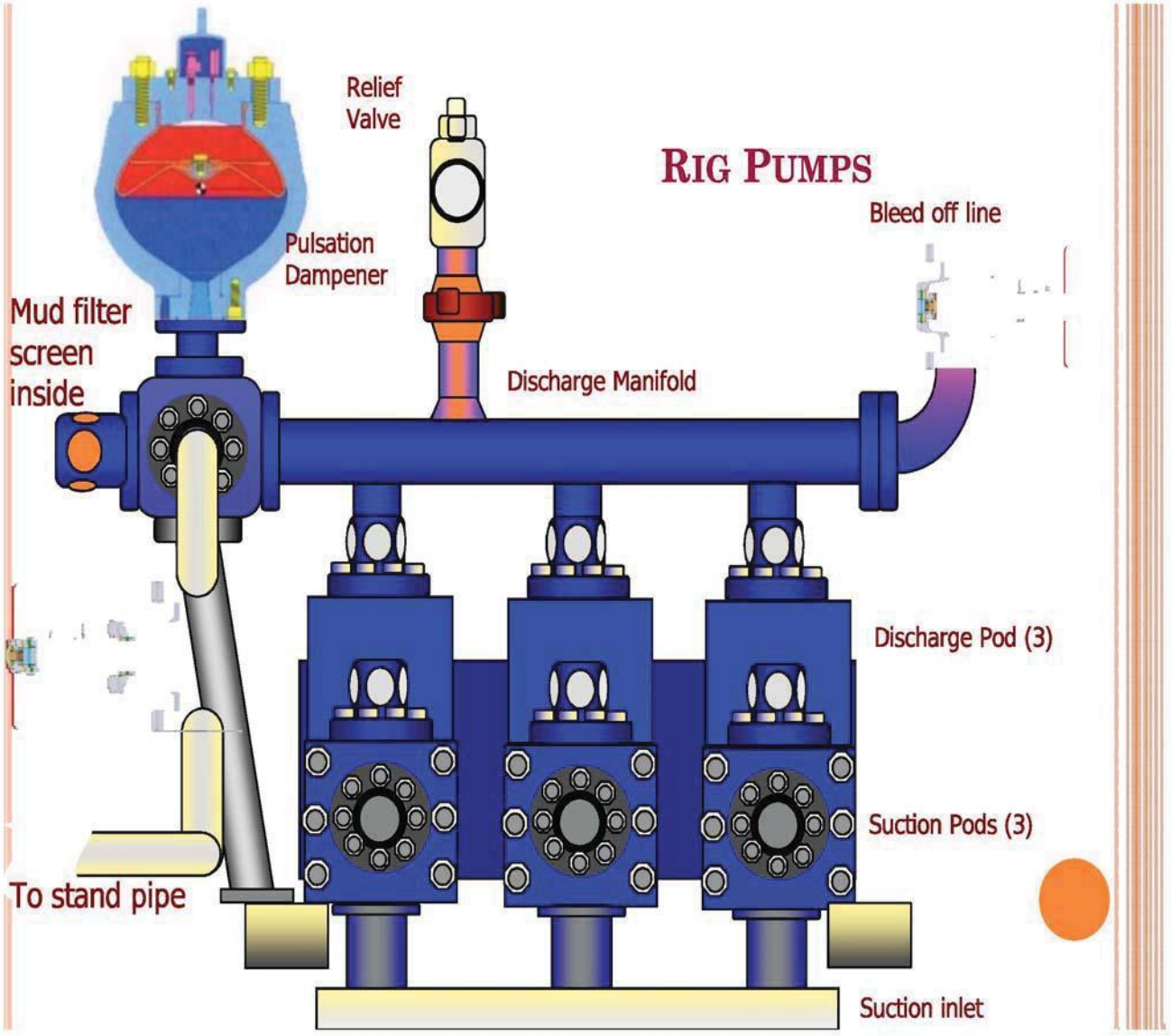
RIG PUMPS


Relief Valve
Pulsation Dampener
Bleed off line
Mud filter screen inside
Discharge Manifold
Discharge Pod (3)
Suction Pods (3)
To stand pipe
Suction inlet


Mud Pits
Mud Pumps

122

123

124

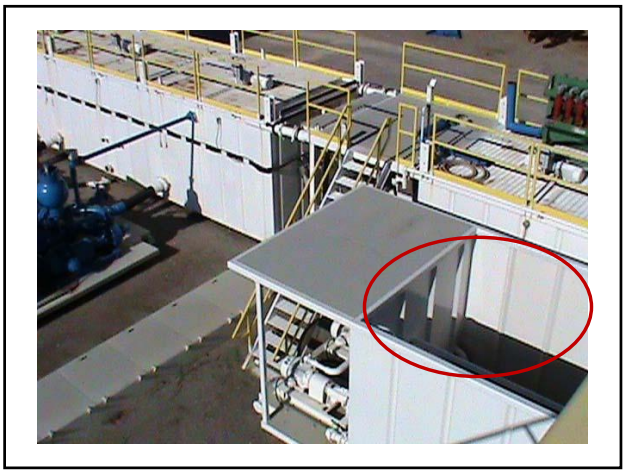
This is a clean out or dump valve. When opened it allows for the mud tanks to be cleaned. Usually this is done by a high pressure hose. The waste is dumped into the reserve pit.

125

Pictured at the end of the mud tank is a mud house. The rig will have sacks of chemicals ready to be mixed stored there. In this mud house a hopper is also housed inside.

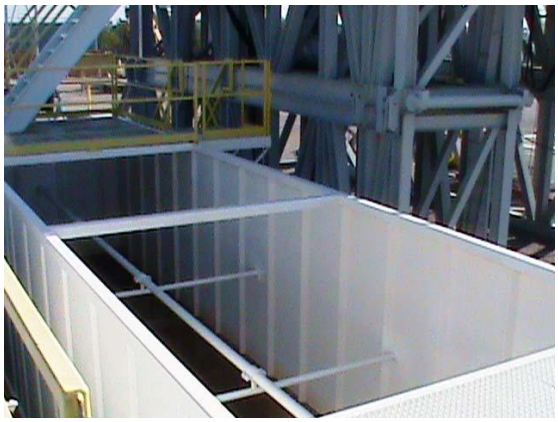
126

Pictured is electrical pumps. They are used for pumping water or mud to stir up the settlings at the bottom of the mud pits.



127

This is a water tank on this rig. But sometimes a Trip tank is placed here.



128

129

Pictured is a FRAC Tank. Many times a drilling rig will have these on location to hold water or sometimes drilling mud.

Shale Shaker over Mud Tank

130

Pictured is a Shale Shaker. When cutting come out of the well bore, the shale shaker is the first cleaning device on the rig. The return crosses a screen that separates the cuttings from the fluid.

De-Sander sets over Mud Tank

131

A de-sander is needed to prevent overload on the de-silters. Generally, a 6-in. ID or larger hydroclone is used, with a unit made up of two 12-in. hydro-clones, rated at 500 gpm per hydro-clone, being common. Large desander hydroclones have the advantage of a large volumetric capacity (flow rate) per hydroclone, but have the disadvantage of making wide particle-size cuts in the 45-to 74-micron range.

De-Silting Cyclones over Mud Tank

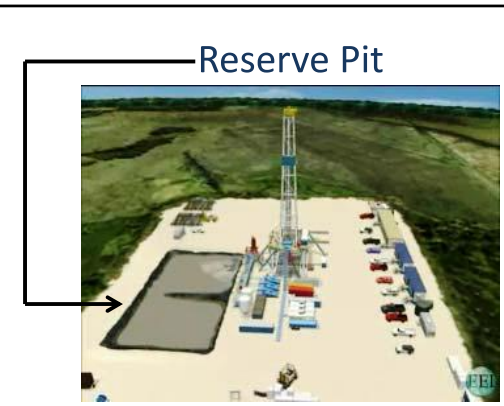
132

To achieve maximum efficiency and prevent overloading the desilter, the entire flow should be de-sanded before being de-silted. Generally, a 4-in. 10 hydroclone is used for de-silting,with a unit containing 12 or more 4-in. hydroclones, rated at 75 gpm per hydroclone, being common. The proper volumetric capacity for de-silters and de-sanders should be equal to 125 to 150% of the circulation rate. Large-diameter wells with high circulation rates require a greater number of hydroclones. Oesilter hydroclones generally process a significant volume of fluid and have amore-desirable narrow cut point more point.

133

A well designed and properly operated 4-in. hydroclone will have a 050 cut point of 15 to 35 microns, with a 090 of around 40 microns. Since barite falls into the same size range as silt, it also will be separated from the mud system by a desilter.For this reason, desilters are rarely used on weighted muds above 12.5 Ib/gal.

134



135

The "Reserve Pit" is where excess fluids and any other run off is stored. The cuttings from the "Shale Shaker" also are deposited here.

136

Generators

137

The Generators supplies all the power to the Drilling Rig, Bunk House, Company Man, Tool Pusher, and Mud Logger Trailer's. They are housed on a skid and covered.

Generators

138

Video

139

Diesel Electric rigs will have multiple, large KW generators.

140

Diesel Electric drilling rigs have an attached housed call an Silicon-Controlled Rectifier house (SCR House).

SCR House

141

SCR House

142

143

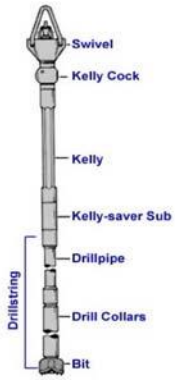
SCR House

144

145

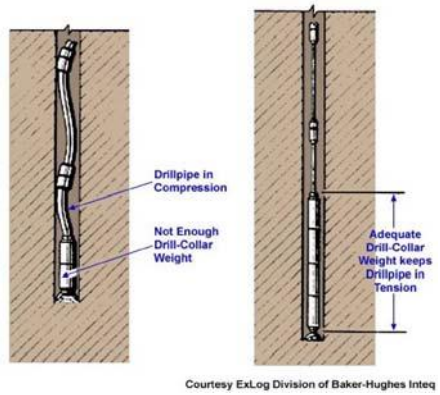
Power lines are housed in "Suit Cases". Workers use these as walkways.

Collars, Drill Pipe, and Drill Bits



146

Collars



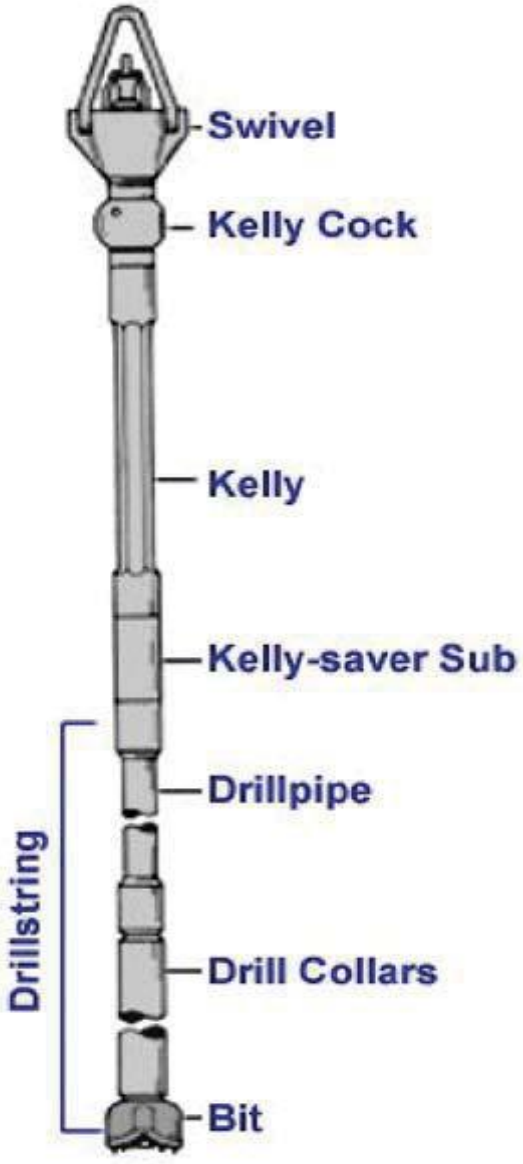
147

Collars provide weight to the drill string. Without the weight drill pipe would twist off at the treads and the well bore hole would not be straight.

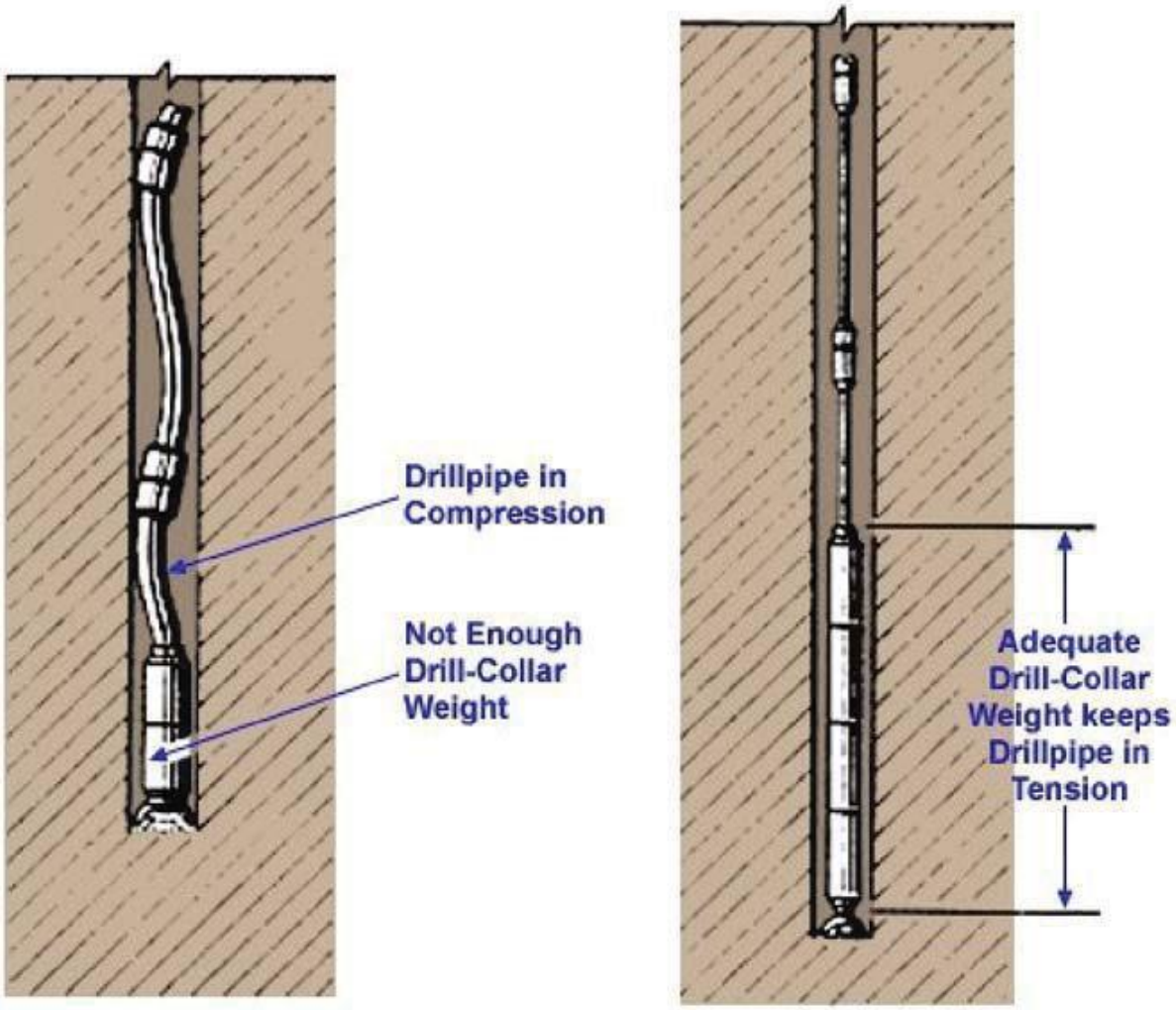
Collars

148

Collars, Drill Pipe, and Drill Bits



Collars



Courtesy ExLog Division of Baker-Hughes Inteq

149

Usually 25 to 30 foot in length and usually up to10 inches in diameter. After the drill bit, the collars are the next pipe that go into the hole.

