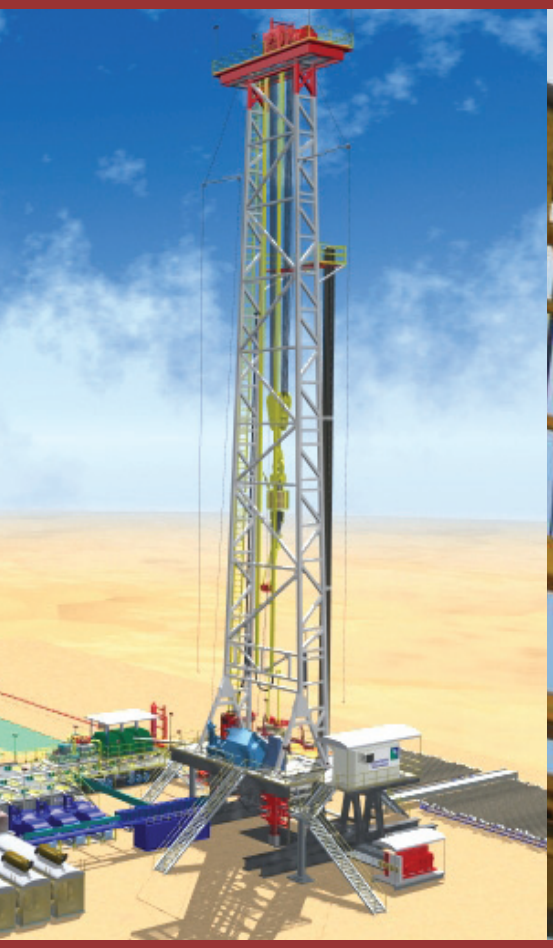
ارامكو السعودية
Saudi Aramco

Instructor Guide

INTRODUCTION TO DRILLING OPERATIONS



Module 5.1
Identify Well Control Systems and Parts

D&WO HR Training & Competency Development Division
Published by T&D
August 2014

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Trainee Handbook

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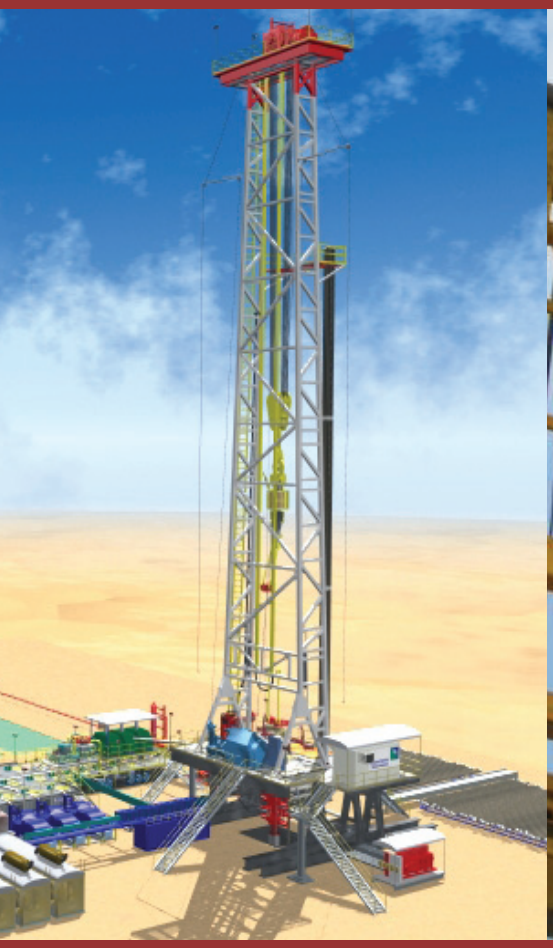

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Identify Well Control Systems and Parts

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Unit 5: State the Function and Operation of Wellhead and Well Control Equipment

Module 5.1
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INSTRUCTOR GUIDE

Unit 5: State the Function and Operation of Wellhead and Well Control Equipment

Module 5.1
Identify Well Control Systems and Parts

TRAINEE HANDBOOK

Item	Action	Aid	Time
PREPARATION	Before class, prepare the classroom. Distribute trainee handbooks.	Instructor Guide. Trainee Handbooks.	
INTRODUCTION	Identify and explain the module objectives. Explain new words.	Information Sheets. Glossary. Oil Industry Terms e-Glossary	1 hr.
OBJECTIVE 5.1.1	List indicators of well control issues. Show PETEX Video "Causes & Prevention of Blowouts Part 1". Have trainees complete the exercise.	Information Sheets, part I. PETEX Video 51-1046. Exercise A.	3 hr.
OBJECTIVE 5.1.2	State the purpose and typical methods of well control. Have trainees complete the exercise.	Information Sheets, part II. Exercise B.	2 hr.
OBJECTIVE 5.1.3	List the main equipment used in well control. Show PETEX Video "Causes & Prevention of Blowouts Part 3". Have trainees complete the exercise.	Information Sheets, part III. PETEX Video 51-1048. Exercise C.	2 hr.
RIG VISIT	Review the function of the main components used in well control.	Information Sheets.	4 hr.
REVIEW	Review objectives.	Information Sheets.	1 hr.
WRITTEN TEST	Administer the written test. Score and record the results. Counsel trainees whose performance is unsatisfactory and provide remedial training as required.	Test Sheets. Test Answer Key.	2 hr.
	Estimated time for a class of 8 trainees.		15 hr.

USING THIS MODULE

This module familiarizes trainees with well control issues and the functions of well control equipment. They also become familiar with the rigmen roles at the rig site in relation to preventing, identifying, and controlling a kick. Use the Saudi Aramco Oil Industry Terms e-Glossary and other online resources to explain new terms or concepts.

RIG VISIT

Use the training rig as much as possible to show trainees the physical parts discussed in the module and their function. Also use practical demonstrations in place of lectures wherever possible. The information sheets are best seen as reference material for your trainees to review information on the equipment that they have been learning about.

KEY TO EXERCISES

EXERCISE A

1. out of control
2. A. insufficient mud weight

   B. insufficient hole fill

   C. lost circulation

   D. swabbing/surging
3. low
4. high
5. light
6. weighting material

7. tripping out of the hole

8. as mud flows into the formation, the level of mud is reduced. This reduces the hydrostatic pressure at the bottom of the hole.

9. pulled up

10. Any four from:

    A. check the mud weight regularly

    B. monitor stock levels of mud materials

    C. check valves and hoses to prevent fluid running into the mud

    D. take care when cleaning equipment to avoid fluid entering the mud tanks

    E. monitor the effects of mud cleaning equipment

    F. do not run the desilter or centrifuge when adding weighting material

    G. monitor the cuttings size, shape, color, and quantity

    H. look for bubbles in the mud

    I. check for changes in the pH and viscosity of the mud

11. A. flow

    B. mud returns

    C. mud volume

EXERCISE B

1. Maintaining the correct mud weight for the formation

2. Kill mud is pumped down the hole to stop the kick

3. A. close the annular preventer

   B. stop the pumps

   C. Close the valves on the choke manifold

4. The choke valve controls the flow of the returns and regulates the annular pressure.

5. Gas that has entered the wellbore and expanded due to upward travel.

6. zero

EXERCISE C

1. A. BOP stack

   B. accumulator unit

   C. choke manifold

2. A. annular preventer

   B. ram preventer

3. shear rams

4. blind rams

5. To pump kill mud when the drill string cannot be used.

6. choke

Date	Reason
August 2014	First Printing

Enabling Objectives

You will, correctly and without help, be able to:

5.1.1
List indicators of well control issues.

5.1.2
State the purpose and typical methods of well control.

5.1.3
List the main equipment used in well control.

Terminal Objective

Identify well control systems and parts.

INTRODUCTION

Well control is the procedure to prevent oil, gas, or water from entering the wellbore unexpectedly.

When a well is out of control, it can cause a blowout. During a blowout, the fluids in the rock formation flow into the wellbore in a way that cannot be stopped. These fluids or gases are often highly flammable and/or toxic. They are extremely hazardous to personnel, the environment, and rig equipment. In most cases, a blowout can be prevented.

A kick is when fluid or gas from the rock formation enters the wellbore. A kick will become a blowout if it is not controlled. Well control equipment is used to prevent a blowout by controlling a kick. The well must be brought back under control as quickly as possible. If a kick cannot be controlled, the well control equipment may be able to ***divert*** the fluids away from the wellbore and rig. This provides time to allow personnel to escape to a safe location.

In this module you will learn about the causes of kicks, well control equipment, and rigmen responsibilities in detecting and preventing a kick.

PART I **OBJECTIVE 5.1.1**

List indicators of Well Control Issues

The key to well control is to identify when the wellbore is gaining or losing fluids as early as possible. Then the proper action can be taken to control the well. Kicks can be prevented if the correct measures are in place. In this part you will learn about the causes of a kick and how they can be prevented. You will also learn some of the signs that will help you identify when well control action needs to be taken.

