An Introduction to Oil & Gas Drilling and Well Operations

Educational Material from the IOM³ Oil and Gas Division

The Institute of Materials, Minerals and Mining

The global network for the materials cycle
Introduction

- The Institute of Materials, Minerals & Mining (IOM³) is a major UK professional engineering institution, incorporated by Royal Charter, with over 17,000 members spread across the world.

- IOM³ exists to promote & develop all aspects of: materials science & engineering, metallurgy, geology, mining & associated technologies and petroleum engineering, as a leading authority in the global materials & natural resource community.

- The Oil and Gas Division represents over 2,300 members of the Institute who are interested in the production of Oil and Gas.

- Membership of IOM³ provides a range of benefits, including access to globally recognised UK professional engineering qualifications such as Chartered engineer (CEng), go to: www.iom3.org

- This slide pack is part of a series of educational material produced by the Oil and Gas Division to provide the Public with information on the production of oil and gas. The IOM³ accepts no responsibility for the contents of this slide pack.
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Why We Drill Wells

- To gain information (e.g. Exploration & Appraisal wells)
- To produce hydrocarbons or support their production through Injection of gas and liquids

Drilling a well is the only way to access a Reservoir and establish what “lies beneath”.

Each well is a multi million pound project involving multi disciplines and each well is as unique as each individual person.
The Well Life Cycle

- **Design:** Agree the well objectives, schedule, costs, order equipment, place contracts for the rig and services, prepare the site.

- **Construction:**
  - **Drill:** The well is created by drilling a hole, isolating with casing and cement and repeating this process until the target depth and location are reached.
  - **Test:** A well may be produced temporarily to establish the Reservoir potential.
  - **Complete/Suspend:** If the well is to be put on production/injection it is completed with tubing and flow control equipment: otherwise downhole plugs are installed.
  - **Commission:** The well is handed over to operations and connected to the process facilities.

- **Operation:** Well performance and integrity are continually monitored. Routine maintenance is performed.

- **Workover:** The well is handed back to the wells team to perform downhole surveillance, improve the well performance or repair/replace downhole equipment. The well may also be “sidetracked” i.e. a new hole is drilled from the existing wellbore to a new target.

- **Abandonment:** When a well becomes uneconomic the wells team return to install downhole cement plugs to isolate hydrocarbon zones and the wellhead is removed.
SI 913: The Offshore Installations and Wells (Design and Construction, etc.) Regulations 1996, Part IV, Wells, General Duty:-

The well-operator, shall ensure that a well is so designed, modified, commissioned, constructed, equipped, operated, maintained, suspended and abandoned that –

(a) so far as is reasonably practicable, there can be no unplanned escape of fluids from the well; and

(b) risks to the health and safety of persons from it or anything in it, or in the strata to which it is connected, are as low as is reasonably practicable

The above requirement applies to UK land wells, a similar requirement exists in SI 398: The Offshore Installations (Offshore safety Directive) (safety Case etc.) Regulations 2015. A key reference for Guidance is the Oil and Gas Well Integrity Guidelines.
Well Design and Construction

**Wellhead**: installed on top of the surface casing to cap and hold the casing strings and completion.

**Conductor**: isolates unconsolidated surface formation and may take structural loads. Typically 36” hole to contain 30” conductor.

**Surface Casing**: isolates surface formations, typically 24” hole with 18.5/8” diameter casing.

**Intermediate Casing**: isolates pressure/problem zones above the reservoir. Typically 17.1/2” hole with 13.3/8” diameter casing.

**Production Casing**: Typically set above the Reservoir, typically 12.1/4” hole for 9.5/.8” casing.

**Production Liner**: Set across the Reservoir into the production casing, typically 8.1/2” hole for 7” liner.
Pipe Handling and the Drill String

Draw works and Rotary Table

Drillers Control Room “Doghouse”

Drill Floor on a North Sea Platform

Main Components of a Rotary Drilling Rig
Tri cone bit with milled steel (left) or tungsten carbide teeth (right) designed to “gouge and scrape”. The longer the teeth the greater the “gouging” action. Use milled steel with large teeth for drilling soft formations and tungsten carbide “buttons” for drilling harder formations.

Fixed cutter bit with PDC or Polycrystalline Diamond Compact (left) or natural diamond (right) inserts – also used for core heads. These drill bits are designed to “chip and crush” to drill harder formations. Like the tri cone bits nozzles provide hydraulic horsepower to clear the drill face, cool and assist drilling. Cut outs provide clearance for drill cuttings and drilling fluid.
Drilling fluids:
- Control pore pressure.
- Stabilise the wellbore.
- Transport cuttings from the drill bit to surface.
- Lubricate the drillstring.

Mud pumps:
- Power the drilling fluid.
- Provide power to mud motors and the drill bit.

Solids control system:
- Cleans and conditions the fluid.

Mud loggers:
- Continually monitor the system and record (log).
Animation showing deployment of cement into a casing annulus, known as a “cement job”.

Plug & Squeeze Cementing for Well Abandonment, Sidetracking or Isolating Open Perforations
Photographs show a subsea BOP stack comprising hydraulic rams and annular elements to seal around the drill string or cut and seal the drill string or close off the open well.
Directional Drilling

Mud Motors and Rotary Steerable Systems
Well Testing and Formation Evaluation

Mud Logging and LWD/MWD

Coring

Electric logging

Drill Stem Testing (DST)
Well Completion

Surface Controlled Subsurface Safety Valve (SCSSV) - may also have an annulus safety valve

Gas lift valves (May also use various types of pumps)

Production casing

Production packer

Seal assembly

Re-entry guide

No Go Nipple

Tubing hanger

Production tubing, typically 3.1/2” to 7” diameter

Pressure/temperature gauge

Landing nipple

Cased & perforated / barefoot / slotted liner or a screen - with or without flow control
Xmas Tree

An assembly of valves installed on the wellhead to control flow from/into the well, allow access for well interventions and monitor pressure/temperature.
Well Intervention

Equipment:
- Pumping
- Slickline
- Electric line
- Coiled tubing
- Snubbing

Objectives:
- Stimulate zones – fracture and/or acidise.
- Acquire downhole integrity, formation and flow data.
- Repair/replace broken equipment.
- Repair/replace equipment to optimise flow.
- Remove debris and deposits.

Typical Slickline Rig Up
Offshore Well Intervention Equipment
Slickline, Coiled Tubing and Subsea Intervention Vessel
Well Integrity

Loss of well integrity during well abandonment North Sea 2012

Flow cut tubing from a water injection well
Summary Points

• Drilling a well is the only way to access a Reservoir and establish what is there.

• Wells are constructed from concentric strings of steel casing, cemented in place with a wellhead on top and a completion inside.

• Each well is a multi million pound project, North Sea wells are typically designed to last for decades and each well is as unique as each individual person.

• Constructing and maintaining a well is a team effort involving many people with different skills – every individual is important.

• The priorities of the wells team are to maintain well integrity, avoid hurting anyone and deliver the objectives on time and in budget.

Key Document: Oil and Gas UK Well Integrity Guidelines
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