Collar Lift Subs

150

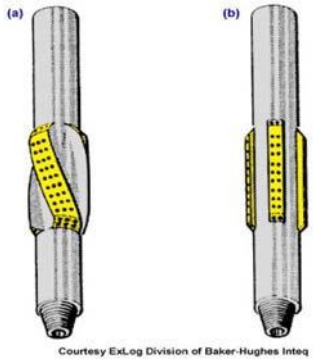
Usually during a trip, collars subs are screwed into the top of the collar to allow the elevators to attached. They are sometimes tightened by using a chain wrench.

Collar Slips and Safety Clamp

151

Special slips called "Collar Slips" are used. Collars can slip through the slips. A "Safety Clamp", sometimes called a "Wedding Band" is tighten above the slips to prevent the collars from slipping.

Stabilizers



Courtesy ExLog Division of Baker-Hughes Inteq

152

Stabilizers help in keeping the collars in the center of the hole also to maintain a full gauged hole.

Reamers

153

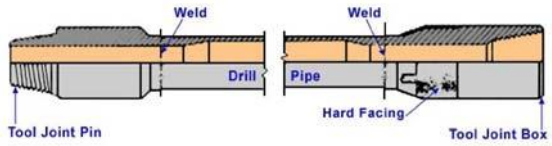
Drill Pipe

$52.00 per foot

Video

154

Drill Pipe



155

DRILLING RIG SELECTION – INSTRUMENTATION

RIG INSTRUMENTATION

Rig instrumentation can operate peumatically-hydraulically or electrically.

Pneumatic- hydrasulic systems are cheap, long life, simple for installing, adjusting, maintenance and needs small amount of spares.

Electrical systems are expensive, installing, adjusting and maintenace must be performed by specialist, needs large quantities of expesive spares.

Basic instrumentation systems conssit of:

- Weight indicator with weight sensor
- Pump pressure, two or three
- SPM, Pump stroke per minute
- RPM, rotary table rotational spped
- Rotary torque
- Tongs pull line force or torque
- Pit level indikator
- Flow meter
- T-Km, Drilling line work
- Recorder, drilling parameters

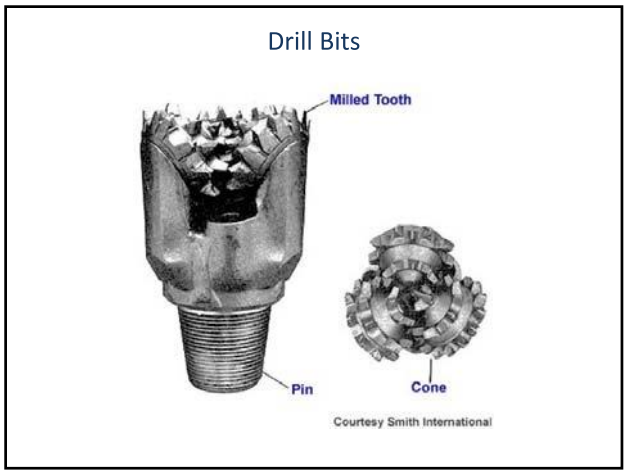
Instrument console

156

Weight and Pump Pressure Indictors

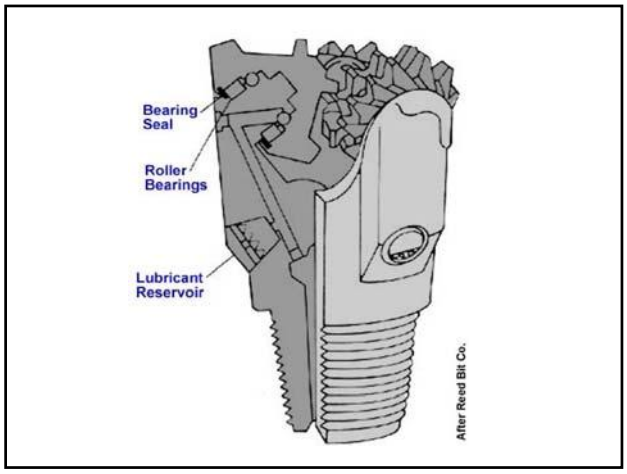
157

Weight indicator is used to determine how much weight is on the drill string and how much is on the drill bit. The Pump indicator displays the amount of pump pressure is being pumped down hole.



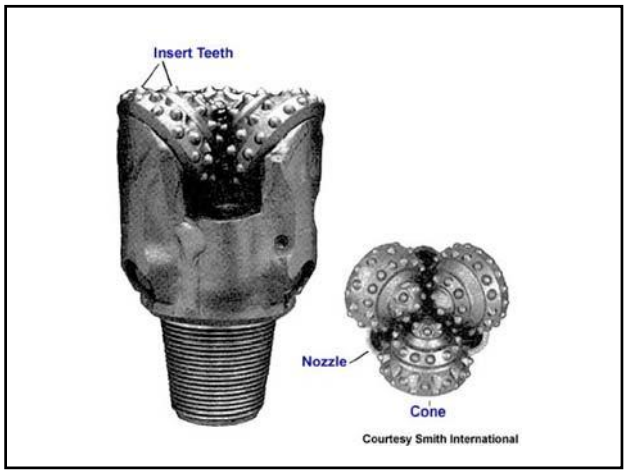
158

Tri-Cone Bits. Surface Bit – Longer teeth for soft formations.

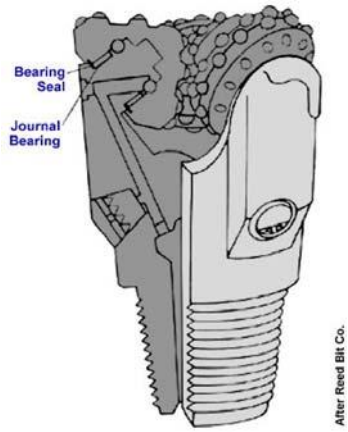


159

Button bits are for harder formations.



160

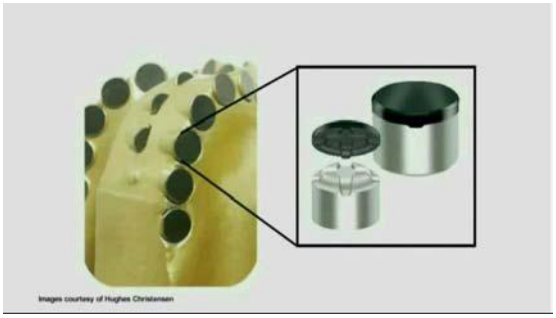


161

Industrial diamond bits.

162

163



Video

164

Rig Personnel and Management

Company Man

In a normal scenario, gas/oil-drilling (exploration) companies rent or lease rigs from another company that owns the rig, the drilling contractor. The Company Man is the on-site representative of the operating/exploration company and is in overall charge of the drilling and associated activities.

165

Toolpusher

Tool pushers are in charge of keeping the rig in all necessary tools, equipment, and supplies. They work closely in conjunction with the representative of the operating/exploration company in regard to the actual drilling of the well. Toolpushers also have taken on somewhat of an administrative role, as they frequently do paperwork related to the rig crew regarding payroll, benefits, and related matters. Toolpushers are also responsible for coordinating services with third party companies related to the drilling of the well.

166

Driller

The driller is in charge of his crew, and running the rig itself. Most of the time, his job is simply to monitor the rig's activity, while the automatic driller runs the breaks and drills the hole. The driller is responsible for interpreting the signals the well gives regarding gas and fluids with high pressure. In an emergency he is also responsible for taking the correct counter measures to stop an uncontrolled well control situation from emerging. The driller will watch for gas levels coming out of the hole, how much drilling mud is going in and other information. While tripping, the driller will run the floor and work the rig.

167

Derrickhand

Duties include but are not limited to: working in the derrick to safely and efficiently assist the Driller in centering, raising and lowering all casing, drill pipe and tubulars through the drill floor rotary table; ensuring the smooth operation and support function of the mud module including preventative maintenance and general repairs of mud equipment as requested by the Driller and Mud Engineer, ensuring chemicals and mud mixture meets the needs of drilling operations.

168

Motorman

Duties include but are not limited to: assisting the Mechanic and ensuring that the regular preventive maintenance activities for all mechanical equipment on the rig occur in a timely manner to prevent down time and ensuring the efficient and continual functioning of the mechanical equipment on the drilling rig ensuring fluids in each piece of mechanical equipment is maintained to operational levels; perform housekeeping duties in and around the engines.

169

Floorhand

Duties include but are not limited to: safely and efficiently performing all manual labor tasks on the drilling floor and B.O.P. area under the direction and supervision of the Driller. New employees start at this position and are usually called a "worm". Usually there are one to two floorhands on a land rig.

170

Mud Engineer

The name given to an oil field service company individual who is charged with maintaining a drilling fluid or completion fluid system on an oil and/or gas drilling rig. This individual typically works for the company selling the chemicals for the job and is specifically trained with those products, though independent mud engineers are still common. The mud engineer is not to be confused with mud loggers, service personnel who monitor gas from the mud and collect well bore samples.

171

Mud Logger (or **sampler**)

The employee who determines positions of hydrocarbons with respect to depth, identifies down-hole lithology, monitors natural gas entering the drilling mud stream, and draws well logs for use by oil company geologists. Rock cuttings circulated to the surface in drilling mud are sampled and analyzed.

DO NOT CONFUSE THIS WITH WELL LOGGING.

172

Rigging Up

Video

173

Rigging up usually takes 3 to 4 days depending on the rig size.

Using a Ramp

Video

174

There are several different ways to move a rig. Some companies use cranes others use ramps.

Rigging Up

175

Unless the rig is skidded,derricks are unpinned and moved on trucks to the new location.

Rigging Up

176

Rigging Up

177

Rigging Up

178

179

Pictured is a Headache rack. The derrick crown will set on this stand until it is raised or lowered.

180

Rigging Up – Raising the Derrick

Video Rigging Down – Lowering the Derrick

181

Rigging Down

182

Skidding

Video

183

Sometimes rigs are moved a few feet to drill multiple holes on one pad. This can be done by skidding the rigs.

Rigging Down

Video

184

Spudding In

Video

185

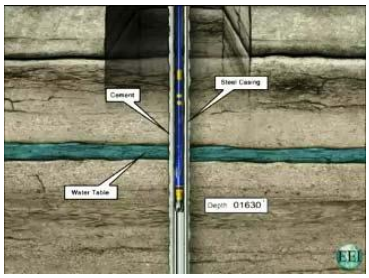
Making a Connection

Worm Connection

Video

186

Drilling (Setting) Surface



Video

187

Drilling surface (Fast hole) uses a long tooth bit because it is usually drilled in a day or two and extends past the water table. Surface casing (Large 10”) is placed into the hole and then cemented into place. After casing is cemented and before the drilling begins again the BOP is set into place (called "nippling" up.

Surface Casing

188

After surface is drilled, large steel pipe is inserted into the well bore hole to protect the water table.

Surface Casing

189

Casing

190

Like drilling rigs, there are several different ways to run casing.

Casing Centralizer

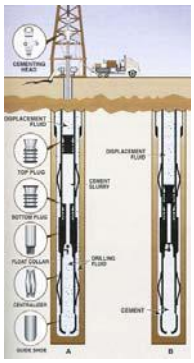
191

Centralizers are used to center the pipe in the well bore hole.

Casing

192

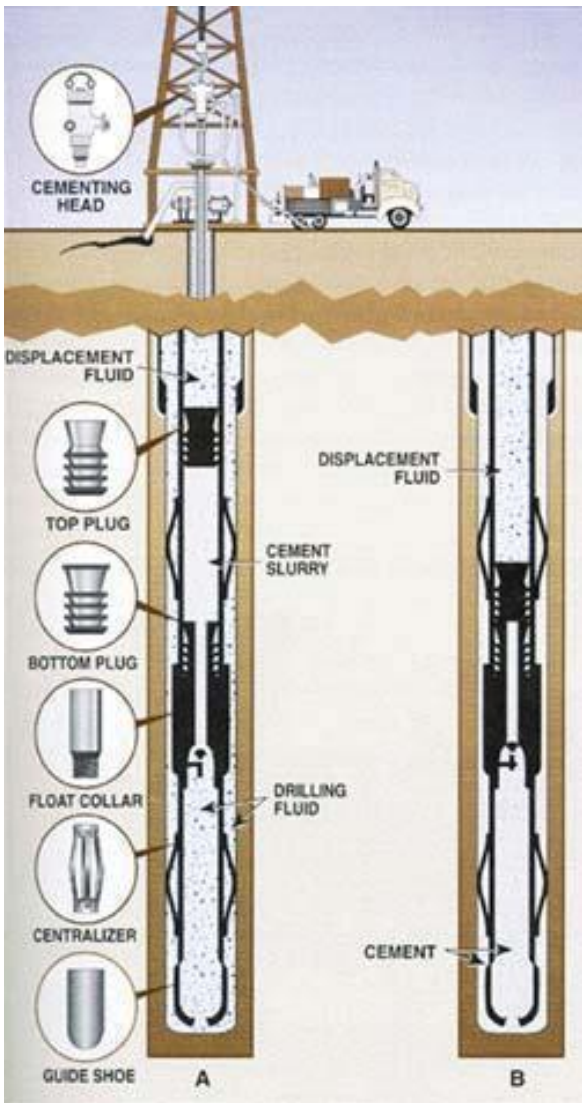
Cementing Tools



Video

193

Cementing


CEMENTING HEAD
DISPLACEMENT FLUID
TOP PLUG
BOTTOM PLUG
FLOAT COLLAR
CENTRALIZER
GUIDE SHOE
CEMENT SLURRY
DRILLING FLUID
DISPLACEMENT FLUID
CEMENT
A
B

Surface Casing

Video

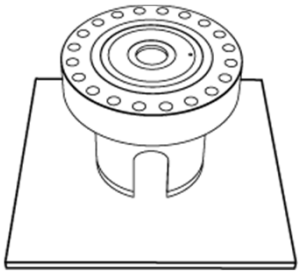
194

Running Casing

Video

195

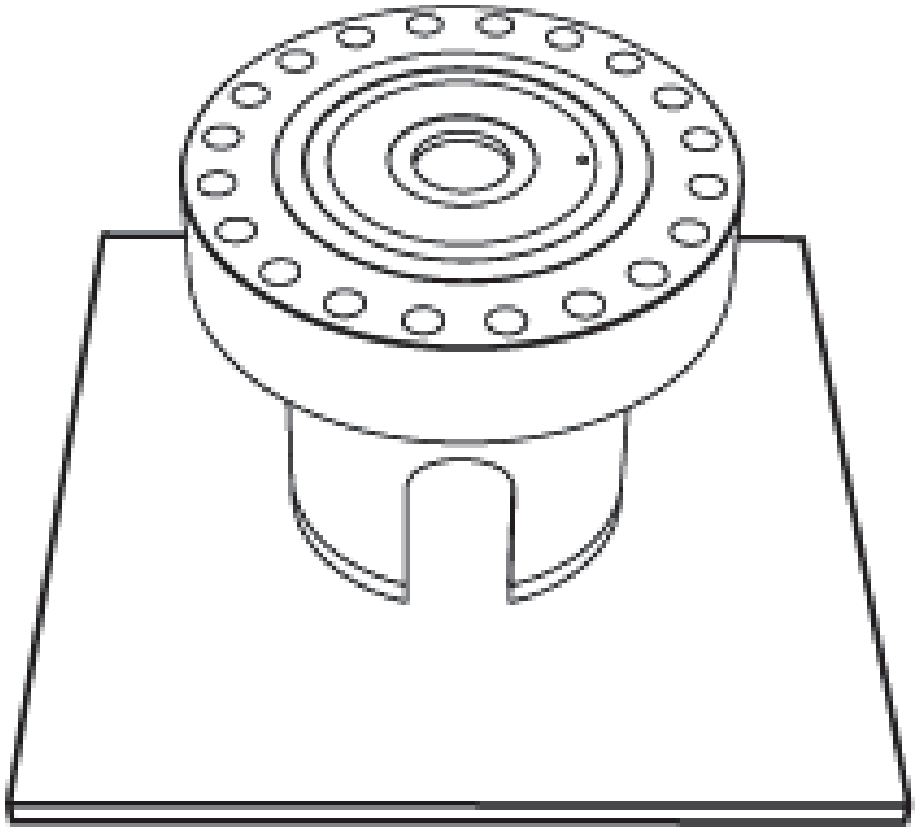
Flange Welded on Casing



196

After cementing surface, the long bell nipple is removed and the casing is cut off just below ground level (in the cellar). A flange, called the bradenhead is welded on.
The flange is where the blow out preventer is positioned and bolted on to. The blow out preventer is supported using turn buckles attached to the substructure.