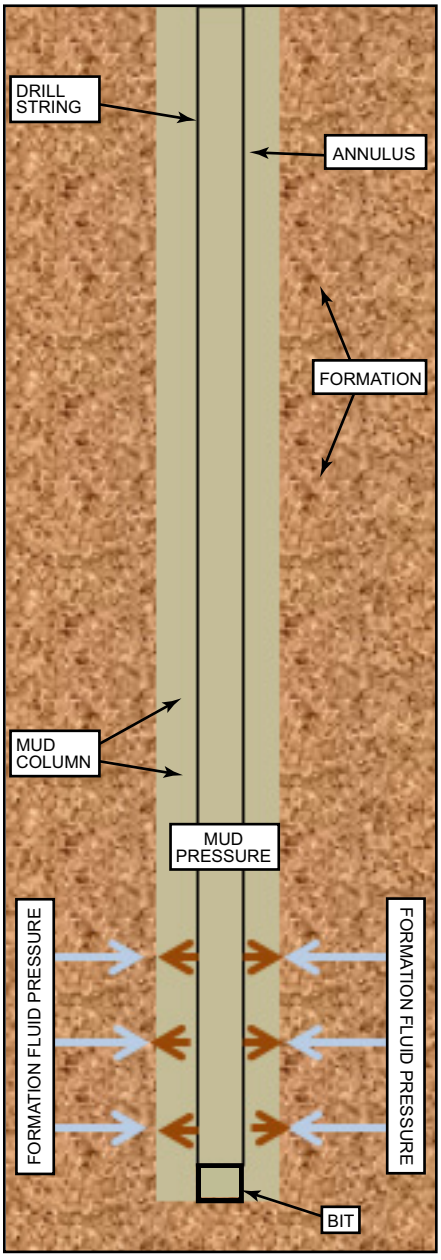

Figure 1
Mud Column

CAUSES OF A KICK

Most kicks are the result of human error. The causes of a kick include:

- ❏ insufficient mud weight
- ❏ insufficient hole fill
- ❏ lost circulation
- ❏ swabbing/surging

Insufficient Mud Weight

As you have learned, one of the main functions of drilling fluid is to prevent formation fluids from entering the wellbore. As shown in figure 1, the column of mud in the wellbore creates pressure that is applied to the rock formation. The pressure of the mud in the hole must be equal to, or greater than, the pressure of the fluids in the formation.

The formation fluid pressure can be predicted from ***geological*** information, or data from previous wells drilled in the same area. The mud engineer uses this information to maintain the correct mud weight.

The pressure that the column of mud applies to the formation is affected by the weight of the mud. As the weight of the mud is increased, the hydrostatic pressure created by the column of mud also increases. If the weight of the mud or the height of the mud column is lowered, then the hydrostatic pressure created by the column of mud is also lowered.

Hydrostatic pressure is the pressure applied by a non-flowing fluid at a given point within the fluid. This pressure is due to gravity. The hydrostatic pressure will increase with depth, because of the increasing weight above.

A kick due to insufficient mud weight can result from:

- ❏ poor planning
- ❏ poor mud management
- ❏ unexpected geological formations

Poor Planning

When likely formation pressures are known, the mud engineer must use this information. He must make sure that there are sufficient supplies to maintain the correct mud weight. The rigman helps the mud engineer by telling him when supplies to make mud are getting low.

Poor Mud Management

Mud management requires balance. The mud weight must be kept high enough so that the mud column creates enough hydrostatic pressure. This prevents formation fluids from entering the wellbore. Hydrostatic pressure must also be kept low enough, so that the downhole circulating pressure does not force the mud to flow into the formation. This causes lost circulation.

A rigman assists the mud engineer by mixing and testing mud. It is important that the correct amount of material is mixed into the mud over the specified time. If too much fluid is added to the mud, or not enough weighting material (see figure 2) is added, the mud weight will be too low.

Figure 2
Mud Weighting Material

Fluid can be accidentally added to the mud by opening the wrong valve at the mud pits. Rigmen should also avoid allowing water to enter the mud pits when cleaning rig equipment.

The equipment used to clean the mud returns from the wellbore can also affect the mud weight. The desilter and centrifuge remove small particles from the mud, but can also remove weighting material. Mud cleaning equipment is turned off if it reduces the mud weight by too much.

Unexpected Geological Formations

Unless the well is being drilled in a completely new area, the likely formation pressures can be predicted in advance. However, a high pressure formation may be drilled into sooner than expected. The rigmen help identify when the bit has drilled into a new formation. They notify the driller if they see any significant changes in the shape, size, color, or quantity of cuttings returning over the shakers (see figure 3).

Figure 3
Cuttings Returns

Constant monitoring of the shakers and the mud in the mud system is vital to maintain well control. Also vital is watching for bubbles in the mud or sudden changes in pH or viscosity. These too can be early warning signs that the bit has drilled into a new formation.

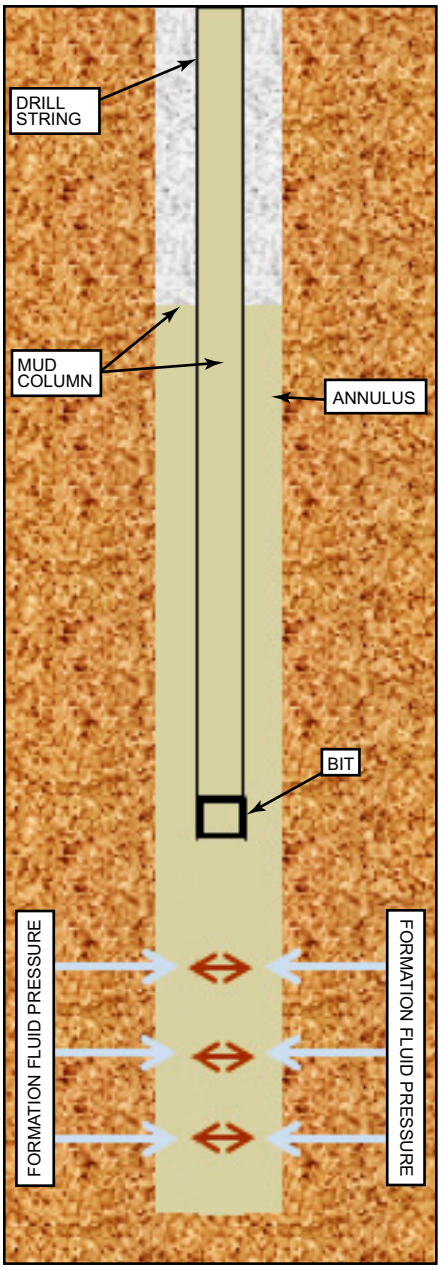

Figure 4
Insufficient Hole Fill

Insufficient Hole Fill

The wellbore must be kept full of mud at all times. If the hole is not full of mud, the height of the mud column is reduced. This reduces the hydrostatic pressure of the mud column. If the hydrostatic pressure is less than the formation pressure a kick may occur.

Most kicks occur as the drill string is pulled out of the hole. This happens if the hole is not filled with enough mud to replace the pipe that is removed from the hole. Figure 4 shows that as drill pipe is pulled out of the hole, the height of the mud column is reduced and the pressure applied to the formation decreases. This situation can lead to a kick.

Rigmen watch the hole when tripping and make sure it is being filled. They notify the driller if the height of the mud is getting low or if they cannot see the mud.

Lost Circulation

Although the mud weight is normally kept high enough to prevent a kick, it should not be too high. If the mud weight is too high, the downhole circulating pressure can damage the formation. This creates cracks that the mud will flow into. If mud flows into the formation it can lead to a 'lost circulation' situation, as shown in figure 5.

A lost circulation situation can lead to a kick. As the mud flowing into the formation reduces the height of the mud column, the overall hydrostatic pressure applied by the mud is also lowered. As with insufficient mud weight, mud losses can occur as a result of poor planning or mud management, and/or unexpected geological formations.

If the mud is not cleaned properly when it returns to the surface, a loss of circulation can occur. The solids that enter the mud in the wellbore increase the mud weight. Rigmen are responsible for running and inspecting the mud cleaning equipment to prevent solids from entering the tanks. They ensure that chemicals or material are added to the mud as instructed by the mud engineer.

A loss of circulation can also occur when drilling into faults or formations that are weak or very porous. The excessive mud column pressure creates fractures, cracks or caverns (caves) in the formation that allow the drilling fluid to drain away.

