INTRODUCTION TO WELL CONTROL
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Course Overview

This course has been written for people who are new to the complex subject of well control. All rig types are catered for: - land rig, jack-up, tender-assist, semi-submersible, platforms and drill ships. The following media are used:-

1) Lectures / Discussions (the Trainer began his career 35 years ago and has worked both on and offshore worldwide on land rigs, jack-ups, platforms, tender-assist, semi-submersibles and drill ships for Operators & Drilling Contractors. He is a certified IADC WellCap Plus Well Control Instructor and has been teaching Well Control for 10 years);

2) PowerPoints (written by the Trainer);

3) Videos and Digital Film;

4) Case history examples;

5) Teamwork exercises at introductory level;

6) IWCF Well Control Formulae Sheets & Well Kill Sheets

Provision is also made for delegates to discuss any aspect of well control in order to attain understanding of this often difficult subject and all its areas.

Aims & Objectives

By the end of the course, delegates will understand well control at introductory level which will enable them to know the causes of well control events, what can be done to prevent them and what to do should one occur. Well control equipment will also be reviewed.

Delegates will also benefit from reviewing previous well control events to assist their learning.

The theoretical and practical nature of the course will assist delegates with their job and with their advancement to the next level of well control.

Who Should Attend

People new to the drilling industry, pump-men, derrick-men, young trainee Drilling Engineers, Service Company Personnel, anybody who is worried about taking their well Control exam

Level

Introductory
Your Dedicated Coach

Michael Gibson (PhD)

Overview

- Seasoned professional with 35 years’ worldwide experience on drill-ships, semi-submersibles, tender-assist units, platforms, jack-ups and land rigs.
- Extensive experience both onshore and offshore in engineering and operations for Operators and Drilling Contractors on exploration, appraisal & development wells.
- Extensive risk assessment, advisory, planning and rig-site work experience ranging from Drilling Engineer through to Drilling Supervisor, Superintendent & Drilling Manager.

Training

Training experience worldwide ranges across Operators, Drilling Contractors and Service Companies both in-house and public in the following areas:

- HPHT
- Stuck Pipe Prevention & Fishing
- Deepwater Well Engineering
- Deepwater Operations
- Directional Drilling
- Horizontal & Multilateral Wells
- Accelerated Drilling Programmes for Drilling Contractors
- Graduate Drilling Engineering for Operators
- Optimised Drilling Practices
- Well Planning & Engineering
- Well Construction
- Well Control (Advanced, Understanding, Deepwater & HPHT)

Consultancy

Engineering & Operations Advisor to Operators, Drilling Contractors, Banks & Insurance Companies worldwide re Drilling & Field Development, Risk & Blowouts

- Hazard Analysis
- Offshore Operations
- Technical Advisor for HPHT Developments
- Well Control
- Technical Advisor for Deepwater Operations

Project

- Project Manager for HPHT Field Development; Standard Field Development
- Production Optimisation
- Risk Mitigation
- Brownfield Re-development
- Deepwater
- Well Control
- Management Systems

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This section of the course, following the Introduction, helps people to understand the key basics of well control. How events happen; why they happen and what we can do when they do happen. We begin with basic calculations and go on through to details relating to well control downhole.

INTRODUCTION

- Basic Calculations
- Primary Well Control

Mud weight (i.e. the primary barrier) must be checked regularly

- Where does the pressure come from? In this subsection we will look at where and how pore pressure builds up in the reservoir and how the gas / condensate / oil can enter the well whilst it’s being drilled (i.e. if Primary Well Control Barrier fails)

Pressure in the pores of the reservoir (in this case sandstone) cause the kick / influx if the mud weight (hydrostatic) is not heavy enough

- How to calculate hydrostatic pressure;
- Worked examples as to how influxes can occur (e.g. the well in under-balanced plus swab pressures for example) and what the Driller has to watch out for;
- System pressure losses (throughout the circulating system) e.g. standpipe and surface pressure losses, top drive system, drill pipe, heavy-weight drill pipe, the drill collars, the BHA (motors, MWD / LWD) and bit;
- Formation fracture pressure (this is when the rock actually breaks or fractures if it’s not strong enough to take hydrostatic mud-weight or ECD Equivalent Circulating Density (see below):-

Leak-off Test Procedure

The leak-off test procedure is used after casing has been run and cemented in place and the shoe has been drilled out 5 metres or so. The bit and BHA are then pulled back into the casing just drilled out. Then the annular preventer is closed and the well pressured-up. Pressure is noted on the vertical axis of the chart and barrels pumped noted on the horizontal axis. As soon as the straight line begins to curve, the test is stopped and the pressure noted. This pressure plus the hydrostatic pressure is the maximum pressure the well can be drilled with.

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MAASP & MAMW

MAASP stands for Maximum Allowable Annular Surface Pressure and is determined by calculation once the Leak-off value at the shoe has been determined. MAMW stands for Maximum Allowable Mud Weight and is also calculated.

When, How & Where to take SCR’s

SCR’s stand for Slow Circulating Rates, and are taken typically with the pumps working at 20 / 40 / 60 strokes per minute. The corresponding pressures associated with the varying strokes per minute rates are recorded and are utilised in the Well Kill Sheets.

INFLUX INTO THE HOLE

An influx of formation fluids (gas, oil or water) into the hole occurs when the hydrostatic pressure of the column of mud in the hole is less than the formation pressure. Unable to balance or “stay on top of” the formation pressure, the formation pressure enters the annulus as depicted in the above schematic. This situation occurs through the mud weight being too light or when pulling out of the hole too fast (termed “swabbing”).