Flange Welded on Casing



Blow-out Preventers (BOP)

Video

197

Video

198

199

200

A **blowout preventer** is a large, specialized valve used to seal, control and monitor oil and gas wells.

The primary functions of a blowout preventer system are to:

Confine well fluid to the wellbore;

Provide means to add fluid to the wellbore;

Allow controlled volumes of fluid to be withdrawn from the wellbore.

201

Regulate and monitor wellbore pressure;

Center and hang off the drill string in the wellbore;

Shut in the well (e.g. seal the void, annulus, between drillpipe and casing);

"Kill" the well (prevent the flow of formation fluid, influx, from the reservoir into the wellbore) ;

Seal the wellhead (close off the wellbore);

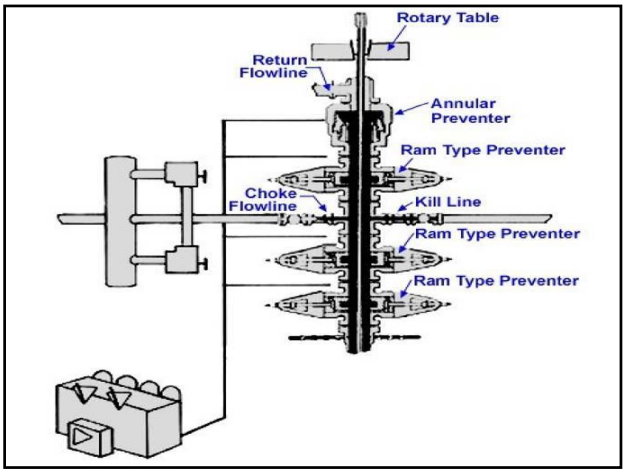
Sever the casing or drill pipe (in case of emergencies).

202

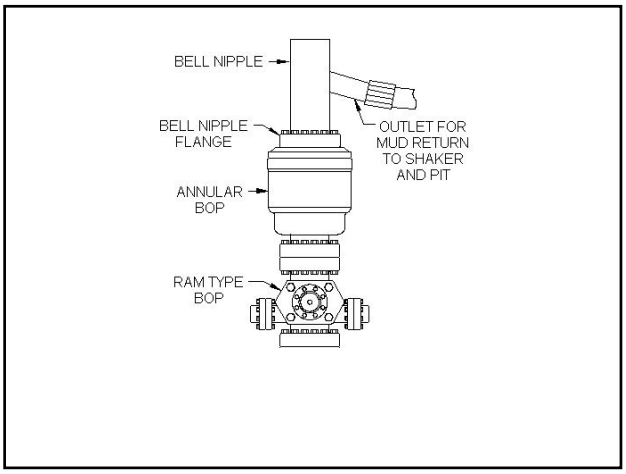
BOP Stack

203

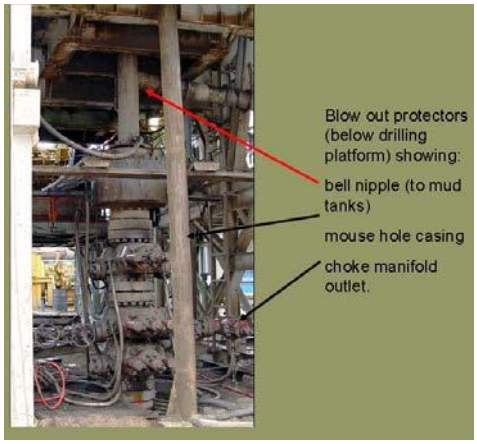
All of the rams and Annular together make up a BOP Stack.



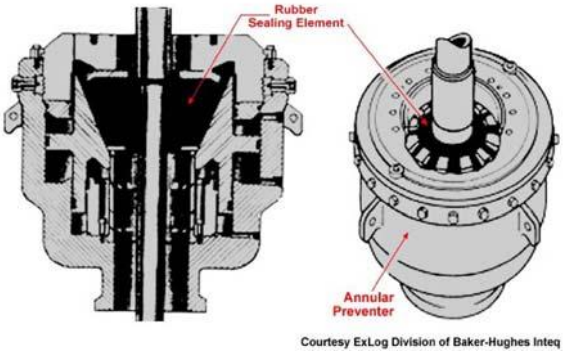
204



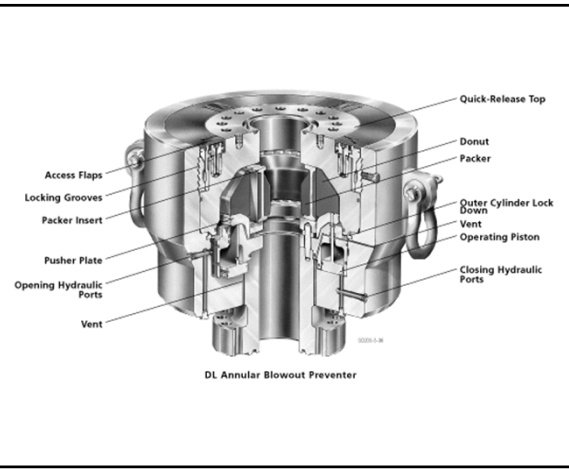
205


Blow out protectors (below drilling platform) showing:
bell nipple (to mud tanks)
mouse hole casing
choke manifold outlet.

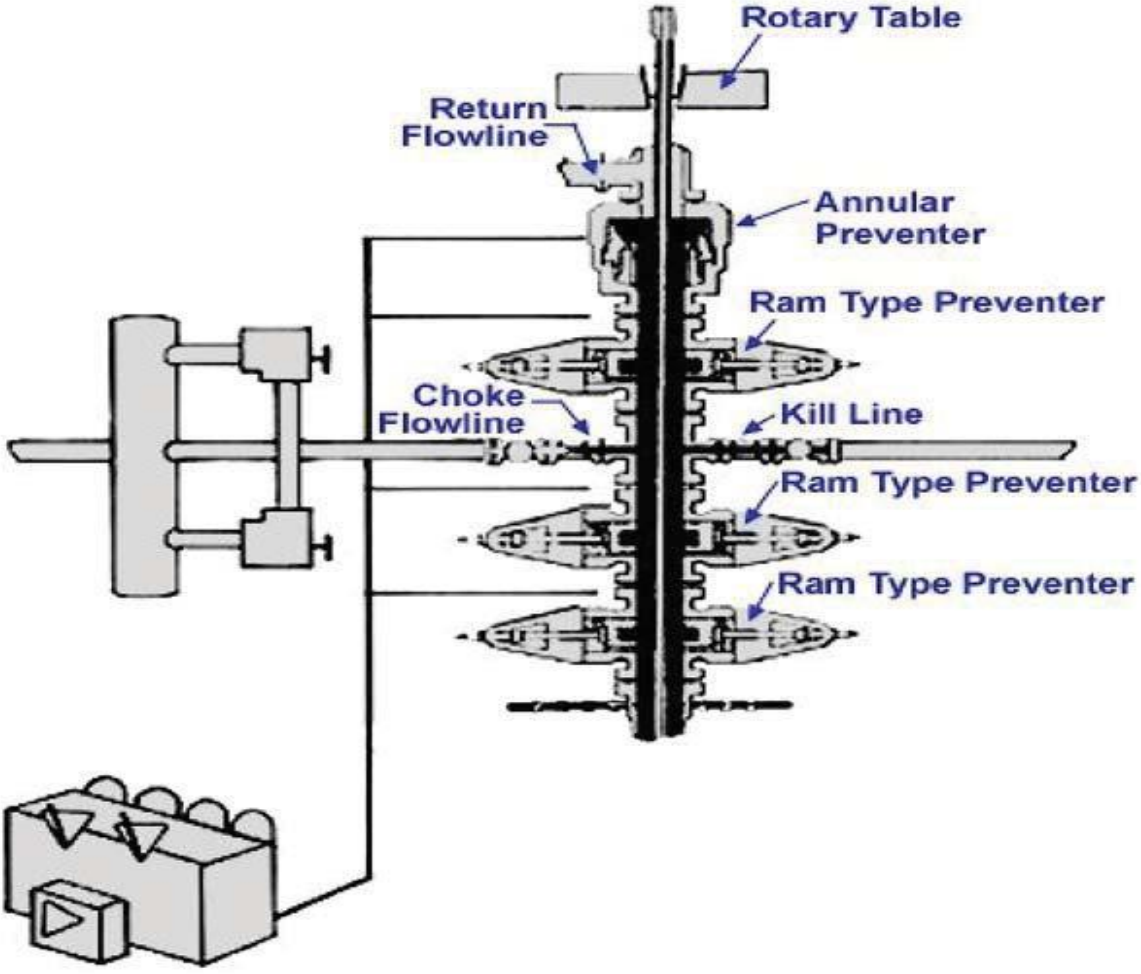
206

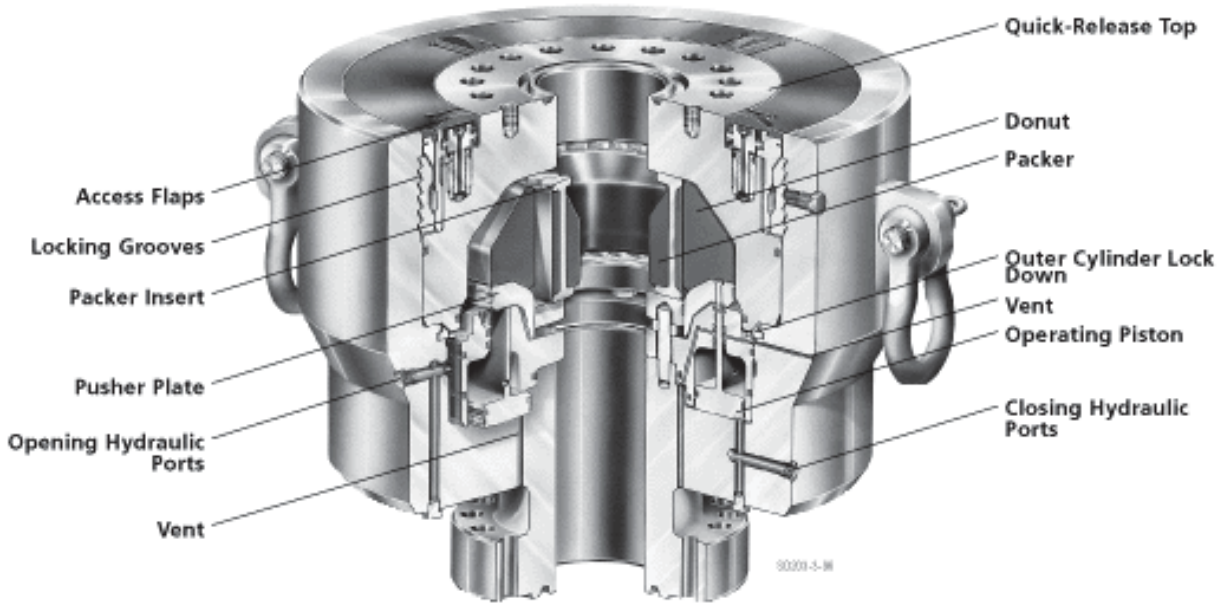

Rubber Sealing Element
Annular Preventer
Courtesy ExLog Division of Baker-Hughes Inteq

207

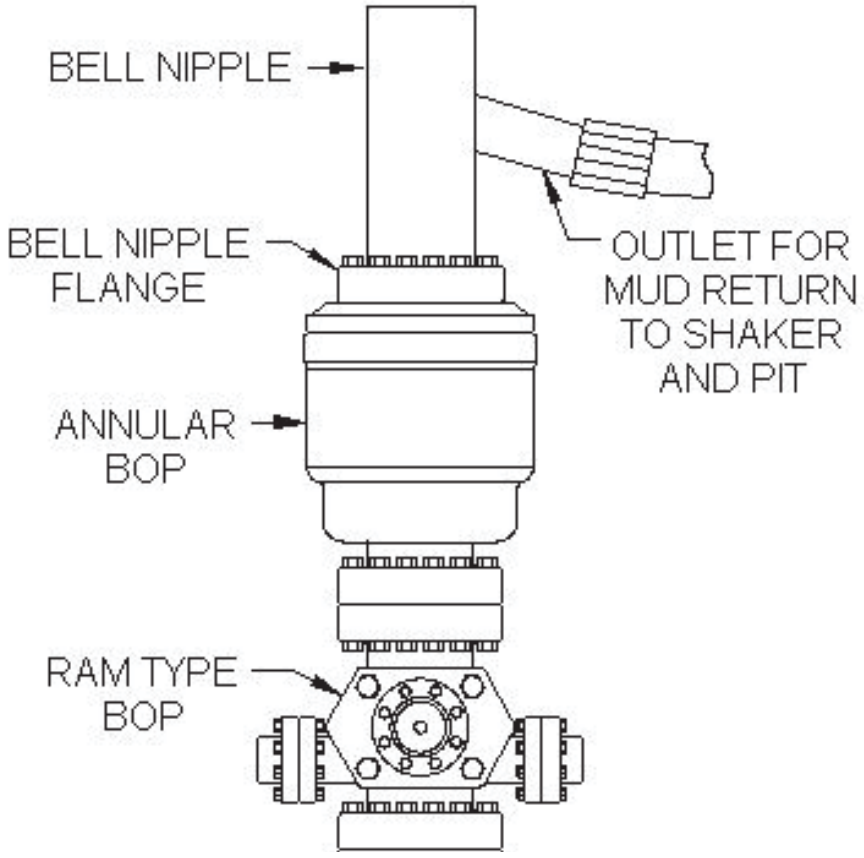

Quick-Release Top
Donut
Packer
Access Flaps
Locking Grooves
Packer Insert
Outer Cylinder Lock Down
Vent
Operating Piston
Pusher Plate
Opening Hydraulic Ports
Closing Hydraulic Ports
Vent
DL Annular Blowout Preventer

208


Rotary Table
Return Flowline
Annular Preventer
Ram Type Preventer
Choke Flowline
Kill Line
Ram Type Preventer
Ram Type Preventer



DL Annular Blowout Preventer

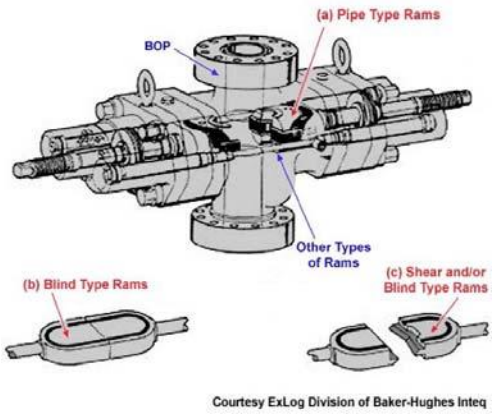


Blow out protectors (below drilling platform) showing:

bell nipple (to mud tanks)

mouse hole casing

choke manifold outlet.