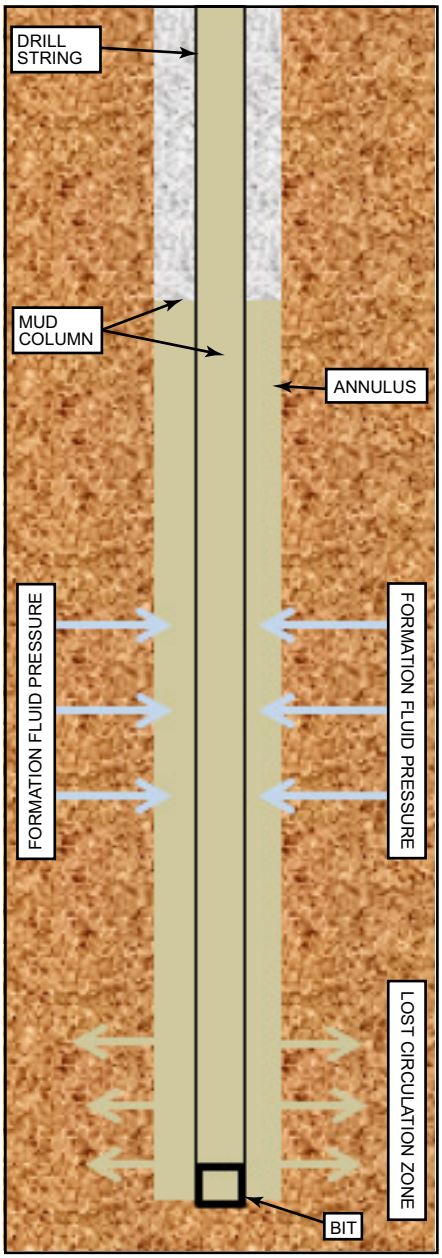

Figure 5
Lost Circulation

Lost Circulation Material (LCM) is a special mix of solid material with different shapes and sizes. It is pumped downhole to stop lost circulation by plugging the holes that mud is flowing into.

Rigmen monitor the weight and keep it within the safe operating limits provided by the mud engineer. They are also responsible for mixing the lost circulation material (LCM) used to plug the losses (see figure 6).

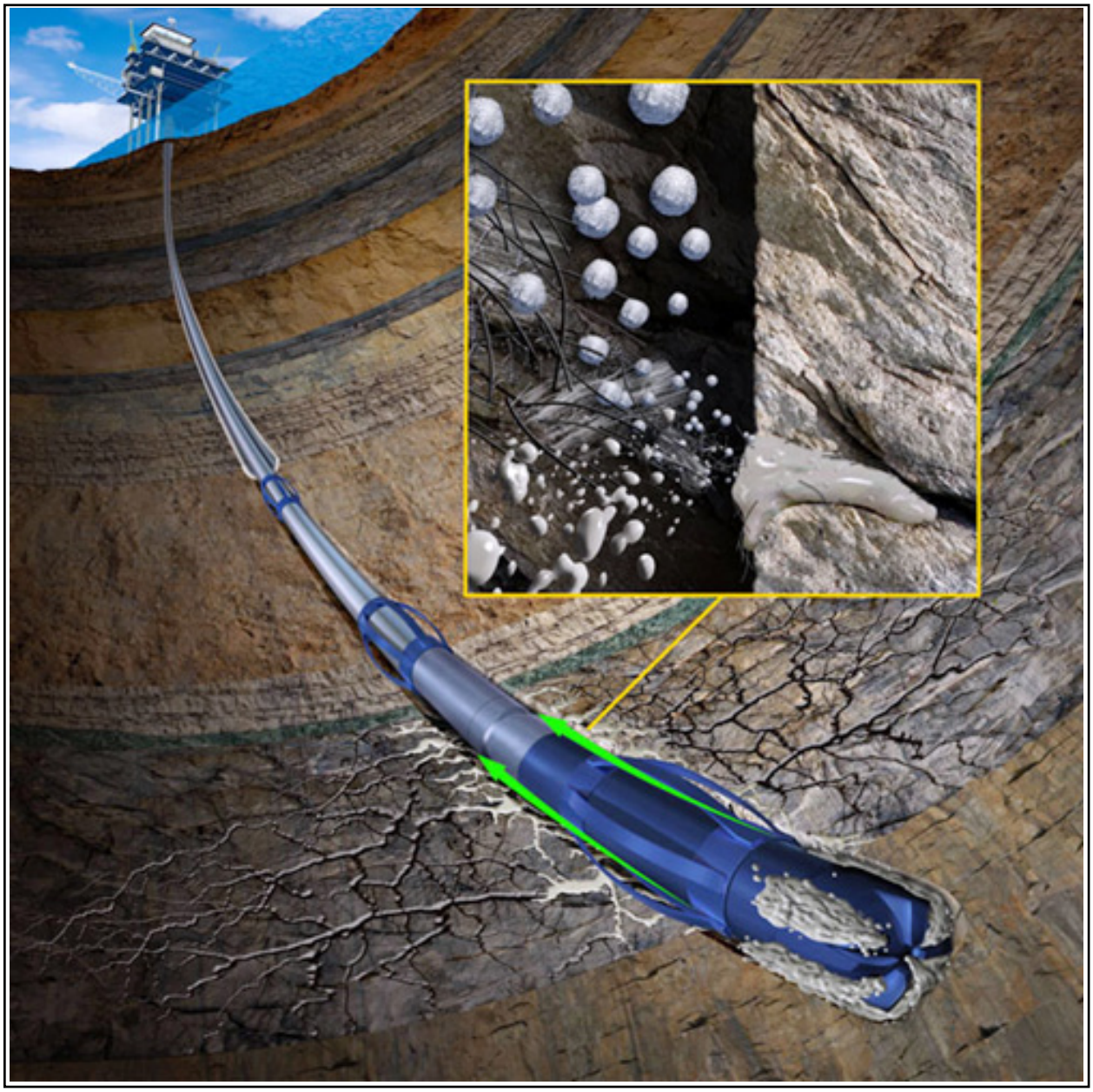

Figure 6
LCM

Swabbing/Surging

The movement of the drill string in the wellbore can have an effect on the pressure below the drill bit.

Swabbing can happen as the drill string is pulled upwards (see figure 7). Similar to a ***piston*** during the suction stroke of a pump, this effect can draw formation fluid or gas into the hole. Formation fluids and gas are generally lighter than mud, so the overall mud weight is reduced. This lowers the hydrostatic pressure, possibly resulting in a kick.

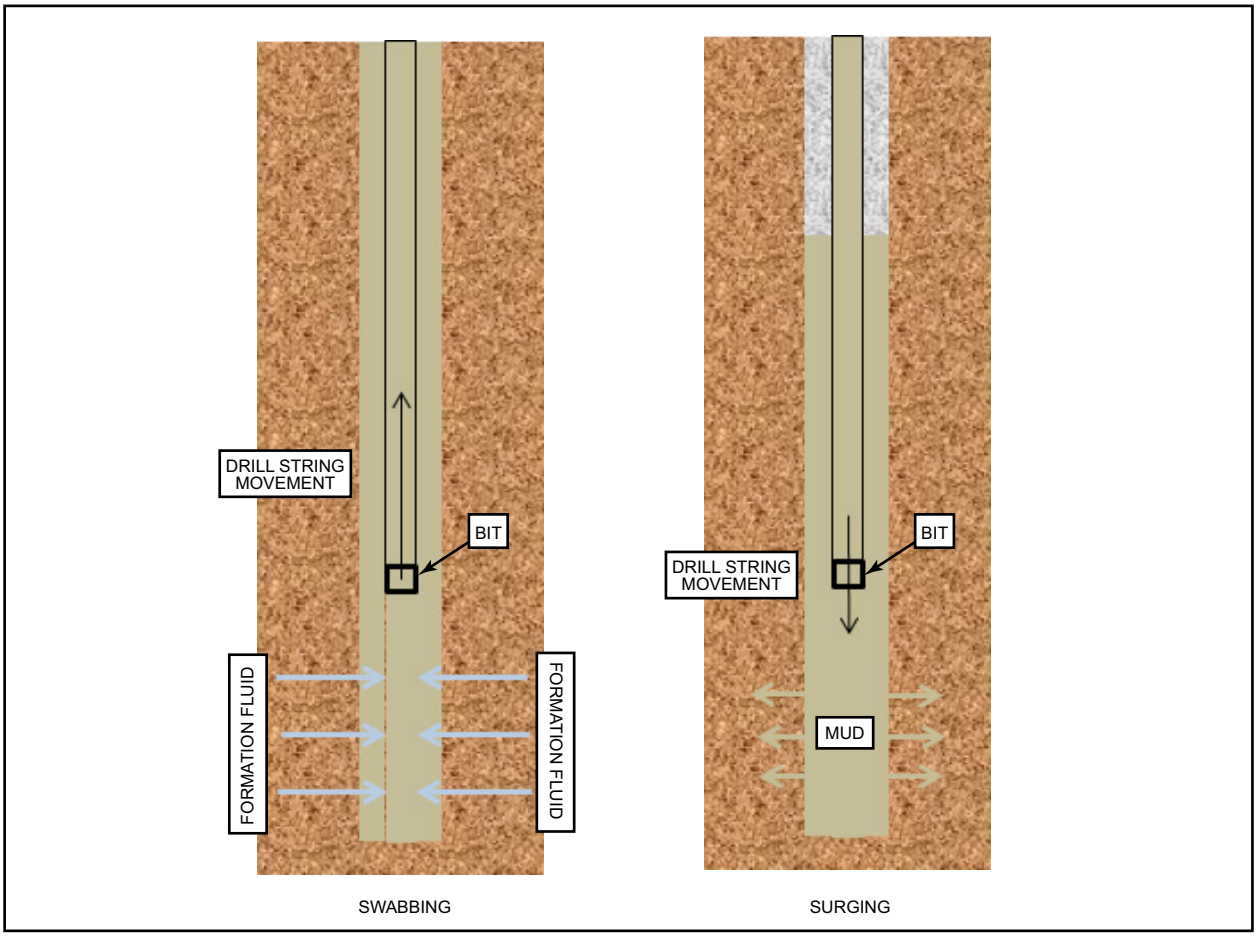

Figure 7
Swabbing and Surging

Surging is the opposite effect from swabbing. This happens as the drill string is moved downwards (see figure 7). Similar to the discharge stroke of a piston in a pump, the downward movement increases the pressure below the bit. The excessive pressure increase may fracture or damage the formation, causing losses.

