An Introduction to Oil & Gas Drilling and Well Operations in the United Kingdom

Educational Material from the IOM³ Energy Transition Group

The global network for the materials cycle
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The Institute Energy Transition Group covers the production of oil and gas and the technologies involved in the transition to a lower carbon future.

This slide pack is part of a series of educational material produced by the Energy Transition Group 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 the injection of liquids (typically water or gas).

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.
- as unique as each individual person.
- an adventure, a journey to where no one has been before.
First oil from Hardstoft No. 1 well: The London Illustrated News June 14th 1919, eight months after the well was spudded.
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 wells located onshore and internal waters in Great Britain. For wells in external waters a similar requirement exists in SI 398: The Offshore Installations (Offshore safety Directive) (safety Case etc.) Regulations 2015.
“‘Reasonably practicable’ is a narrower term than ‘physically possible’ ... a computation must be made by the owner in which the quantum of risk is placed on one scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time or trouble) is placed in the other, and that, if it be shown that there is a gross disproportion between them – the risk being insignificant in relation to the sacrifice – the defendants discharge the onus on them.” (HSE Reference: Edwards v. National Coal Board, [1949] 1 All ER 743)<http://www.hse.gov.uk/risk/theory/alarpglance.htm>
ALARP in practice

Compare the examples below from UK coal mines:-

1914: men manually cutting and loading coal working under unsupported roof without even a hard hat for protection

1984: men using a tunneling machine to cut and load rock with the roof fully supported with steel arches and hard hats for personal protection.

What is reasonably practicable changes as technology, working practices, cost, income, availability of equipment and public expectations evolve.
Summary of Key UK Legislation for Offshore Wells

Health & Safety At Work Act 1974

- Offshore Specific Regulations
- Safety Case Regulations
- Management & Administration Regulations
- PFEER
- Wells Design & Construction

General UK H&S Legislation applying offshore

- Noise at work
- Display Screen Equipment
- Management of Health & Safety at Work
- Personal Protective Equipment
- Provision and Use Of Work Equipment
- Control of Substances Hazardous to Health
- Reporting of Injuries Diseases & Dangerous Occurrences
- Manual Handling
- Lifting Operations & Lifting Equipment
- Ionising Radiation

Pollution Prevention and Control Act 1999 & Energy Act 2008

- Oil Pollution Preparedness, Response & Co-operation
- Assessment of Environmental Effects
- Offshore Chemical Regs
- Emergency Pollution Control
- Oil Pollution Prevention and Control
Legislation, Standards and Guidance

- European Union Directive
- Act of Parliament
- Statute (Regulation)
- Approved Codes of Practice
- Codes of Practice
- HSE Guidance
- Industry Guidance (Oil and Gas UK Guidelines)
- Company Policies, Practices, Procedures, Guidelines
Well Design & the Principle of Inherent Safety

**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.
Surface Wellhead
Subsea Wellhead

Guide post and wire
Bullseye level
Guide base
Seafloor
Wellhead
Rig Types

- Land
- Platform
- Jack Up
- Semi Submersible
- Drill Ship
- Tension Leg
1st UK Offshore Well – 1963 Lulworth banks
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
Drill Bits

Roller cone bit with milled steel or tungsten carbide teeth

Fixed cutter bit with PDC or natural diamond inserts – also used for core heads
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).
Cementing

Plug & Squeeze Cementing for Well Abandonment, Sidetracking or Isolating Open Perforations
Blowout Preventer

Annular BOP: a “doughnut” shaped element that seals around any size of pipe when pressure is applied.

Ram BOP: contains inserts designed to seal around specific diameters or blades designed to cut pipe and seal the open hole.
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)
Geo steering in the oil bearing Andrew sands

Well cross section

Andrew Top Reservoir

GOC - 2496m TVDSS
OWC - 2554m TVDSS
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
Artificial Lift Techniques
Perforating

Anatomy of a Perforation

Entrance hole 0.2" to over 1" - loosens some diameter going through casing.

Perf diameter in formation is 0.25" to 0.75", tapering to a point.

Length = 6" to 24"+ depending on type, size and design of charge; casing properties, formation strength and reservoir pressures.

"loose" sand in bottom of perforation - can cause confusion on sanding rate tests

Hole through cement usually slightly larger than in formation.

Liner, crushed cement and formation debris plug in last 1" or more of perf.
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.
Subsea Xmas Tree

88 MT subsea Xmas tree configured for diverless operation.
Sand Control

Glen Lyon

Subsea layout

Digging out sand

Downhole sand control

Sand screens
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
Coiled tubing and water injection: 1942-45

**HMS Conundrum**
- 70 miles of 3” diameter coiled tubing

**Fuel transport network**
- 120,000 gallons/day
- 172 million gallons pumped
Wax

Wax from a sucker rod. Wax is typically deposited from crude oil as the temperature drops e.g. in a subsea flowline or in a shallow land well.

Hot oiling unit in Dorset
Calcium carbonate scale formed when carbon dioxide releases into the gas phase as the pressure drops. In the well where pressure drops occur above the downhole safety valve and across the Xmas tree. Calcium carbonate is easy to dissolve with hydrochloric acid (HCL) and can be mechanically removed by milling/jet-blasting or slickline gauge cutters.

Barium Sulphate formed when naturally occurring barium mixes with sulphates from seawater and there is a pressure drop e.g. in a production well where there has been injected seawater breakthrough. The resulting scale is very hard and virtually impossibly to dissolve requiring mechanical removal e.g. milling.
Stimulation
Well Integrity

Loss of well integrity during well abandonment North Sea 2012

Flow cut tubing from a water injection well
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, UK 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 a productive well on time and in budget.

Key Document: Oil and Gas UK Well Integrity Guidelines
An Introduction to Oil & Gas
Drilling and Well Operations

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