209

Pipe rams close around a drill pipe, restricting flow in the annulus (ring-shaped space between concentric objects) between the outside of the drill pipe and the wellbore, but do not obstruct flow within the drill pipe. Variable-bore pipe rams can accommodate tubing in a wider range of outside diameters than standard pipe rams, but typically with some loss of pressure capacity and longevity.

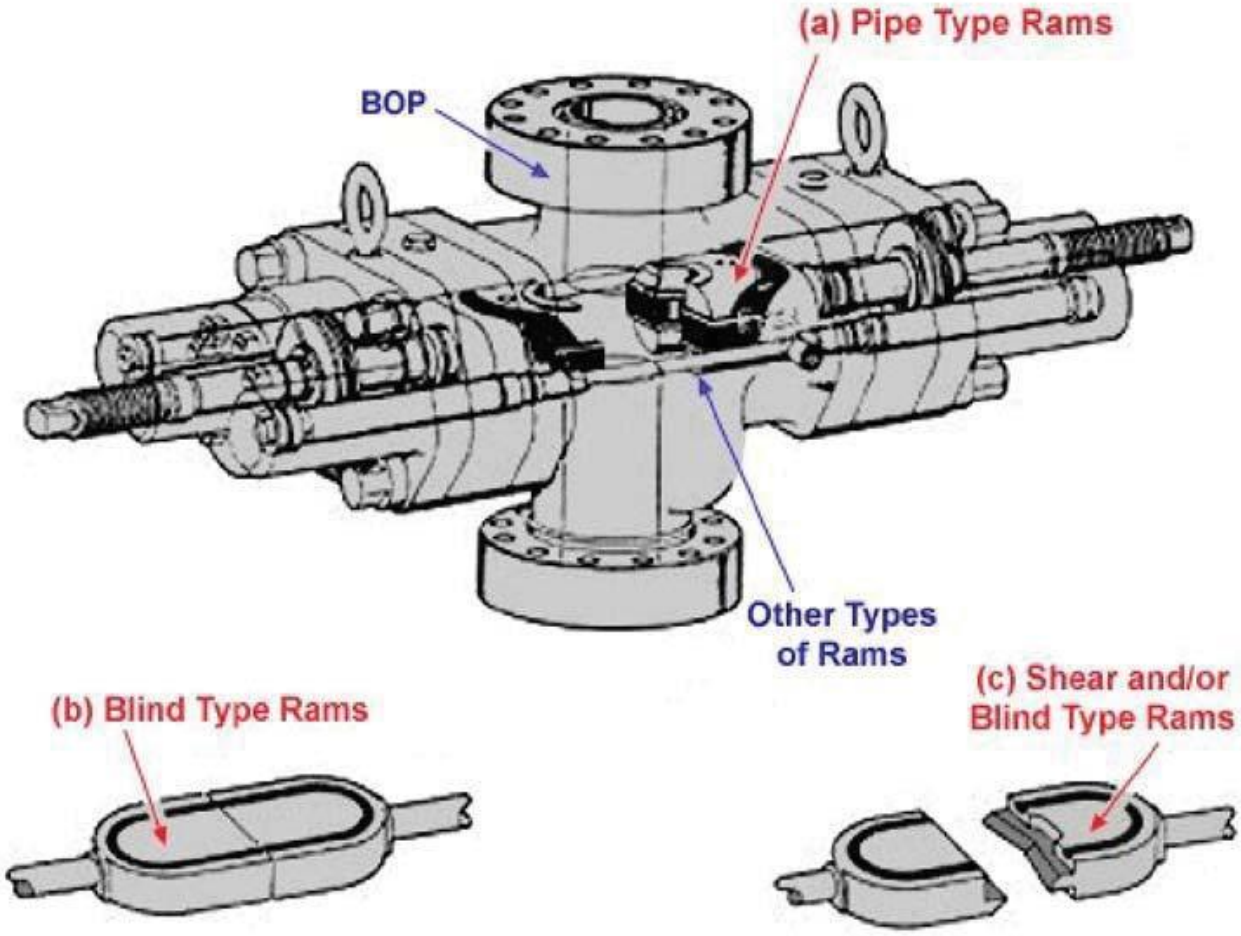
Blind rams (also known as sealing rams), which have no openings for tubing, can close off the well when the well does not contain a drill string or other tubing, and seal it.

210

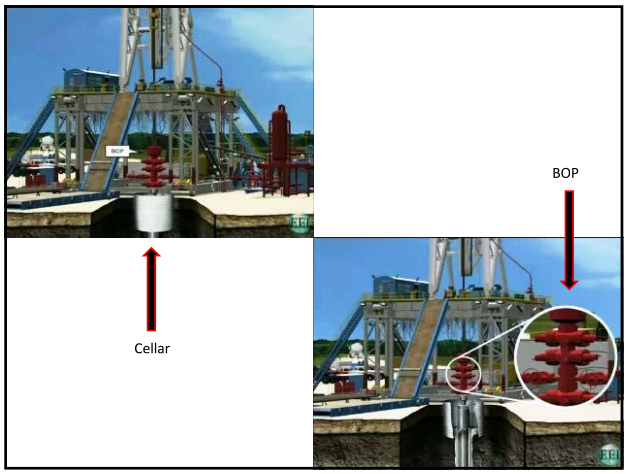
Shear rams cut through the drill string or casing with hardened steel shears.

Blind shear rams (also known as shear seal rams, or sealing shear rams) are intended to seal a wellbore, even when the bore is occupied by a drill string, by cutting through the drill string as the rams close off the well. The upper portion of the severed drill string is freed from the ram, while the lower portion may be crimped and the "fish tail" captured to hang the drill string off the BOP.

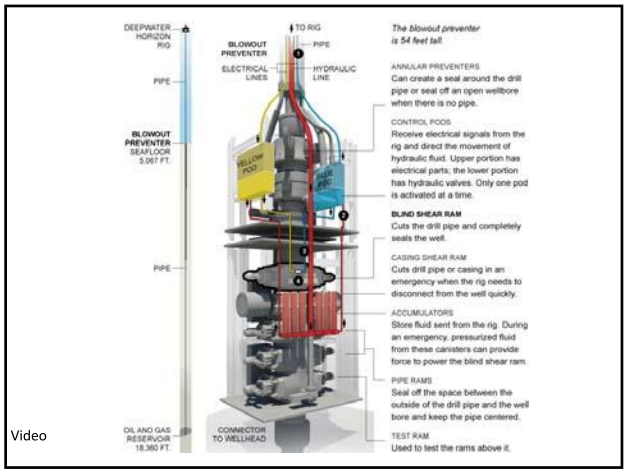
211



Courtesy ExLog Division of Baker-Hughes Inteq



212

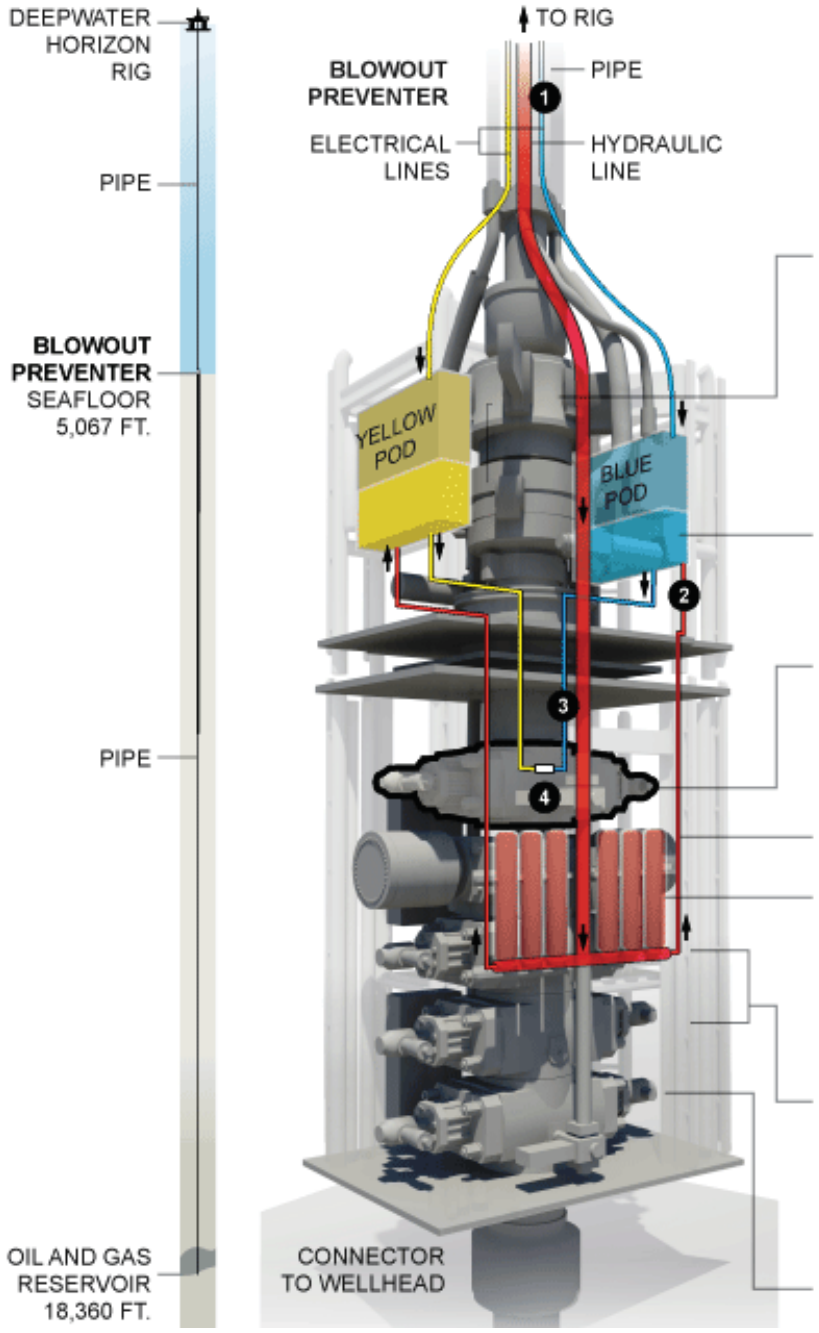


Video

213

Accumulators

214



The blowout preventer is 54 feet tall.

ANNULAR PREVENTERS
Can create a seal around the drill pipe or seal off an open wellbore when there is no pipe.

CONTROL PODS
Receive electrical signals from the rig and direct the movement of hydraulic fluid. Upper portion has electrical parts; the lower portion has hydraulic valves. Only one pod is activated at a time.

BLIND SHEAR RAM
Cuts the drill pipe and completely seals the well.

CASING SHEAR RAM
Cuts drill pipe or casing in an emergency when the rig needs to disconnect from the well quickly.

ACCUMULATORS
Store fluid sent from the rig. During an emergency, pressurized fluid from these canisters can provide force to power the blind shear ram.

PIPE RAMS
Seal off the space between the outside of the drill pipe and the well bore and keep the pipe centered.

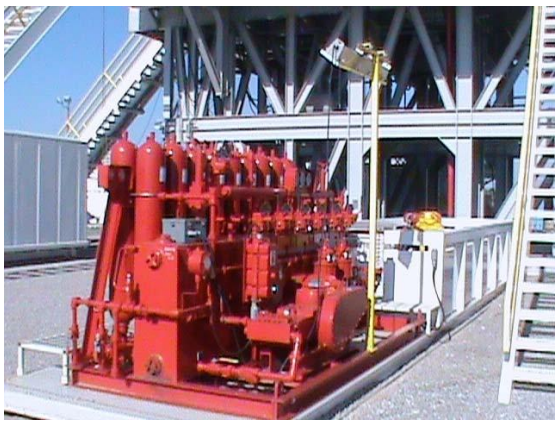
TEST RAM
Used to test the rams above it.

Accumulators

215

Accumulators can be electric or hydraulic. Most land rigs are hydraulic. They can be located inside the substructure or out in front of the rig like shown in the picture. They close the rams and hydrill.

216



217

218

A remote control unit is placed on the rig floor or inside the top doghouse for quick access during emergencies. There is a delay when activating.

Choke Manifold and Gas Separators

219

There is a line from the BOP that goes to a choke manifold to a gas separator where gas can be bled off. Sometimes the choke manifold goes directly to the mud pit.

220

Functions of Drilling Mud

- Remove cuttings from well
- Control formation pressures
- Seal permeable formations
- Maintain wellbore stability

221

Functions of Drilling Mud

- Cool, lubricate, and support the bit and drilling assembly
- Transmit hydraulic energy to tools and bit
- Ensure adequate formation evaluation
- Control corrosion (in acceptable level)

222

Functions of Drilling Mud

- Facilitate cementing and completion
- Minimize impact on environment

223

Composition of Drilling Mud
Most Common Ingredients

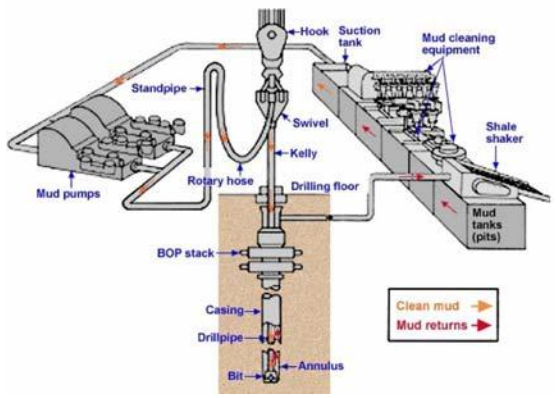
- **Bentonite Clay (Gel)**
- **Barium Sulfate (Barite)**
- **Calcium Carbonate (Chalk) Or Hematite**

224

Composition of Drilling Mud
Most Common Ingredients

Various thickeners are used to influence the viscosity of the fluid, e.g. xanthan gum, guar gum, glycol, carboxymethcellulose, polyanionic cellulose (PAC), or starch. In turn, deflocculants are used to reduce viscosity of clay-based muds; anionic polyelectrolytes are frequently used.

225

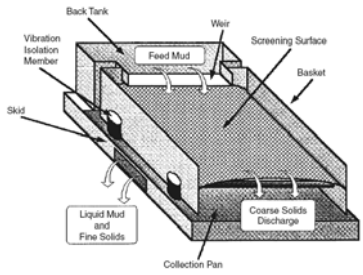


Video

226

This is the Circulating System of an Oil and Gas well.