Rigmen reduce the risk of a kick due to swabbing or surging by monitoring the hole as the drill string is moved. Swabbing would cause mud to come out of the hole as the drill string is pulled upwards. It is important to monitor this when the bit is first pulled off the bottom of the hole.

Surging would result in little or no mud coming out of the hole as the drill string is moved downwards. Rigmen notify the driller if they see signs of swabbing or surging.

KICK PREVENTION

You now know the causes of a kick. The rigman plays an important role in preventing them. Table 1 summarizes how the rigman responsibilities can help in kick prevention.

KICK CAUSE	RIGMAN KICK PREVENTION RESPONSIBILITIES
Insufficient mud weight	Check the mud weight regularly.
	Monitor supply levels of mud materials.
	Mix mud and add materials as directed over the specified amount of time.
	Check valves and hoses to ensure that excessive fluid is not added to the mud.
	Take care when cleaning equipment to avoid the run-off entering the mud tanks.
	Monitor the effect of mud cleaning equipment on the mud weight.
	Do not run the centrifuge or desilter when adding weighting material.
	Monitor the cuttings size, shape, color, and quantity.
	Look out for bubbles in the mud.
	Check for changes in pH and viscosity of the mud.
Insufficient hole fill	Monitor the hole fill during tripping.
Lost Circulation	Mix LCM to mud engineer specifications.
	Run centrifuge and desilter to remove excess solids and keep the mud weight below maximum.
	Inspect shaker screens.
	Set up the mud tanks to skim light mud from the top.
	Run the agitator in the suction pit.
Swabbing/Surging	Monitor the hole fill as the drill string is picked up off bottom, and as it is run in the hole.

Table 1

Rigmen monitor changes to the mud and any transfers within the storage facilities. If mud is being transferred for any reason, they inform the driller.

INDICATORS OF A KICK

The easiest way to determine if the well is kicking is if the mud continues to flow when the pumps are turned off.

The most common indicator of a kick is a change in the mud returns. Simply, the amount of mud that is pumped into the hole should be equal to the amount that comes out. However, this is not completely true. Certain variations in mud returns are expected.

More mud is required to fill the wellbore as drilling continues and the hole gets deeper. It is also expected that some of the drilling fluid will seep into the formation as a filter cake is built up. A small amount of mud is also lost at the solids control equipment. All the mud cannot be fully cleaned off from the cuttings that are removed.

The driller and other personnel on the rig will be monitoring for well control indicators. Rigmen also need to be aware of what to look for. The three main factors that they monitor to identify well control problems early are:

- ❏ flow
- ❏ mud returns
- ❏ mud volume

Flow

The mud is considered static when the pumps are off. The mud may flow for a few seconds after the pumps are turned off as the surface equipment and return lines drain. Once the return lines and surface equipment have drained, mud should not flow unless the pipe is moved. If the mud continues to flow after the pumps have stopped, rigmen must notify the driller immediately.

Mud Returns

The returning mud may give signals that there is a well control problem. Some of the things to watch for in the mud include:

- ❏ gas cut mud
- ❏ increased returns

Gas Cut Mud

When gas from the formation enters the mud, it becomes gas cut. Gas cut mud may appear aerated or frothy, or as small patches of bubbles in the return lines or shaker box (see figure 8). The viscosity or pH of the mud may also change. Sometimes you smell gas in the mud returns.

Figure 8
Gas Cut Mud

Increased Returns

The mud pumps are usually pumping mud into the hole at a constant flow rate. Any changes in the return flow can indicate a well control issue. For example, an unexplained increase in flow from the well could mean that formation fluid is entering the wellbore. The more fluid or gas that enters the wellbore, the lighter the mud will become, eventually leading to a blowout if it is not stopped.

Mud Volume

If the volume of mud in the active pit (see figure 9) changes significantly, this may indicate a well control issue. An increase in the mud volume (gains) can mean that a kick is occurring. A significant decrease in volume (losses) means that mud is being lost to the formation.

Figure 9
Active Pit Volume

SUMMARY

In this part, you have learned that well control issues can lead to a blowout if they are not quickly resolved. A kick happens when fluid or gas enters the borehole from the formation. A kick generally occurs when the pressure of the mud column is not high enough to balance the pressure of the formation fluids. The pressure of the mud column is reduced when the weight or volume of the mud is decreased.

Rigmen perform tasks that help prevent a kick. To identify well control issues, they must be aware of changes in the flow-rate and volume of the mud returns.

Now complete exercise A, before learning about methods of controlling the well in the event of a kick. 

EXERCISE A

Directions: *Answer the following questions.*

1. A blowout is when the well is _____.

2. What are the four main causes of a kick?

   A. _____

   B. _____

   C. _____

   D. _____

3. Fluid will enter the wellbore from the formation if the mud weight is too _____.

4. Mud will flow into the formation if the mud weight is too _____.

5. Adding too much fluid to the mud, or not enough weighting material will result in the mud weight being too _____.

6. The desilter and centrifuge should not be used when adding _____ to the mud.

7. During which rig operation do most kicks occur?

   _____

8. How can a lost circulation situation lead to a kick?

   _____

9. Swabbing can happen as the drill string is _____.

10. What are four ways that the role of a rigman can prevent a kick due to insufficient mud weight?

    A. _____

    B. _____

    C. _____

    D. _____

11. What are the three factors that rigmen should monitor to identify a kick?

    A. _____

    B. _____

    C. _____

PART II **OBJECTIVE 5.1.2**

State the Purpose and Typical Methods of Well Control

You have learned that if the downhole pressure of the mud column is less than the formation pressure, fluids may enter the hole. You also learned that the correct mud weight must be maintained to prevent a kick. You know what signs indicate that a kick might be occurring.

In this part, you will learn about how the well is controlled if a kick is detected.

WELL CONTROL PURPOSE

The first defense against kicks is to maintain the correct mud weight for the expected formations. If a kick has been detected, it must be stopped as soon as possible before it leads to a blowout. Stopping a kick is known as killing the well.

The purpose of killing the well is to safely replace the mud and formation fluid that are in the hole with heavier mud. The heavier mud needs to stop the formation fluid from flowing into the wellbore. The heavier mud, known as kill mud, must be circulated without allowing any more formation fluid into the wellbore.

WELL CONTROL METHODS

The driller has several methods to kill the well. The objective of all methods is to circulate the kick fluid out of the hole. The hole must then be filled with mud that is heavy enough to prevent any further gains.

The method used by the driller depends on company procedures and the drilling operation underway at the time of the kick. For example, it is generally easier to kill a well when the bit is close to the bottom of the hole. There are also methods that the driller can use if the drill string is not in the hole.

Most well control methods are based on two main methods. These are known as the "driller's" method and the "wait and weight" method.