Gas is the worst influx to have in the hole as it typically continues to rise at quite a fast rate if the well stays shut-in and it’s not circulated out of the hole.

To prevent an influx into the hole from occurring the hydrostatic pressure (determined from the basic formula Hydrostatic Pressure (psi) = Mud Weight (ppg) x True Vertical Depth (feet) x 0.052) must be at least equal to (but preferably greater than) formation pressure. Also, the hydrostatic pressure should not be momentarily reduced through pulling out of the hole too fast (swabbing).
During Day 2 we begin to study more about important events downhole.

- **Influxes - Continued**

Gas influxes in oil based mud can be problematic to handle, so greater care should be taken when drilling with an oil based mud. This is because gas goes into solution and small influxes may be masked and not fully noticed until the gas breaks out of solution as it approaches the surface.

One sure sign of an influx is an increase in pit level with the pumps off. This is because the influx in the annulus literally pushes the mud up out of the hole hence the rise in pit level. Also, pit levels will rise as gas rises up the hole due to expansion.

On traditional rigs, the pit level indicator will rise causing the alarm indicators to go off.

Modern 5th and 6th generation rigs may also be fitted with highly sensitive Electromagnetic or Coriolis meters. These can detect inflow / outflow discrepancies of fluid volumes as low as 1 barrel. This means that the well can be shut-in with a low influx volume, which is far more preferential than the rig having to handle large influx volumes.

As soon as the driller notices any indication of an influx (or kick as it’s sometimes called) the well should be shut-in in accordance with the approved procedures.

If the influx is due to the well being under-balanced due to mud weight being too light, then the necessary increase in mud weight to balance the well can be calculated from the SIDPP – Shut-In Drill Pipe Pressure reading.

**IF AN INFLUX IS CIRCULATED BY A WEAK CASING SHOE FRACTURING MAY OCCUR**

The strength of the casing shoe – and the immediate rock formation in the vicinity of the shoe – is of vital importance to well control since it determines how much of an influx can be circulated out of the hole.

The strength of the casing shoe is typically determined after casing has been run and cemented and circa 15 feet of new formation has been drilled. What is known as a formation Leak Off Test or formation Integrity test is then carried out: surface pressure is applied to the mud hydrostatic pressure up to either a certain value or until the gradient of the graph of pressure versus barrels pumped changes.
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DAY TWO

When an influx is circulated up toward a weak casing shoe the pressure of the influx may break down the casing shoe / the formation in the shoes’ vicinity casing the cement / rock to fracture. If the fracture occurs all the way back up to the mud-line (as depicted in the above schematic) then the influx can also work its way up to the mud-line causing “broaching” which is potentially very dangerous on land rigs, jack-up rigs and on platforms.

• Gauge Readings

UNDERSTANDING WHAT THE GAUGE READINGS MEAN IS VITAL

At the time of the influx the shut-in casing pressure gauge will rise as will the shut-in drill pipe pressure. Typically the casing pressure will exceed the drill pipe pressure since the influx will be in the annulus. The drill pipe pressure gauge tells you how much the hydrostatic of the mud is under-balanced. So, if you’re at a depth of, say, 10,000 ft. and the SIDPP gauge reads 600 psi then the well is under-balanced by 600 psi. During the course we talk about what the gauges mean and how to circulate the influx out properly and professionally.

▪ Choke Line Friction, How to Determine and It’s Effects
▪ Drilling Fluids
▪ Pump Speed and Mud Weight Effects on Pressure Losses
▪ Formation Trends
▪ Top Hole Drilling / Shallow Gas

Drill-ship South China Sea Becomes Unstable & Sinks due to Shallow Gas Blowout
Changes in Formation Pressure

Causes of Kicks

There are many causes of kicks (or influxes) downhole. The causes range from a) insufficient mud weight (hydrostatic), b) swabbing, c) underground blowout etc. This sub-section goes into detail as to how and why kicks / influxes happen, and what can be done to prevent them from happening.

Tripping

It has often been said that many kicks / influxes occur whilst the drill-crew are tripping. Thus, everything that can be done to prevent this must be done. One reason could be swabbing; if this might be the case then you may wish to pump out of the hole.
This section looks at very important aspects of well control, as follows:-

- Kick Indicators & Response
- Secondary Well Control, Shut-in procedures
- API Standard 53
- Monitor & Record Shut-in Data
- Shut-in Calculations
- Kill Methods

Jack-up BOP Stack (left) & Semi-submersible BOP Stack (right)
During this day of the class we look the two main methods of killing the well, which are:

- The Driller’s Method
- Wait & Weight Method.

We spend quite a large amount of time looking at both areas in order to understand the differences between them, their relative advantages and their relative disadvantages.

We also spend quite a large amount of time looking at BOPE (Blowout Prevention Equipment) – both surface and subsea in order to avoid the scene below:

Influx Taken due to Rise in Pore Pressure
During the last day of class, we fill-out a kill sheet in order to help us understand the well killing process in more detail.

By the end of the course, delegates will be ready to take their IWCF / IADC Well Control course. They will have learnt the how to carry out the following:

- Calculate and use all the formulae given
- Demonstrate a knowledge of the importance of taking & recording SCR’s
- Be familiar with IADC WellCap and IWCF formulae and kill sheets
- Identify drilling trend changes & know how to respond accordingly
- Describe well shut-in procedure
- Describe what needs to be done / information required to fill-in sheet
- Fill out Kill Sheet
- Identify components of BOP Equipment
- Demonstrate understanding of well control through past case studies

Open Forum – Q & A (This section id for any questions)
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