Shale Shaker



227

Shale Shaker

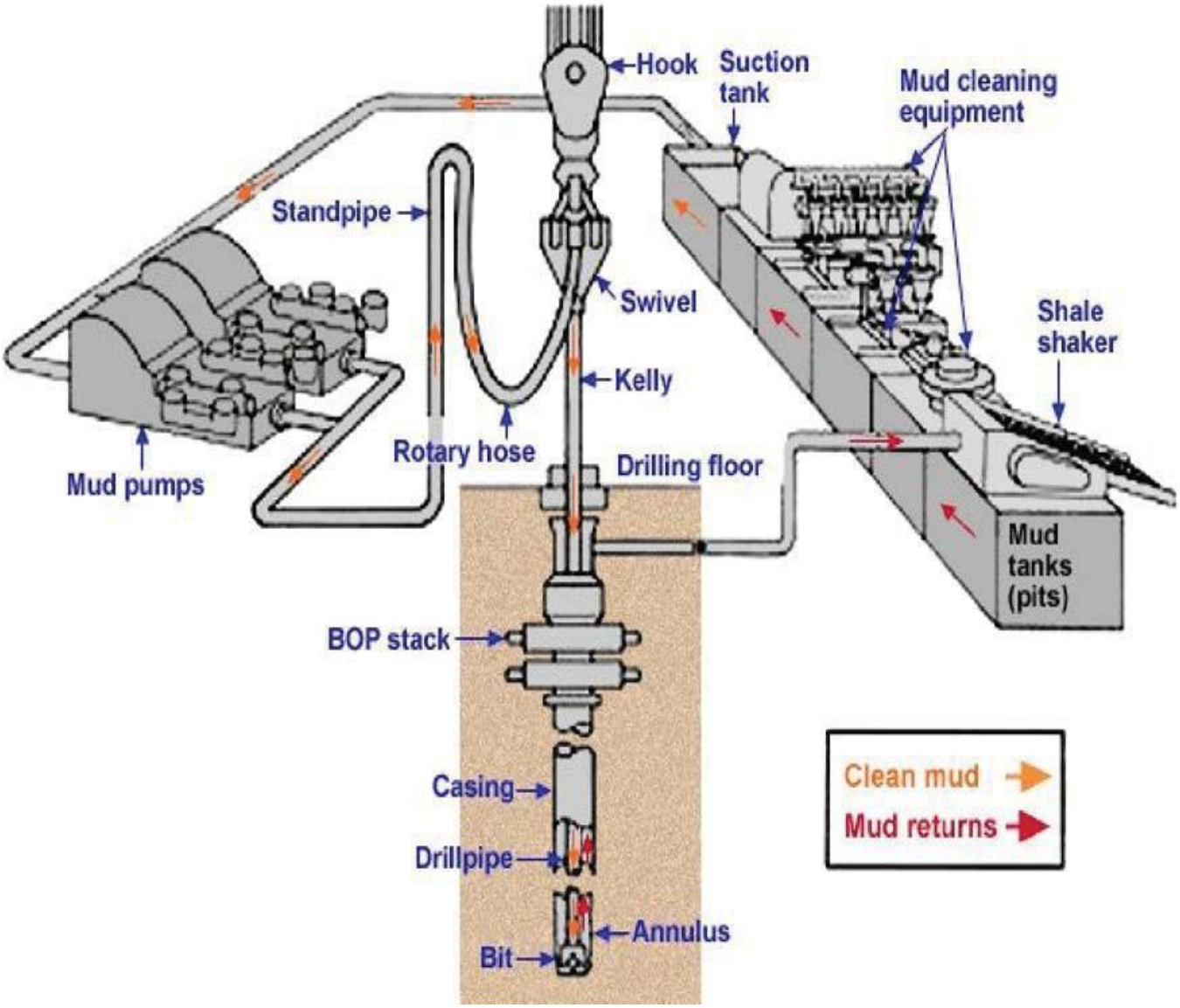
Video

228

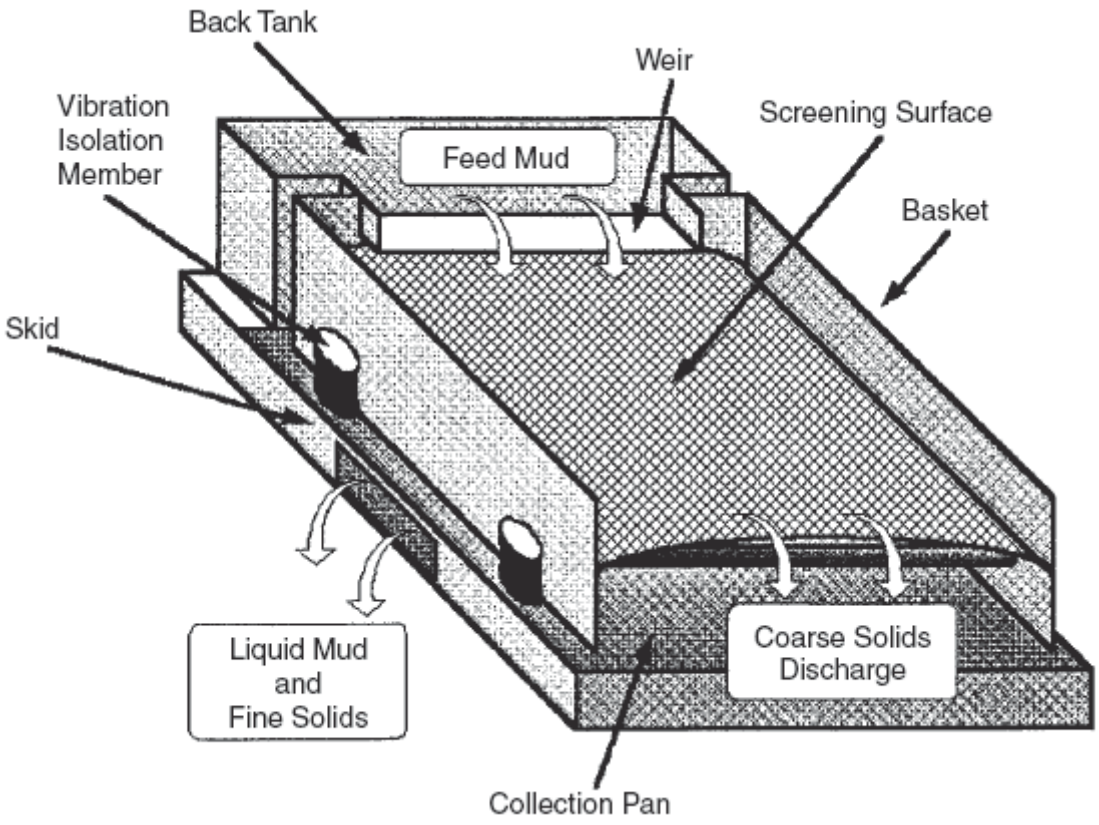
Hopper to Mix Mud

Electric Pump

229


Hook
Suction tank
Mud cleaning equipment
Standpipe
Swivel
Shale shaker
Kelly
Rotary hose
Drilling floor
Mud pumps
Mud tanks (pits)
BOP stack
Casing
Drillpipe
Annulus
Bit
Clean mud
Mud returns

Shale Shaker



Hopper to Mix Mud

230

The Hopper is where the chemicals are mixed. They are usually covered to prevent the chemicals from getting wet.

Caustic Soda Barrel

231

Caustic soda is one of the common names for sodium hydroxide. It is a corrosive.

Tripping Out Pipe

Video

232

There are several reasons to "Trip Pipe" or take all the pipe out. Run casing (i.e.Surface, Intermediate, and Final), Replace a Drill Bit, lost of pump pressure wash-out), specialized tools.

Tripping Out Pipe (1)

Video

233

Tripping Out from Derrick (2)

Video

234

Tripping in from Derrick (3)

Video

235

Running Collars in the Hole

Video

236

Running Collars in the Hole

Video

237

Tripping back into the Hole

Video

238

Help!!!

Video

239

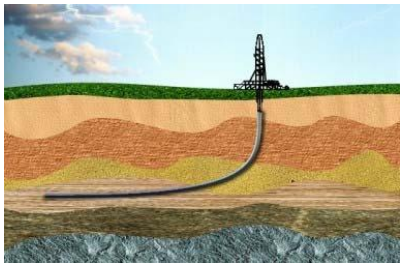
What are they doing here?

Video

240

On Top drive rigs the driller does most of the work during connections. Top drive units can connect 3 joints at a time.

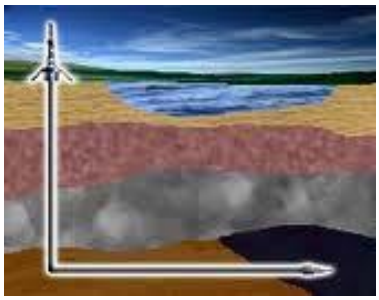
Directional and Horizontal Drilling



Video

241

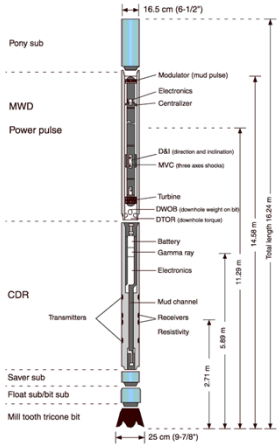
Extreme Horizontal Drilling



Video

242

Measurement While Drilling (MWD)



Video

243

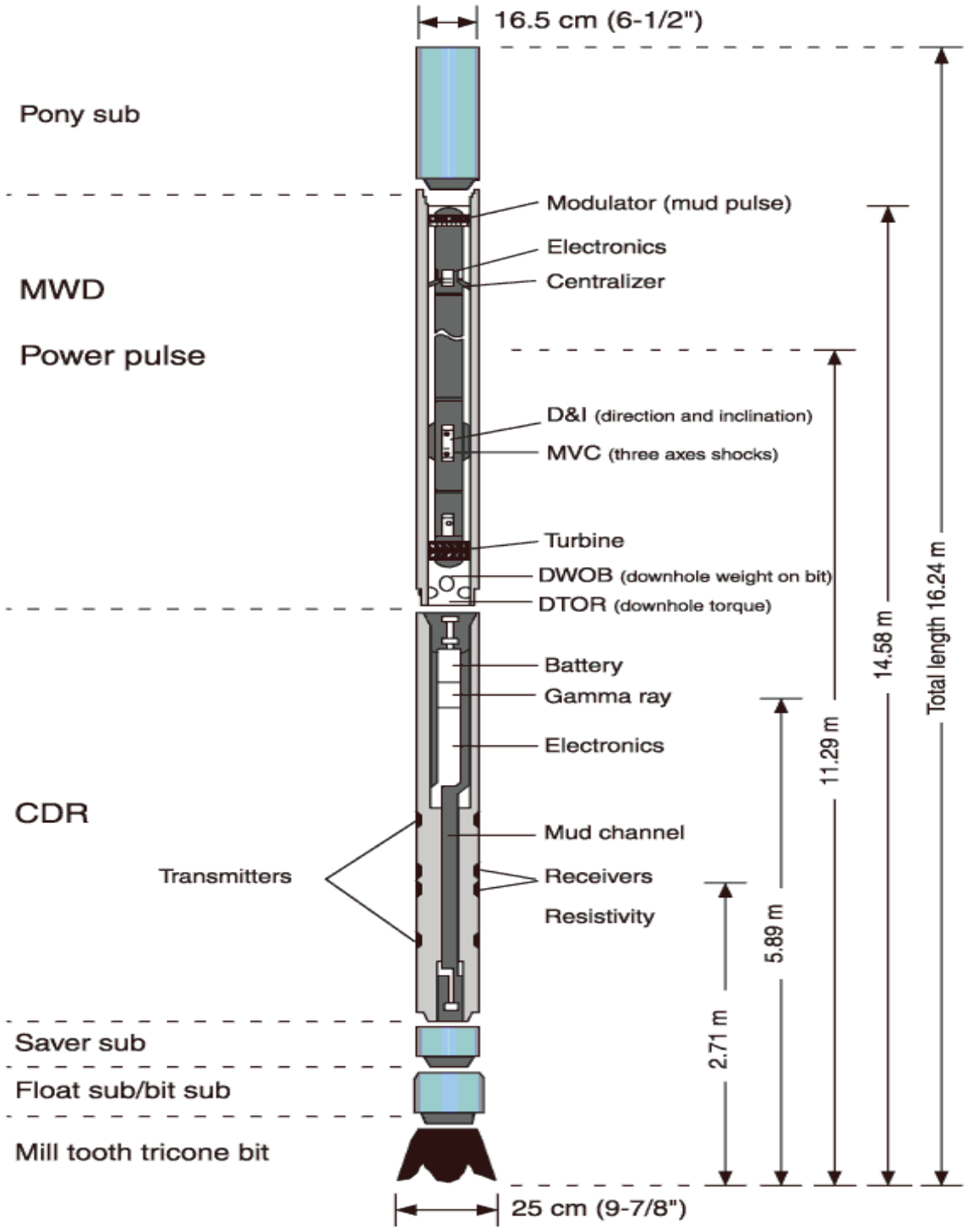
MWD stands for Measurement While Drilling in the oil & gas industry. A directional driller needs to know about the ground formations that they are drilling through. MWD provides this information. Previous to MWD measurements were taken at various parts of the drilling process, but MWD has allowed these measurements to be sent to the surface continuously while the hole is being drilled. This allows for faster drilling, more accurate drilling, and safer drilling.

(MWD)

Video

244

Measurement While Drilling (MWD)



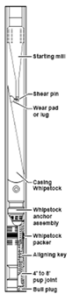
Measurement While Drilling (MWD)

Video

245

MWD systems can take several measurements such as Gamma Ray, compass direction(shown as azimuth), tool face (the direction that your bit is pointing), borehole pressure, temperature, vibration, shock, torque, etc. The MWD also provides the means of communication for operating rotary steering tools (RSTs).The measured results are stored in MWD tools and some of the results can be transmitted digitally to surface using mud pulser telemetry through the mud or other advanced technology such as electromagnetic (EM) frequency communications or wired drill pipe.

Whipstock



Video

246

Long steel casing that uses an inclined plane to cause the bit to deflect from the original borehole at a slight angle. Whipstocks are sometimes used in controlled directional drilling, in straightening crooked boreholes, and in sidetracking to avoid un-retrieved fish.

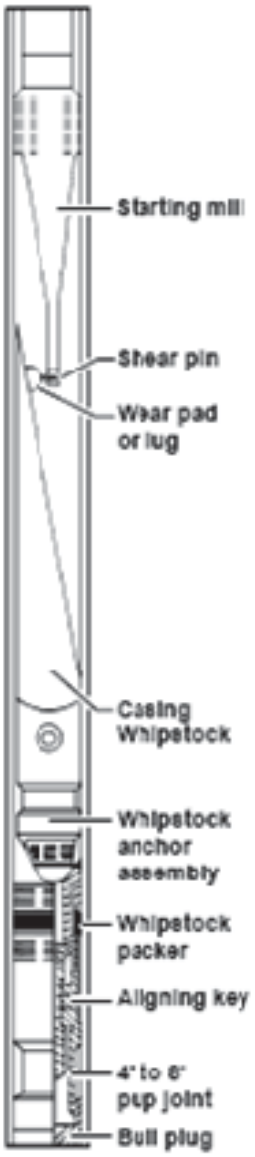
Coring

Video

247

Coring provides operators with a reliable means of correlating their conventional logs with actual subsurface conditions.