Figure 10 shows the process of killing the well using the wait and weight method. The kick fluid and drilling mud are displaced by heavier kill mud. Drilling can continue once the circulation system and hole is displaced with mud that is heavy enough to prevent fluid from entering the wellbore. The four stages shown in figure 10 are:

- ❏ shut in the well
- ❏ pump kill mud
- ❏ displace the kick fluid
- ❏ complete kill operation

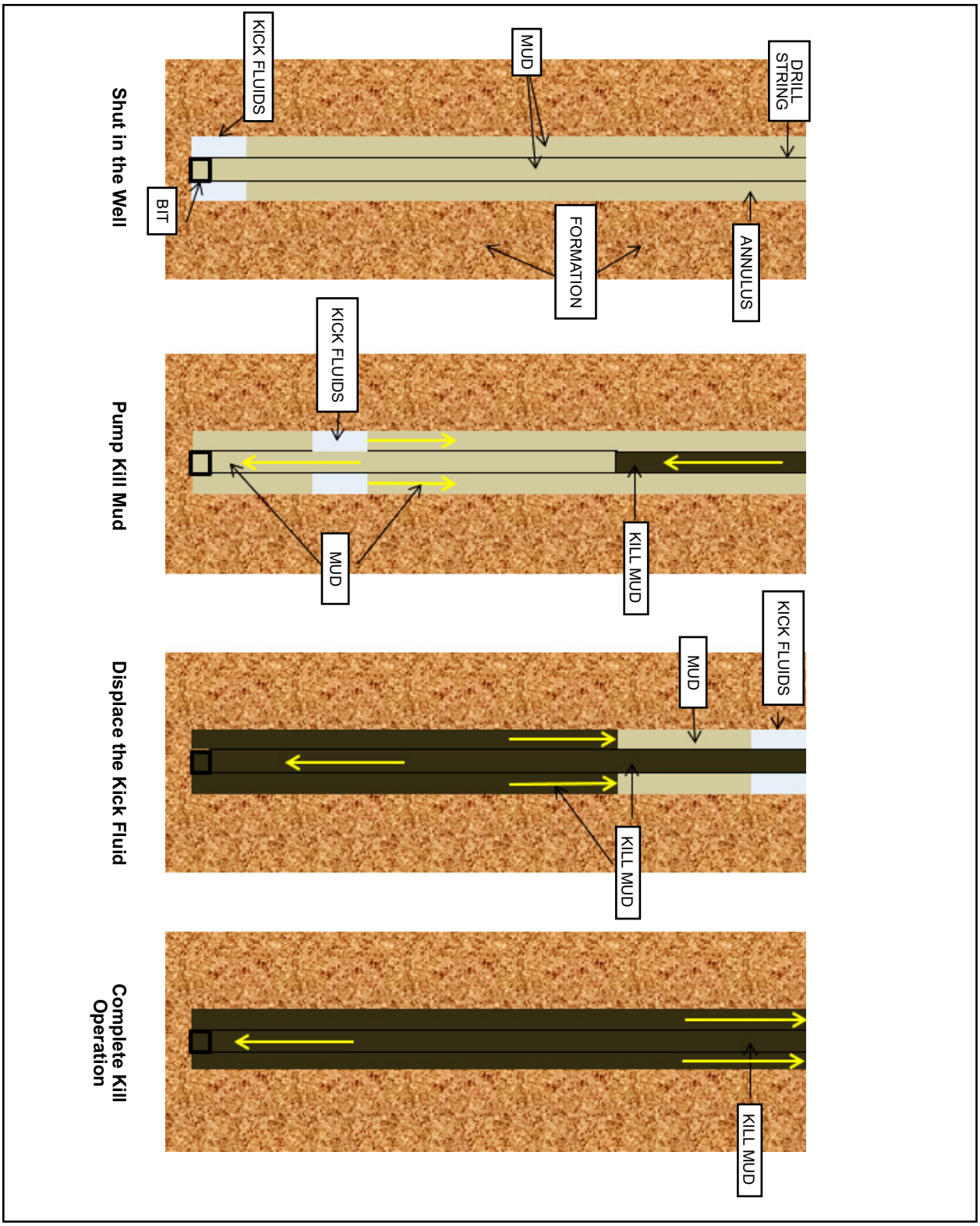

Figure 10
Killing the Well

Shut in the Well

As soon as a kick is detected, the driller will stop the mud pumps and close the annular preventer on the BOP. The annular preventer is a part of the BOP that closes around the drill pipe, shutting in the annulus. The mud returns can now be diverted to the choke manifold. The line valves on the choke ***manifold*** are closed so that the well is now 'shut in'. The shut-in pressure at the drill string and annulus are recorded and used to calculate the required weight of the kill mud.

Pump Kill Mud

When the kill mud has been prepared, it is pumped down the drill string. The heavier kill mud will push the drilling mud down and force the kick fluids up the annulus. The choke valve is adjusted to control the rate of flow of the mud returns, and maintain a set annular pressure. The weight of the kill mud will stop any more kick fluid from entering the well.

Displace the Kick Fluid

As the kill mud is pumped down the drill string, the kick fluids are pushed up the annulus. The kick fluids are eventually displaced out of the annulus through the choke. The kick fluids may be water, gas, or oil, and can be disposed of appropriately. The degasser is used to remove gas from the mud during well control. Gas may travel up the annulus faster than the fluid, expanding as it gets closer to the surface. This may cause a pressure increase at the choke manifold.

Complete Kill Operation

The driller continues to pump kill mud down the drill string until it has displaced all the drilling mud and kick fluids in the annulus. The well has been killed if there is no flow from the annulus, and the shut-in pressure is zero. Now that the hole is stabilized, it can be conditioned and filled with mud that is heavy enough to prevent further kicks.

This procedure is similar to the driller's method. With the driller's method, the kick fluids are circulated out without changing the mud weight. Once the kick fluids have been removed, the mud is then displaced with heavier mud.

SUMMARY

In this part, you learned the procedures and equipment used in the event of a kick. The purpose of well control procedures is to safely kill the well and prevent a blowout. The well is killed by filling the wellbore with mud that is heavy enough to balance the formation pressure.

After completing exercise B, you will learn more about the equipment used for well control. 

EXERCISE B

Directions: *Answer the following questions or complete the statement.*

1. What is the first defense against kicks?

   _____

2. What is kill mud used for?

   _____

3. What are the three actions that will shut in a well?

   A. _____

   B. _____

   C. _____

4. What is the purpose of the choke valve?

   _____

   _____

5. What may cause a pressure increase at the choke manifold earlier than expected?

   _____

6. The shut-in pressure of the well should be _____ when the well has been killed.

PART III **OBJECTIVE 5.1.3**

List the Main Equipment used in Well Control

You have learned about how a well is controlled if a kick is detected. You learned that the driller will close the annular preventer on the BOP when a kick is detected. You also learned that the choke is used to control the flow of fluid as it comes out of the hole. In this part you will learn more about the function of the equipment used in well control situations including:

- ❏ BOP stack
- ❏ accumulator unit
- ❏ choke manifold

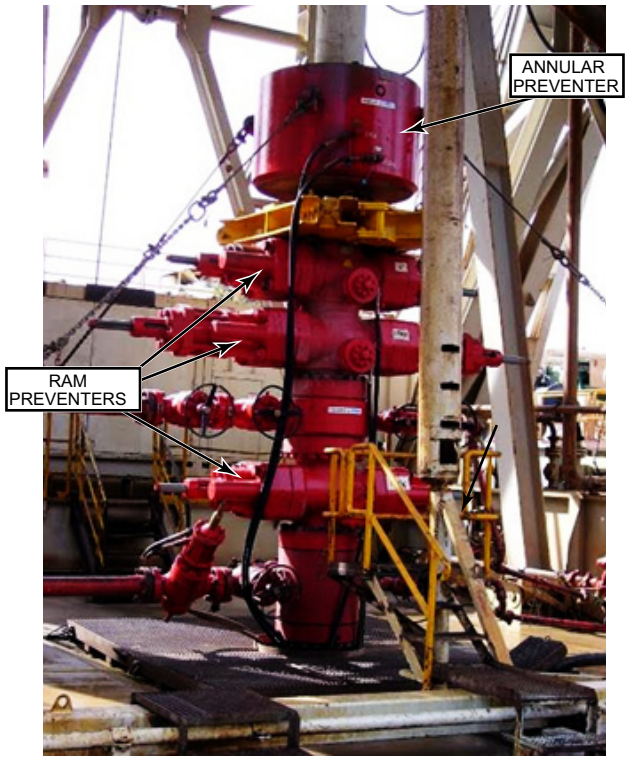

Figure 11
Blowout Preventer

BOP STACK

The blowout preventer, shown in figure 11, is one of the most important pieces of equipment on a rig. In an emergency it will shut in the well until the well is under control. The BOP will divert returns to the choke when the well is shut in. The BOP is placed at the top of the wellbore, known as the wellhead, so that the drill string passes through it. Most rigs use a BOP ***stack*** with a number of preventers that can shut in the well. BOP stacks usually have both annular and ***ram*** preventers that are controlled from the rig floor.

Annular Preventers

As shown in figure 12, the annular preventer can close around the drill pipe, casing, or other parts of the drill string. This type of preventer seals against the pipe, but allows some vertical movement and rotation of the drill string. If there is no drill string in the hole, the annular preventer can still close and shut in the well.

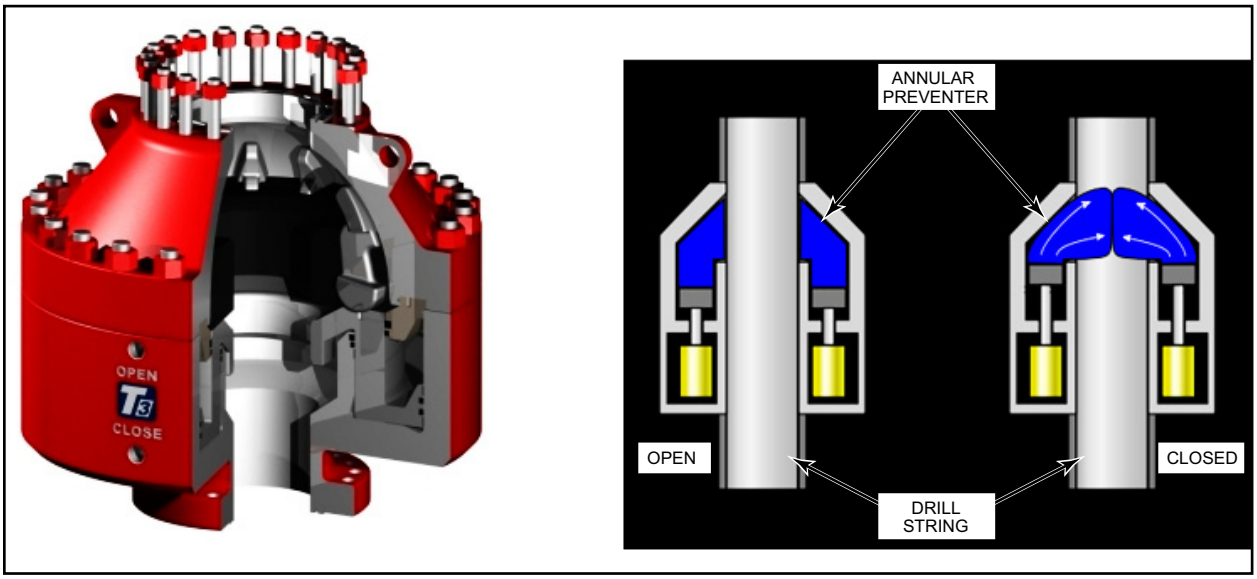

Figure 12
Annular Preventer

Ram Preventers

The ram preventers use a different design to shut in the well. Two rams close against each other and create a seal. There are three main types of rams normally used.

- ❏ pipe rams
- ❏ blind rams
- ❏ blind shear rams

Pipe Rams

Pipe rams (see figure 13) close against drill pipe that is in the hole. This shuts in the annulus so returns are diverted to the choke manifold. The pipe rams can be changed to accommodate different sizes of drill pipe. Rams that can close against different sizes of tubular are also available. Pipe rams cannot shut in the well if there is no pipe in the hole.

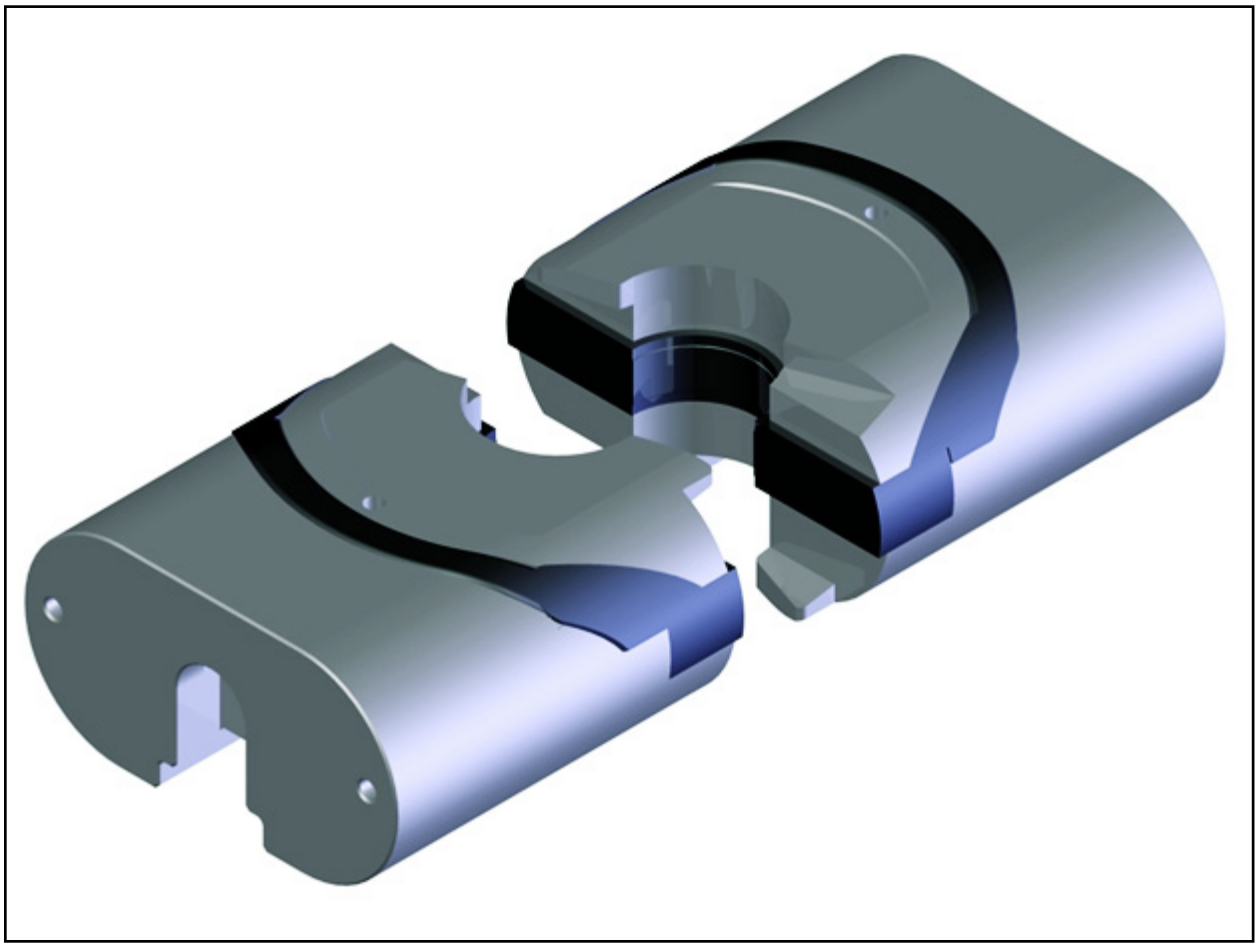

Figure 13
Pipe Ram Blocks

Blind Rams

Blind rams are used when there is no pipe in the hole. They seal against each other and shut in the well (see figure 14). These are more effective than the annular preventer when there is no pipe in the hole.

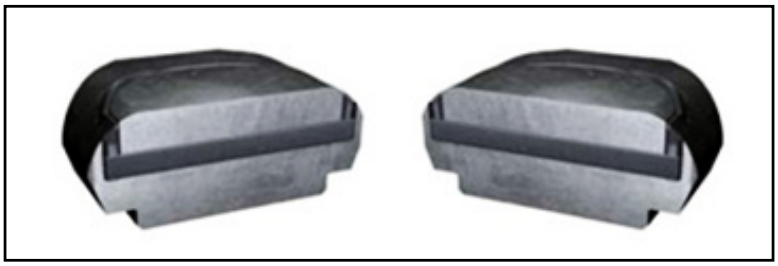

Figure 14
Blind Ram Blocks

Blind Shear Rams

As shown in figure 15, blind shear rams cut through the drill string, or any tubular that is in the wellbore, and seal in the well. These are mostly used on mobile offshore rigs when the rig has to move in an emergency, and there is no time to pull the drill string out of the hole.