Whipstock


Starting mill
Shear pin
Wear pad
or lug
Casing
Whipstock
Whipstock
anchor
assembly
Whipstock
packer
Aligning key
4' to 6'
pup joint
Bull plug

Core

248

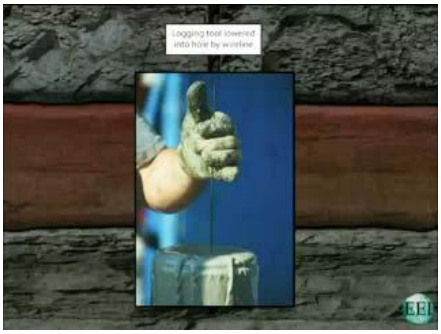
Because of the core weight, cores are broken off in sections on the rig floor and usually laid out on the catwalk, packaged, and sent off to a lab.

Well Logging

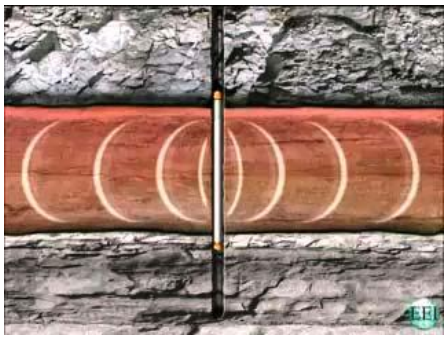
Video

249

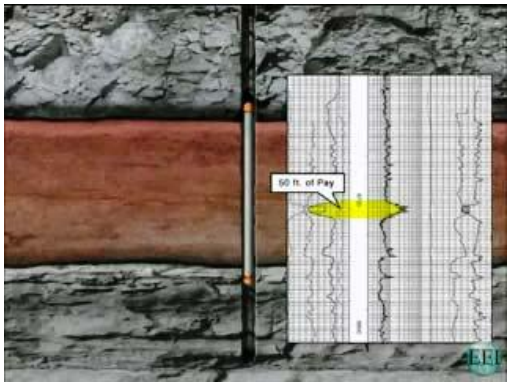
The oil and gas industry records rock and fluid properties to find hydrocarbon zones in the geological formations intersected by a borehole. The logging procedure consists of lowering a 'logging tool' on the end of a wireline into an oil well to measure the rock and fluid properties of the formation. An interpretation of these measurements is then made to locate and quantify potential depth zones containing oil and gas (hydrocarbons).



250



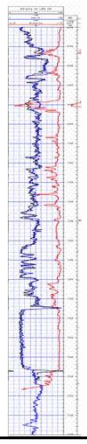
251



252

Neutron porosity measurement employs a neutron source to measure the hydrogen index in a reservoir, which is directly related to porosity. The Hydrogen Index (HI) of a material is defined as the ratio of the concentration of hydrogen atoms per cm3 in the material,to that of pure water at 75oF. As hydrogen atoms are present in both water and oil filled reservoirs, measurement of the amount allows estimation of the amount of liquid-filled porosity. Density porosity measurement. The bulk density of soil depends greatly on the mineral make up of soil and the degree of compaction. What loggers look for is the crossover.

Well Logging



253

Down-Hole problems

Video

254

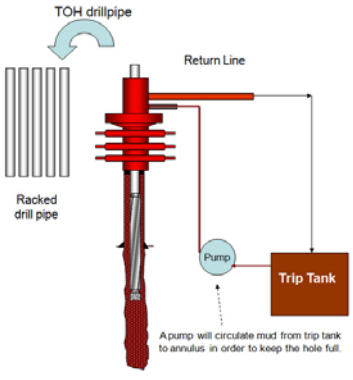
Trip Tank

Trip tank: A small mud tank with a capacity of 10 to 15 barrels, usually with 1-barrel or h-barrel divisions, used to ascertain the amount of mud necessary to keep the wellbore full with the exact amount of mud that is displaced by drill pipe. when the bit comes out of the hole, a volume of mud equal to that which the drill pipe occupied while in the hole must be pumped into the hole to replace the pipe.

When the bit goes back in the hole, the drill pipe displaces a certain amount of mud, and a **trip tank** can be used again to keep track of this volume.

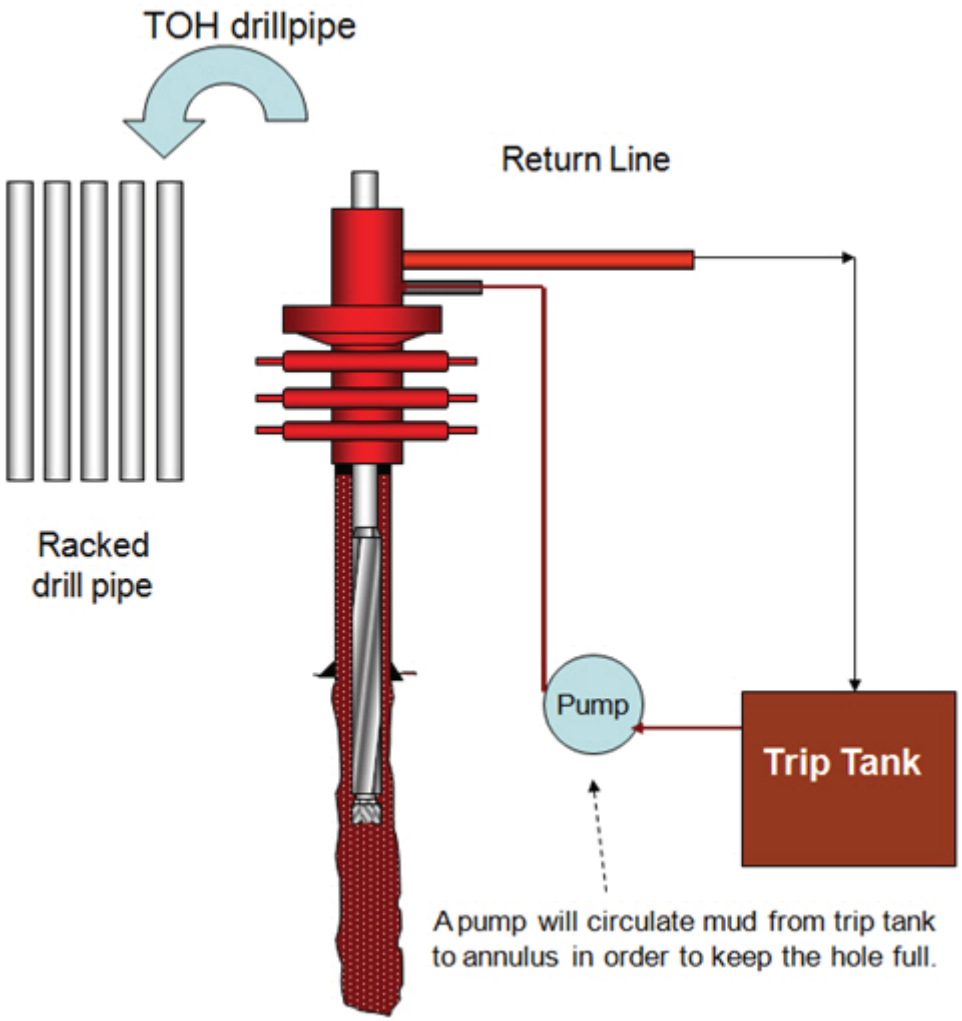
255

Trip Tank



256

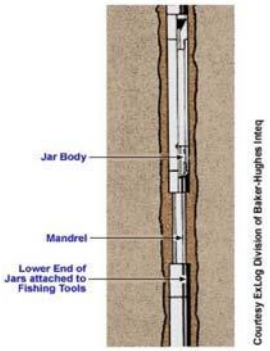
Trip Tank


TOH drillpipe
Return Line
Racked
drill pipe
Pump
Trip Tank
A pump will circulate mud from trip tank
to annulus in order to keep the hole full.

Trip Tank

257

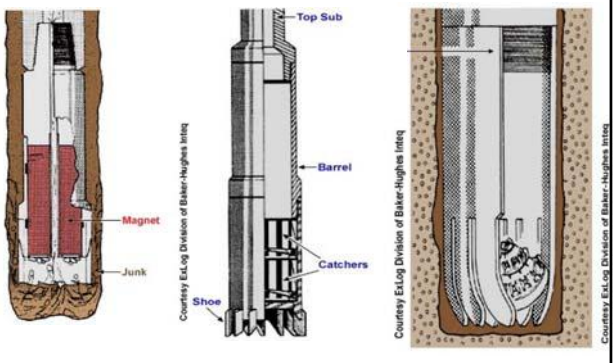
Down-Hole problems-Stuck



Video

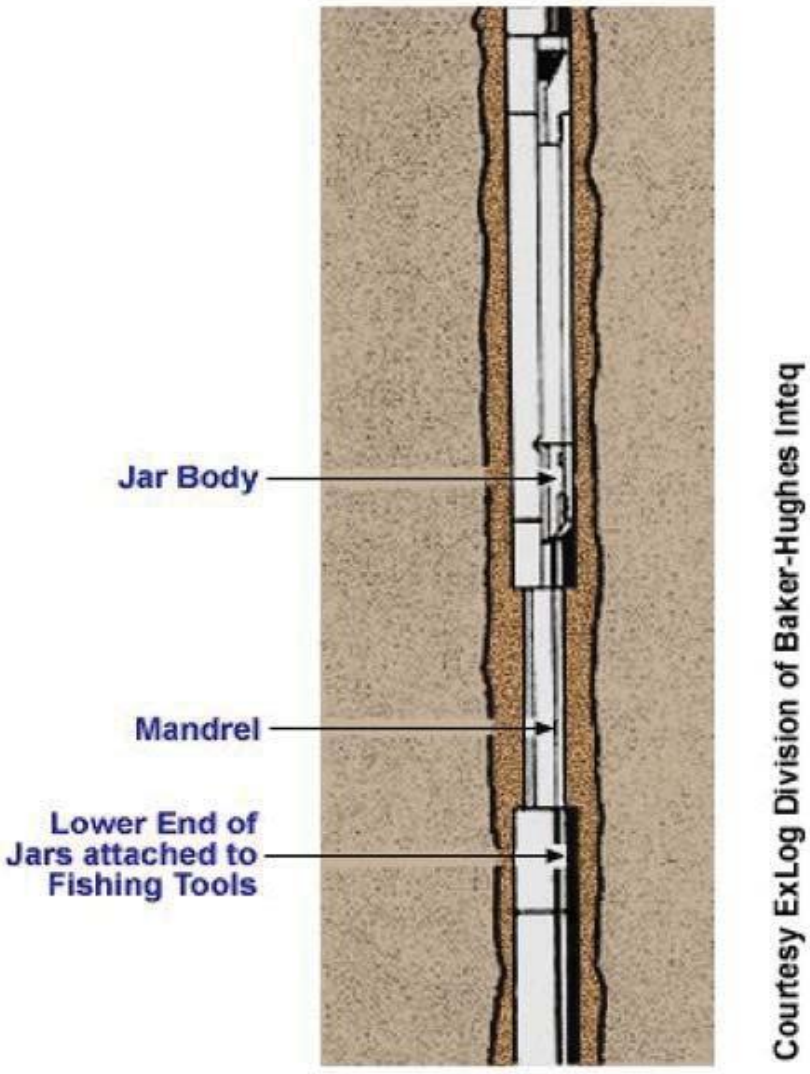
258

Down-Hole problems-Junk

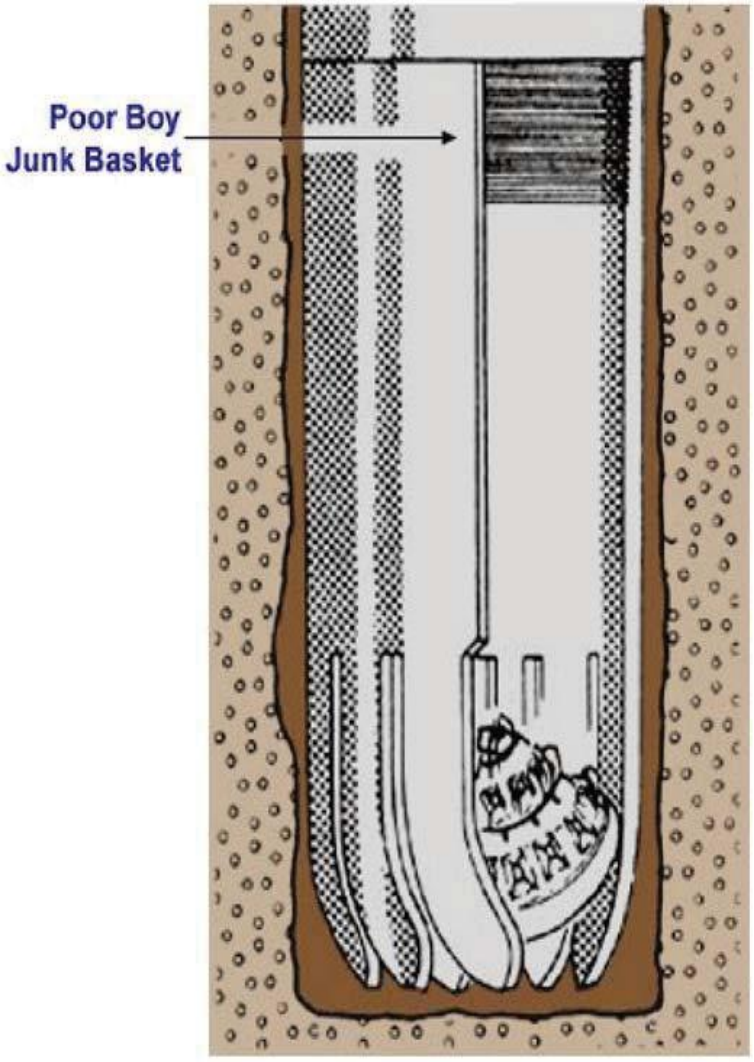


259

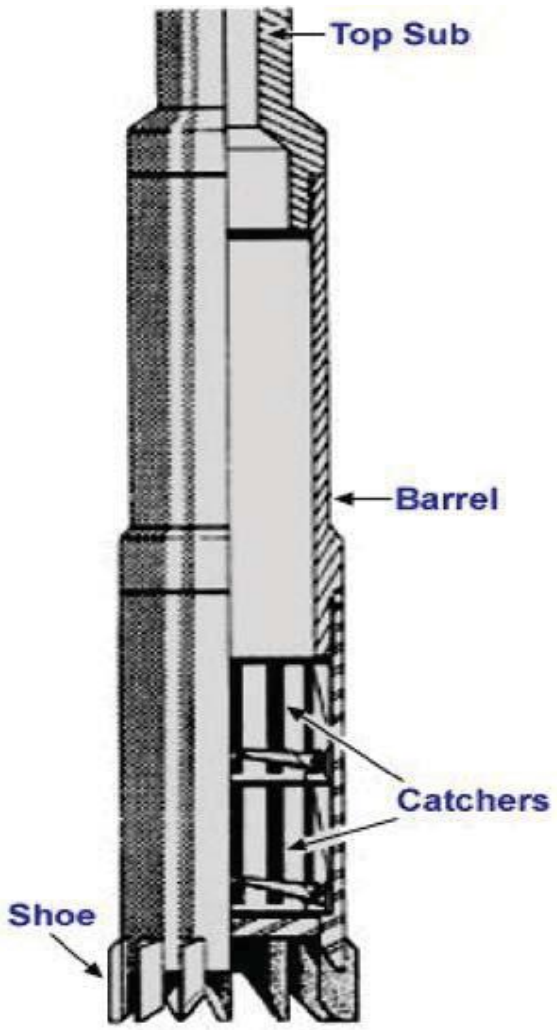
Jars


Jar Body
Mandrel
Lower End of
Jars attached to
Fishing Tools
Courtesy ExLog Division of Baker-Hughes Inteq