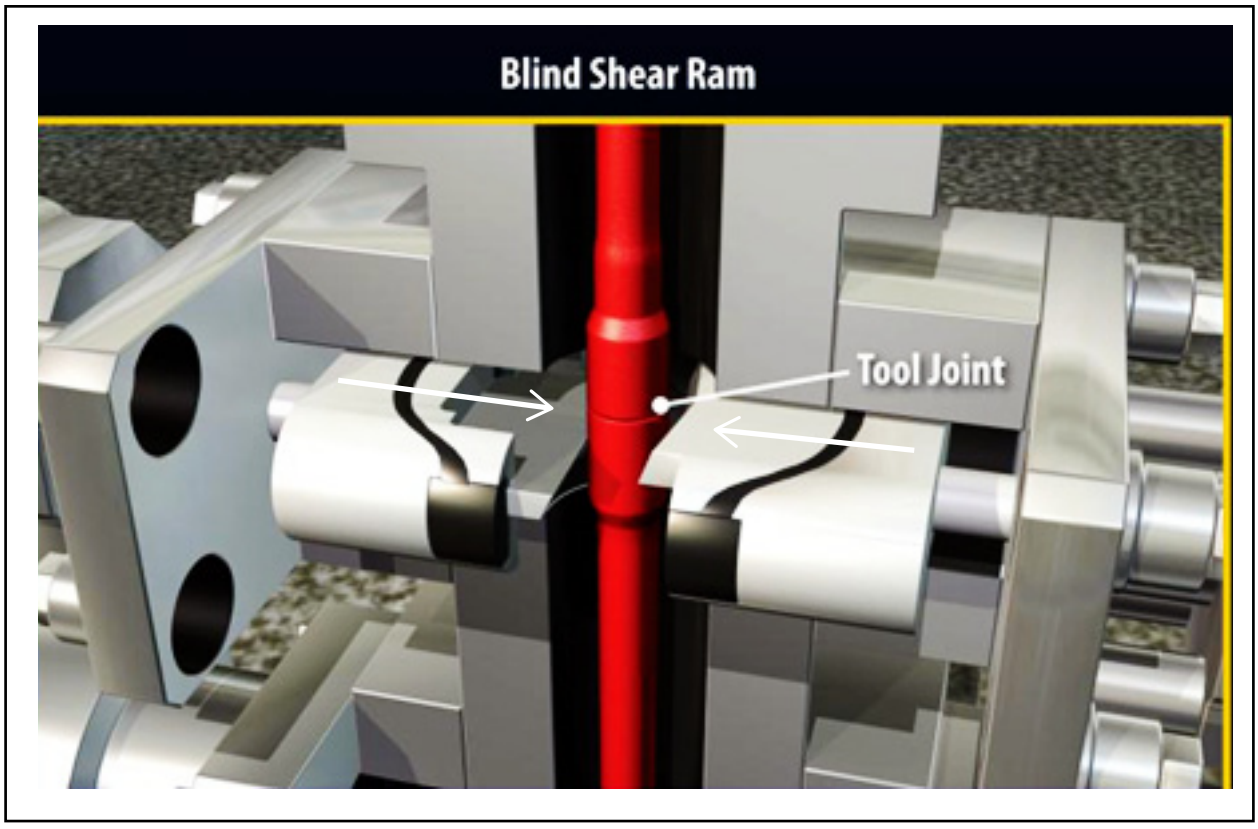

Figure 15
Blind Shear Rams

BOP Control

There is a BOP control panel in the doghouse that the driller can access quickly. These controls operate the preventers on the BOP stack remotely by hydraulics from an accumulator unit. Figure 16 shows a BOP control panel. 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 16
Remote Control Panel for Preventer Operation

ACCUMULATOR UNIT

An accumulator unit provides the high pressure hydraulic fluid for activating the BOP and choke manifold. Figure 17 shows the hydraulic accumulator unit. As shown in figure 17, the rams can also be controlled from the accumulator.

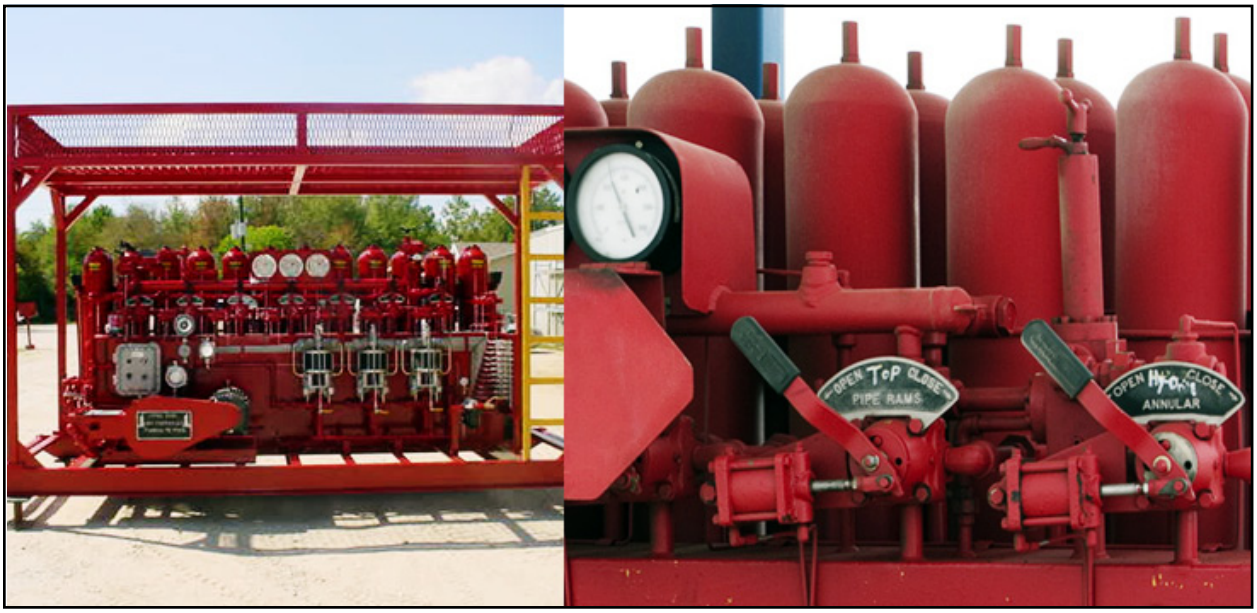

Figure 17
Accumulator Unit

Armored hoses from the accumulator to the BOP transfer the hydraulic pressure to control the rams. Figure 18 shows the BOP hoses.

On offshore rigs, the BOP stack may be on the seabed. In this case, the accumulator may also be located on the seabed. The preventers may be controlled electrically from the surface. Manual activation by divers or an underwater remotely operated vehicle (ROV) is also possible as a back-up.

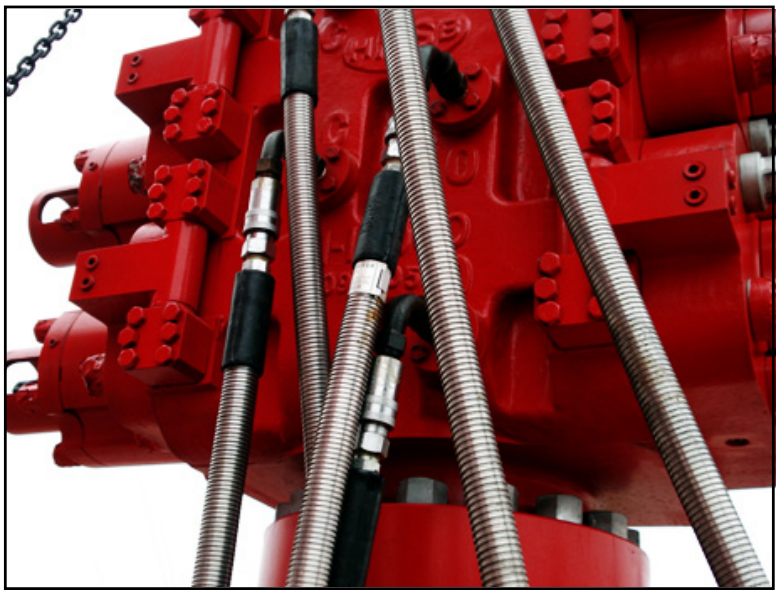

Figure 18
BOP Hydraulic Armored Hoses

CHOKE MANIFOLD

You learned that a choke line diverts mud returns from the BOP stack to the choke manifold when a preventer is closed. Figure 19 shows a choke manifold.

Figure 19
Choke Manifold

A choke (see figure 20) is a special type of valve that is used to control flow. During a well-kill operation, the choke is adjusted so that the annular pressure and flow can be regulated.

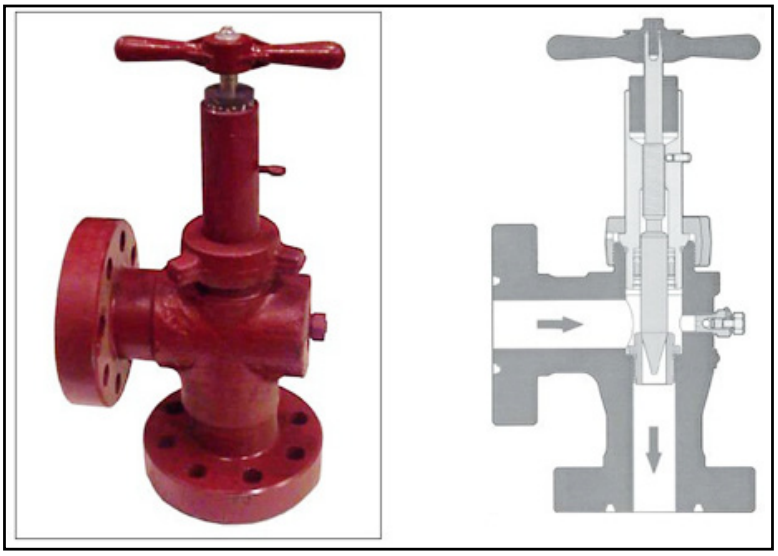

Figure 20
Manual Choke Valve

The choke can usually be controlled hydraulically from a control panel at the doghouse, and other locations around the rig. It is also possible to operate the choke manually at the manifold.