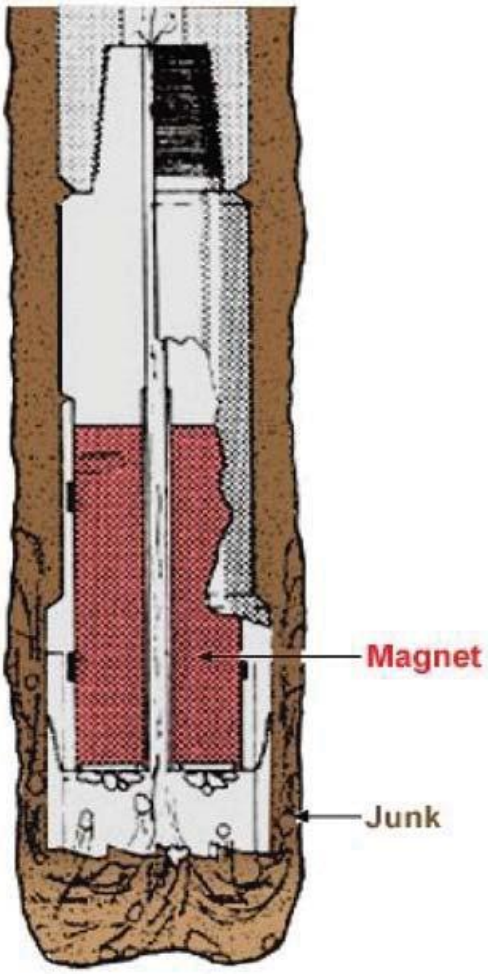
Junk Baskets



Courtesy ExLog Division of Baker-Hughes Inteq

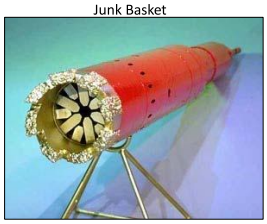


Courtesy ExLog Division of Baker-Hughes Inteq



Courtesy ExLog Division of Baker-Hughes Inteq

Junk Basket



Magnet

Video

260

Down-Hole problems-Fishing

Video

261

Down-Hole problems-Fishing

Video

262

Down-Hole problems- Lost Circulation

Video

263

Final Production Casing

Video

264

Laying the Drill Pipe Down One at a time

Video

265

Video

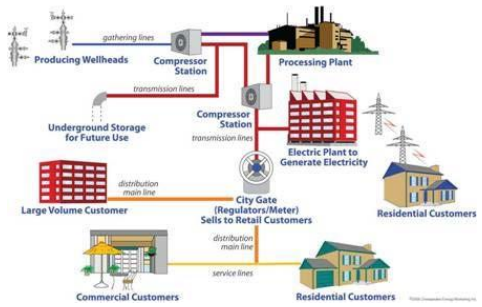
266

Hydraulic Fracturing

Video

267

The Flow

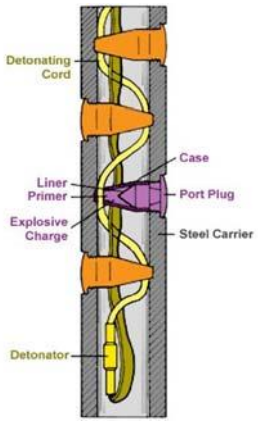


268

Eagleford Fracking

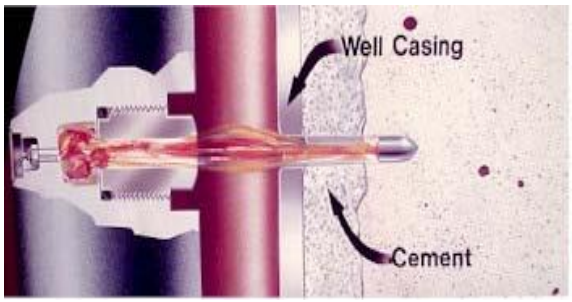
- Currently, operators are implementing between 15 to 20 frac stages per well drilled in order to optimize reservoir recovery. This higher number of frac stages undertaken (relative to practices one year ago) is placing a slight bottleneck on completions and is fostering an environment for price escalation. Based on this environment, adding a 10% to 15% premium to our price estimates above (from early 2011 observations) may be more indicative of what operators will spend this summer to drill & complete an Eagle Ford well.
- A majority of wells being drilled in the Eagle Ford are targeting depths between 9,000 to 16,000 feet, with horizontal laterals ranging from 5,000 to 7,000 feet. Currently, target depths for E&P firms drilling for oil are greatest in Live Oak County at 13,250 feet versus an average target depth of 11,550 feet across all counties drilling for oil.

269



270

Perforating Gun



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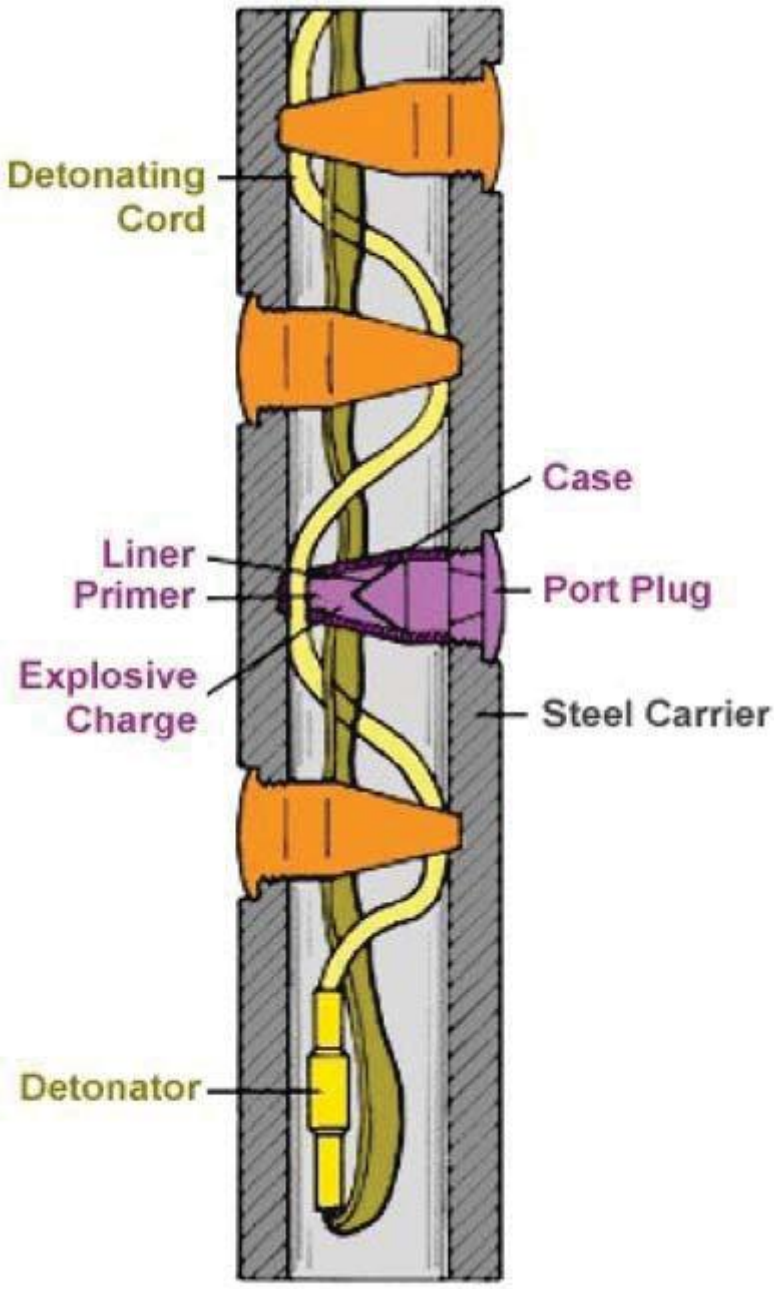
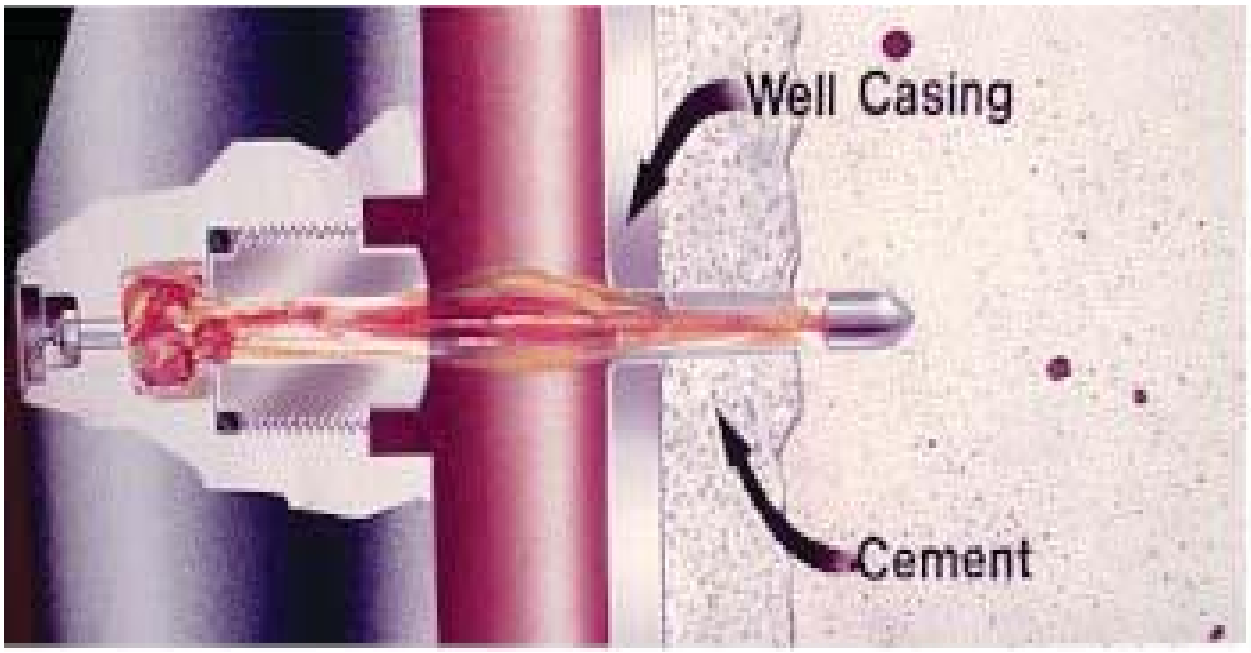
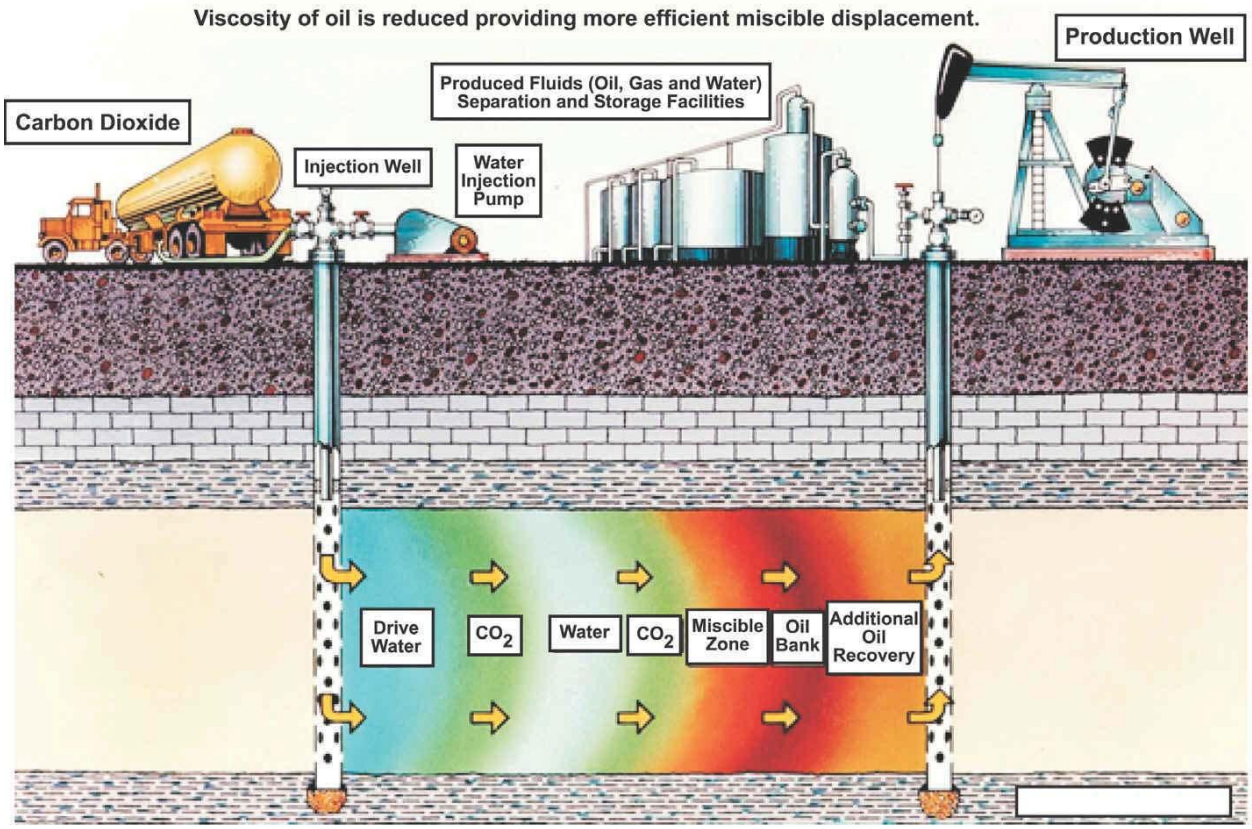
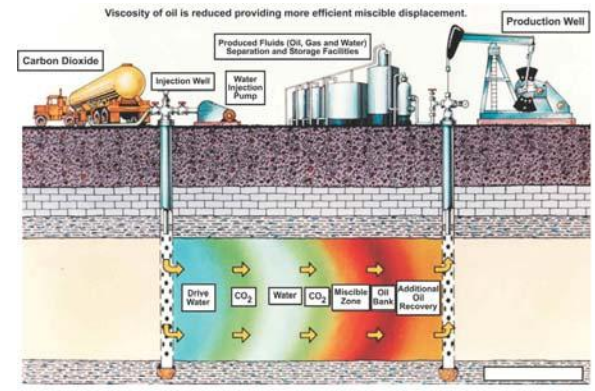
Perforating Gun




Well Casing
Cement

CO2 Injection





Video

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Bubbles in the Susquehanna River

Video

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Shallow Gas

Video

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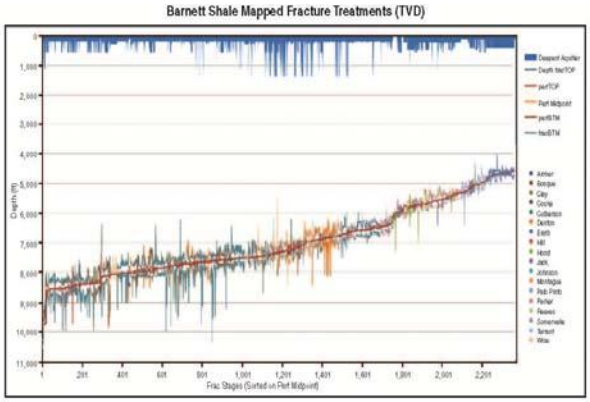

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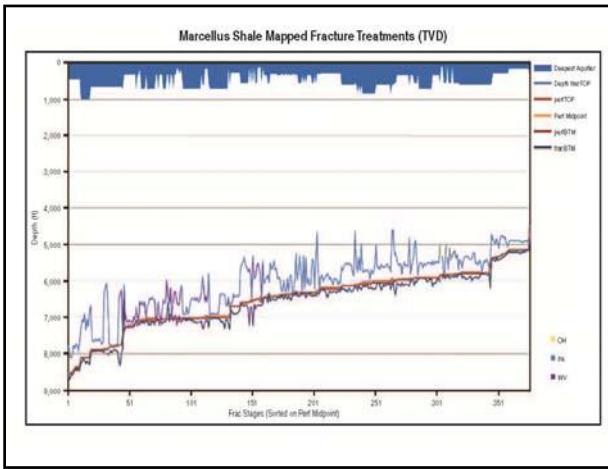

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Cementing

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Cementing
Mitigating casing vent flows

- Poor mud displacement in the primary cement placement.
- Cement sheath failure, commonly reference to as sheath cracking.
- Gas migration through the setting cement creating gas channels in the cement.
- Low cement top.

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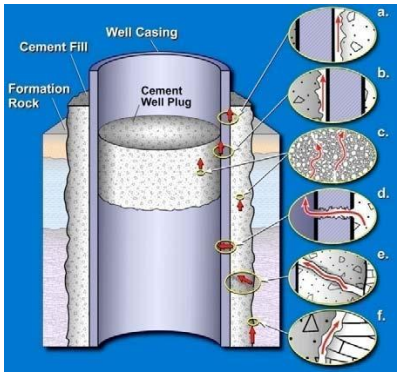
Possible leakage pathways in an abandoned well.



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Water Usage

ESTIMATED WATER NEEDS FOR DRILLING AND FRACTURING WELLS IN SELECT SHALE GAS PLAYS

Shale Gas Play	Volume of Drilling Water per well (gal)	Volume of Fracturing Water per well (gal)	Total Volumes of Water per well (gal)
Barnett Shale	400,000	2,300,000	2,700,000
Fayetteville Shale	60,000*	2,900,000	3,060,000
Haynesville Shale	1,000,000	2,700,000	3,700,000
Marcellus Shale	80,000*	3,800,000	3,880,000

* Drilling performed with an air "mist" and/or water-based or oil-based muds for deep horizontal well completions.
Note: These volumes are approximate and may vary substantially between wells.
Source: "Modern Shale Gas, A Primer", p. 64

Source: Oklahoma Corporation Commission

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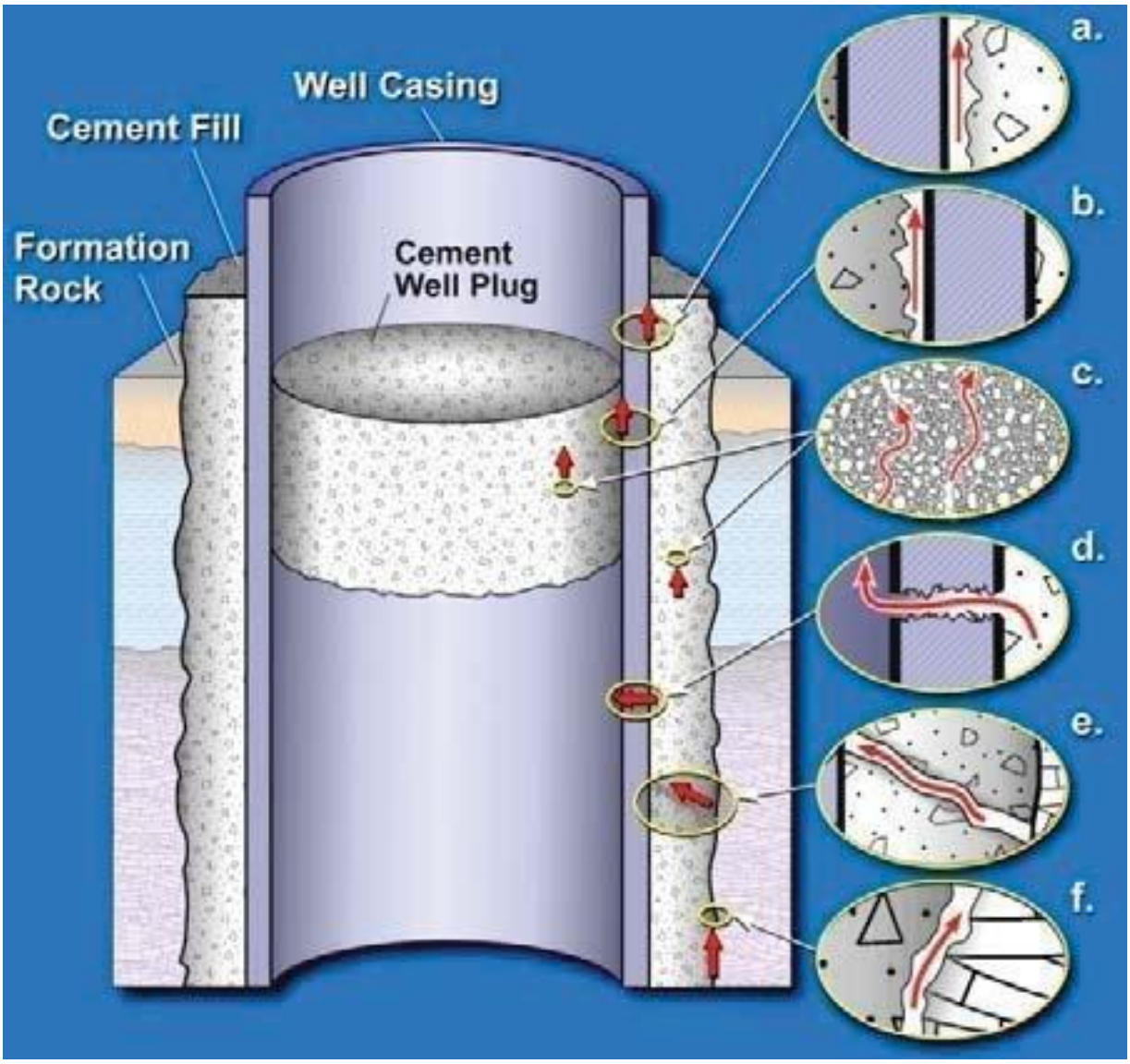
Possible leakage pathways



Web Site FracFocus

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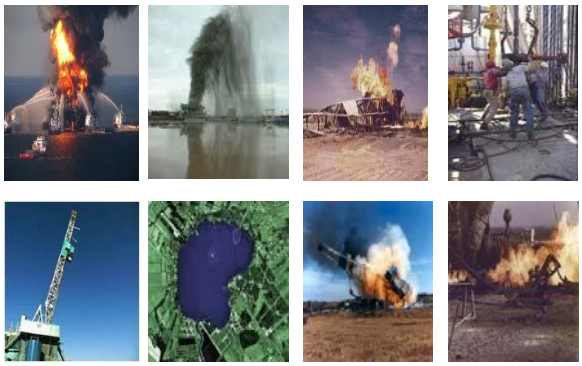
Accidents on Rigs



Video

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Long-Term Explosure

Video

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Over pulling

Video

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Saturday, June 11, 2011

- Two Big Spring men were killed Saturday morning in an oilfield incident near Lamesa in Dawson County, the result of an accident on a Robinson Drilling Company platform.
- Jason Bolt, 25, and Sandy Daves, 28, were killed when bushings on the oil rig they were working on failed, according to members of the victims' families.
- Robinson drilling has been plagued by a number of oilfield accidents during the past year. In June of 2010, two Robinson Drilling employees were rushed to Midland Memorial Tuesday following an accident at a oil derrick located 10 miles north of Midland in Glasscock County. According to officials with Robinson Drilling, neither man sustained life threatening injuries in the accident.
- In April 2010, William Ryan Locke, 35, died following an oil rig drilling accident at a location between Midland and Gardendale. Locke was believed to have been working from a ladder on the drilling rig when a piece of high pressure pipe broke away, releasing enough pressure in the Big Spring man's direction to knock him from the ladder and platform.

285

Safety On Drilling Rigs

- Never go unescorted to any rig floor.
- Always be aware of your surroundings
- Listen for alarms – or verbal warnings
- Distractions and complacency kills

286

Hydrogen Sulfide (H_2S)

- Low 0-10 ppm
  Irritation of the eyes, nose and throat
- Mod 10-50 ppm
  Headache, Dizziness, Nausea and vomiting,
  Coughing and breathing difficulty
- High 50-100 ppm
  Severe respiratory tract irritation, Eye irritation / acute conjunctivitis, Shock, Convulsions, Coma, Death in severe cases

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Video

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What to do?

1. Look for warning signs
2. Respirator if available
3. Stay upwind
4. Avoid low surface areas
5. Call for help
6. Check in

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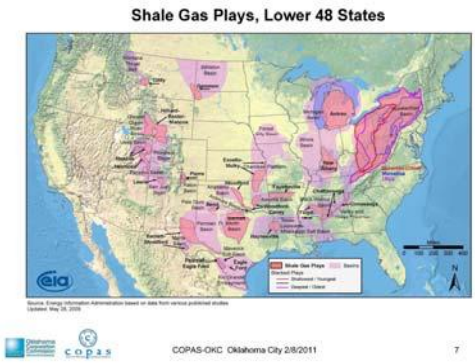

Video

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Pollution

- Benzene, Toluene, Ethylbenzene and Xylene (BTEX)
- Carbon Monoxide
- Dust
- Hydrogen Sulfide
- Natural Gas
- Nitrogen Oxides
- Ozone
- Particulate Matter
- Sulfur Dioxide
- Volatile Organic Compounds

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Construction Activity

A certain amount of construction accompanies every phase of oil and gas development (exploration, field organization, production, and site abandonment). Each requires disturbing the soil to some degree through the use of construction machinery. These activities generate particulate matter and stir up dust, which in turn react with the other prerequisites to form ground-level ozone, or smog.

293

Engines

Drilling, completion and workover trucks, rigs and equipment such as pumps typically run off of diesel-powered or gasoline engines. The exhaust fumes from gasoline and diesel fuels can produce emissions that are noticeable to people living downwind. Diesel engines on a rig can consume 800 gals a day. Up to 15,000 gals to complete a frackuring job. Polycyclic aromatic hydrocarbons (PAHs) are found in exhaust from motor vehicles and other gasoline and diesel engines. A long list of other air pollutants, including nitrogen oxides, carbon monoxide, BTEX, formaldehyde and metals are also contained in diesel fuel combustion products.

294

Condensate Tanks

Some natural gas wells produce a semi-liquid condensate along with the gas. Condensates are hydrocarbons that are in a gaseous state within the reservoir (prior to production), but become liquid during the production process. Condensates are composed of hydrocarbons (typically those containing five or more carbon molecules), as well as aromatic hydrocarbons such as benzene, toluene, xylenes and ethylbenzene (BTEX). Condensates may give off a characteristic hydrocarbon or petroleum-type smell. BTEX give off a sweet, aromatic odor. Most people can smell benzene when it reaches levels of approximately 1.5 - 5 parts of benzene per million parts of air (ppm). The Occupational Safety and Health Administration (OSHA) has set maximum exposure levels for workers at 1 ppm (over an 8-hour period) and 5 ppm (over a 15-minute period). At levels above 150 ppm some people may begin to experience serious and irreversible health effects.

The vapors of benzene, toluene and xylenes are heavier than air and may accumulate in low-lying areas.

295

Dehydrators

If the gas wells use glycol dehydrators to remove water from the gas, the dehydrator may release aromatic organic chemicals to the atmosphere. If the natural gas undergoing dehydration contains benzene, toluene, or other volatile organic compounds, significant quantities of these compounds can be released when the glycol solution undergoes regeneration.

296

Flaring

Flaring is the practice of burning gas that is deemed uneconomical to collect and sell. Flaring is also used to burn gases that would otherwise present a safety problem. It is common to flare natural gas that contains hydrogen sulfide (i.e., sour gas), in order to convert the highly toxic hydrogen sulfide gas into less toxic compounds.

Flares emit a host of air pollutants, depending on the chemical composition of the gas being burned and the efficiency and temperature of the flare. Flaring results in hydrogen sulfide emissions if hydrogen sulfide is present in large enough amounts in the natural gas. There may also be additional by-products formed if some of the chemicals used during the drilling or hydraulic fracturing process are converted to a gaseous form and are burned along with the natural gas.

297

Pits

Earthen pits are often used to store or evaporate produced water and waste water from natural gas dehydration or oil/gas separation units. Additionally, prior to disposal drilling wastes (muds and cements) and hydraulic fracturing (fracking) wastes are often stored in earthen or metal pits that are open to the air. There are hundreds of different chemicals that may be used during drilling, fracking and workover procedures, including acids, biocides, surfactants, solvents, lubricants and others.

Chemical compounds that are naturally present in natural gas, or chemicals that have been injected downhole during drilling, hydraulic fracturing or well workover operations, will be present in the water or wastes that are held in pits. Some of the lighter or more volatile chemicals and compounds, such as benzene, toluene, hydrogen sulfide, etc., will escape from the produced water pits into the atmosphere. These chemicals may then be transported through the air, into nearby neighborhoods. The odors associated with the natural gases or chemicals will vary, depending on the concentrations, volumes, and combinations of chemicals released.

298

Fugitive Emissions

Fugitive emissions are unintentional leaks of gases. This may occur from breaks or small cracks in seals, tubing, valves or pipelines, as well when lids or caps on equipment or tanks have not been properly closed or tightened. When natural gas escapes via fugitive emissions, methane as well as volatile organic compounds (VOCs) and any other contaminants in the gas (e.g., hydrogen sulfide) are released to the atmosphere.

299

Venting

Venting is the release of gas to the atmosphere. Venting occurs at a number of points in the oil and gas development process (well completion; well maintenance; pipeline maintenance; tank maintenance; etc.).

During oil and gas development, huge quantities of gas may vented to the atmosphere. For example, during well completion, after a well is drilled and stimulated (e.g., hydraulically fractured), the wellbore and surrounding formation must be cleaned out. The solids and fluids from the well go into pits, while the gases are allowed to escape into the atmosphere, or they are burned off (flared). It has been estimated that a single well Wyoming's Jonah field will emit 115 tons of VOCs, and 4 tons of hazardous air pollutants such as benzene, toluene, ethylbenzene, xylene and hexanes. If the gas is flared, rather than vented, the emissions of VOCs and HAPs are reduced to 29 and 1 ton, respectively; but flaring of completion gases also results in the release more than a ton of nitrogen oxides, and almost half a ton of carbon monoxide per well.

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Evaporation Sprayers

301

TCEQ tests on Dish

Video

302

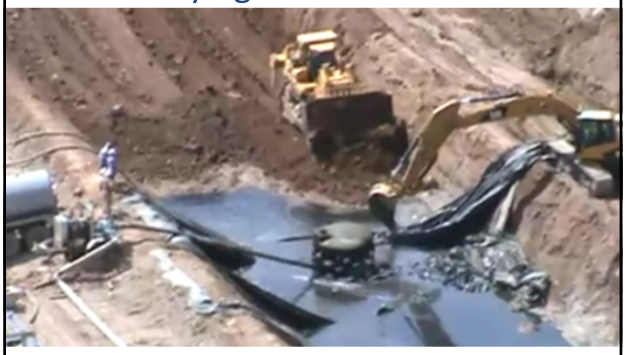
Getting Rid of Cement

Video

Duncan Oklahoma

303

Burying the Reserve Pit



Video

304

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- 2*Department of Mathematics and Department of Mechanical Engineering, University of British Columbia, 2324 Main Mall, Vancouver, BC, Canada, V6T 1Z4. (e-mail: frigaard@math.ubc.ca)*
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