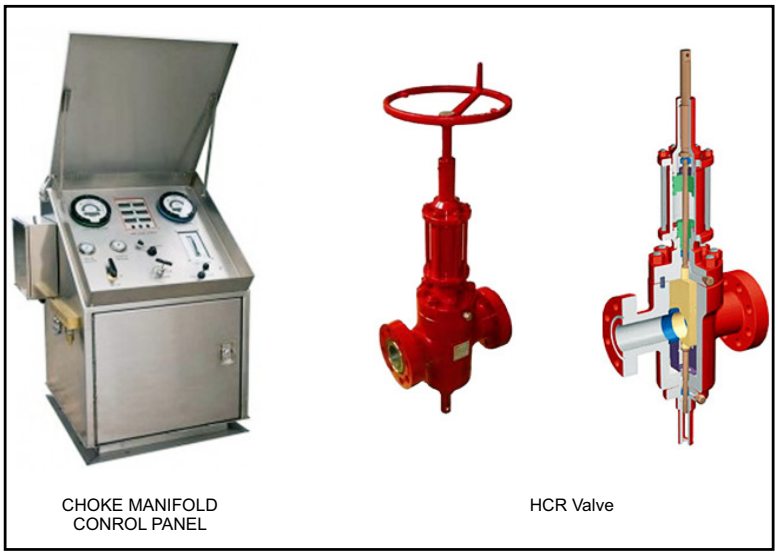

Figure 21
Choke Manifold Control Panel and HCR Valves

The choke manifold may contain more than one choke, and several other valves to line up flow to them. Figure 21 shows a choke manifold control panel and hydraulically controlled remote (HCR) valves. The HCR valves are choke valves that are usually operated hydraulically from the control panel. They can also be operated manually by turning the valve wheel.

Mud flow out of the choke manifold is treated by the mud cleaning system as usual. The mud gas separator (see figure 22) may also be used to remove formation gas.

Figure 22
Mud Gas Separator

The BOP stack also has a kill line that is connected to a kill manifold. The kill line is normally used to circulate kill fluid down the hole if the drill string is not in the wellbore, or cannot be used. In this case, the kill mud is pumped into the wellbore through the kill line.

The kill manifold has valves to line up the flow of kill fluid from the mud pumps to the BOP. It also has a check valve to ensure that the kill mud flows into the well. The check valve allows flow in only one direction. Figure 23 shows a kill line check valve.

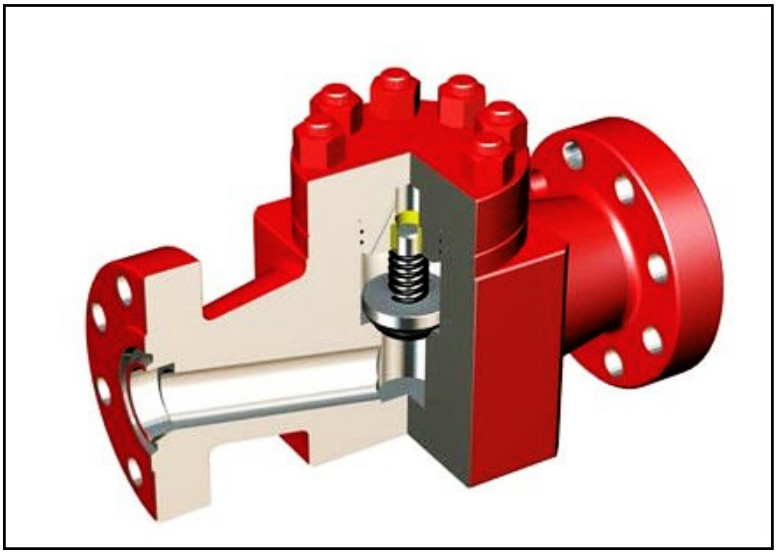

Figure 23
Kill Line Check Valve

The choke and kill manifolds are located together, and often combined into a single 'choke and kill' manifold.

SUMMARY

In this part, you have learned about the equipment used to kill a well. The BOP stack is one of the most important pieces of equipment on the rig. It will shut in the well if a kick is detected, and prevent a blowout.

The choke valve controls the flow of fluid from the annulus as kill mud is pumped down into the wellbore.

The kill manifold is used to pump kill mud down the hole if it cannot be pumped down the drill string.

EXERCISE C

Directions: *Answer the following questions.*

1. What are the three pieces of equipment used for well control?

   A. _____

   B. _____

   C. _____

2. What are the two major types of preventer on a BOP stack?

   A. _____

   B. _____

3. Which type of preventer would be used to cut the drill string and shut in a well during an emergency?

   _____

4. Which type of preventer would be best for shutting in the well when there is no drill string in the hole?

   _____

5. What is the purpose of the kill line that is connected to the BOP stack?

   _____

6. During a well-kill operation, the _____ is adjusted to regulate annular flow and pressure.

Divert
To change the direction of something.

Geological
Relating to the scientific study of the earth's structure.

Manifold
A part with multiple connections for pipes.

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

Ram
A type of piston, usually hydraulic, that closes and seals the BOP.

Stack
A vertical pile of blowout prevention equipment.

Surge
A sudden, large increase in downhole pressure of mud under the bit when the drill string is lowered too quickly.

Swab
To absorb something, the opposite effect of surging.

MAXIMUM: 100

OBJECTIVE 5.1.1

***Directions**: For questions 1 through 8, select the correct answer from the options provided. (5 points each)*

1. A function of drilling fluid is to prevent formation _____ from entering the wellbore.

   a. cuttings
   b. sand
   c. fluid
   d. mud

2. The pressure created by the mud column is affected by the _____ of the mud.

   a. color
   b. weight
   c. pH
   d. storage

3. Adding too much _____ to the mud will cause an insufficient mud weight.

   a. fluid
   b. sand
   c. barite
   d. solids

4. A kick can occur due to insufficient _____ as the drill string is pulled out of the hole.

   a. tripping speed
   b. hole depth
   c. formation pressure
   d. hole fill

5. If the mud weight is too high, it can cause _____ circulation.

   a. slow
   b. fast
   c. normal
   d. lost

6. A kick can occur as the drill string is pulled upwards, due to the _____ effect.

   a. swabbing
   b. surging
   c. drilling
   d. mixing

7. The easiest way to identify a kick is to see if the mud _____ when the pumps are off.

   a. dries

   b. flows

   c. boils

   d. cools

8. A _____ in the active pit mud volume may indicate a kick.

   a. drop

   b. loss

   c. gain

   d. filter

OBJECTIVE 5.1.2

Directions: *For questions 9 through 12, select the correct answer from the options provided. (5 points each)*

9. One purpose of killing a well is to circulate the _____ out of the hole.

   a. kick fluid

   b. kill mud

   c. kick mud

   d. kill fluid

10. As soon as a kick is detected the driller will _____ the well.

    a. keep drilling

    b. shut in

    c. abandon

    d. shut out

11. The driller will pump _____ as part of the procedure to kill a well.

    a. kick fluid

    b. kill mud

    c. kick mud

    d. light fluid

12. A well has been killed if the shut-in pressure is _____ and the well is not flowing.

    a. equal to standpipe pressure

    b. stable

    c. zero

    d. maximum

OBJECTIVE 5.1.3

Directions: *For questions 13 through 20, select the correct answer from the options provided. (5 points each)*

13. A BOP stack will usually have annular and _____ preventers.

    a. ram

    b. wellbore

    c. choke

    d. kill

14. During a well-kill operation, the _____ is adjusted to control the annular pressure.

    a. blind ram

    b. choke

    c. preventer

    d. kick fluid

15. When there is no drill pipe in the hole, the _____ are more effective than the annular preventer at sealing the well.

    a. choke lines

    b. pipe rams

    c. kill lines

    d. blind rams

16. The _____ is used to circulate kill fluid down the hole if the drill string is not in the hole.

    a. choke line

    b. kill line

    c. standpipe

    d. accumulator

17. The high pressure hydraulic fluid used to control the BOP is provided by the _____.

    a. choke manifold

    b. kill manifold

    c. accumulator

    d. mud gas separator

18. The _____ may be used to treat the mud during a well kill operation.

    a. choke manifold

    b. kill manifold

    c. accumulator

    d. mud gas separator

19. The _____ on the kill manifold will allow the kill mud to flow in only one direction.

    a. choke valve

    b. check valve

    c. pipe ram

    d. annular preventer

20. The BOP is placed at the _____.

    a. wellhead

    b. derrick

    c. top drive

    d. doghouse

Trainee name		Badge No.		Date		Score	

MAXIMUM: 100

OBJECTIVE 5.1.1

***Directions**: For questions 1 through 8, select the correct answer from the options provided. (5 points each)*

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   b. sand
   c. fluid
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7. The easiest way to identify a kick is to see if the mud _____ when the pumps are off.

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   b. flows
   c. boils
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   d. filter

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    c. abandon
    d. shut out

11. The driller will pump _____ as part of the procedure to kill a well.

    a. kick fluid
    b. kill mud
    c. kick mud
    d. light fluid

12. A well has been killed if the shut-in pressure is _____ and the well is not flowing.

    a. equal to standpipe pressure
    b. stable
    c. zero
    d. maximum

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Directions: *For questions 13 through 20, select the correct answer from the options provided. (5 points each)*

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    b. wellbore

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    d. kill

14. During a well-kill operation, the _____ is adjusted to control the annular pressure.

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    b. choke

    c. preventer

    d. kick fluid

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    c. top drive

    d. doghouse