OFFSHORE DRILLING WITH FLOATERS (SS or DS)
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

SUMMARY

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- ENVIRONMENTAL DATA ACQUISITION & RIG BEHAVIOUR
- RIG DRILLING EQUIPMENT
  - “surface” equipment
  - “Subsea” equipment
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- RIG MOVING
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- RIG & DRILLING COSTS
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

RIG TYPES

Land rig  Barge  Platform rig  Tender rig  Jack-Up  Semi-sub. moored  Semi-sub. DP mode  Drillship DP-mode
# RIG TYPES

<table>
<thead>
<tr>
<th>Offshore / bottom supported</th>
<th>Offshore / floaters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Barges:</strong> 8 to 25 ft WD</td>
<td><strong>Semi-submersible</strong></td>
</tr>
<tr>
<td>Special artic</td>
<td>Conventional moored</td>
</tr>
<tr>
<td>Posted</td>
<td>(up to 7650 ft WD)</td>
</tr>
<tr>
<td><strong>Submersible:</strong> 30 to 150 ft WD</td>
<td>Dynamic positioning system</td>
</tr>
<tr>
<td></td>
<td>(5000 to 12 000 ft WD)</td>
</tr>
<tr>
<td><strong>Jack-Up:</strong> 100 up to 500 ft WD</td>
<td><strong>Drillships</strong></td>
</tr>
<tr>
<td>Mat supported / Independent leg</td>
<td>Conventional moored</td>
</tr>
<tr>
<td></td>
<td>Dynamic positioning system</td>
</tr>
<tr>
<td></td>
<td>(5000 to 12 000 ft WD)</td>
</tr>
<tr>
<td><strong>Platform Rig</strong></td>
<td></td>
</tr>
<tr>
<td>Self-contained (compact rig)</td>
<td></td>
</tr>
<tr>
<td>Tender supported (tender rigs)</td>
<td></td>
</tr>
</tbody>
</table>

### Onshore/Land rigs
- Wheel/truck mounted
- Standard/conventional rig
  - Type: Drilling depth range (ft)
    - Light: 4000 - 8000 ft
    - Medium: 8000 - 12000 ft
    - Heavy: 12000 - 16000 ft
    - Ultra – heavy: 18000 - 25000 ft

### Offshore / bottom supported
- **Barges:** 8 to 25 ft WD
- **Submersible:** 30 to 150 ft WD
- **Jack-Up:** 100 up to 500 ft WD
- **Platform Rig**
  - Self-contained (compact rig)
  - Tender supported (tender rigs)
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

Semi-submersible

... some references
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

Semi-submersible

“Leiv-Eiriksson”

(in drilling conditions)
The new Aker H-6e is the world's biggest and most advanced drilling semi. It has features that make it particularly well suited for drilling under extreme conditions.
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OFFSHORE DRILLING WITH FLOATERS (SS or DS)

Environmental constraints

- Water depth, Marine currents, Low Temperature.
- Hydrates, Soil Unstability
- Low formation fracture pressures

Impact on drilling

1. Well architecture, drilling units costs,
2. Drilling riser technology and management
3. Safety: hydrates control BOP reliability
4. Drilling Fluids: hydrates control, « Mud Weight Window »
5. Drilling geo-hazards: shallow water flows slope unstability
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

OFFSHORE ENVIRONMENT WITH ....

-- Action of winds,
-- Action of waves,
-- Action of currents

and,

-- impact of water depth,
-- impact of seabed (formation)
MODU (SS, DS) motions in offshore environment.
FLOATING UNITS (SS, DS) BEHAVIOUR vs. OCEANO ENVIRONMENT

- IMPACT OF WATER DEPTH
  
  $$\implies \text{ ON MOORING}$$

- IMPACT OF WIND

- IMPACT OF SEA CONDITIONS
  (waves, swell)
  
  $$\implies \text{ ON FLOATER MOTION}$$

- IMPACT OF CURRENTS
  
  $$\implies \text{ ON DRAG FORCES ON RISERS}$$
  
  $$\implies \text{ ON FLOATER MOTION}$$

- IMPACT OF SOIL DATA
  
  $$\implies \text{ DESIGN OF MOORING GEARS}$$

- IMPACT OF SEABED OBSTRUCTIONS
  
  $$\implies \text{ CONVENT. MOORING ? DYPO. ?}$$
FLOATING UNITS BEHAVIOUR and LIMITS OF OPERATION

Typical criteria for the selection of a floater vs. location assessment:

Refer should be made to amplitude of the motions expressed by RAO curves (Response Amplitude Operator) in meter or in deg./meter of wave for a given period.

For example ...

- the floater must stay in position under 5-yrs storm condition
- the floater can operate under 1-yr storm condition.
DW floaters: Relative heave motion response vs. Wave period

Source: TOTAL Offshore Reference Book
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OFFSHORE DRILLING WITH FLOATERS (SS or DS)

SPECIFIC RIG EQUIPMENT FOR FLOATERS

Surface equipment
DRILLING STRING -- HEAVE COMPENSATOR

Heave compensator will allow to keep constant the weight on drilling bit (WOB).

When the floater is heaving up /- down, the heave compensator cylinders extend /- retract to compensate the vertical motion (heave).

Heave compensator will be also used ...
- for easy/smooth BOP reconnection on wellhead,
- to keep constant tension on DST string,
- etc ...
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

Heave motion compensator ...

to keep on drilling

Riser tensionners ...

to keep the riser under constant tension

Slip joint ...

to accommodate heave motion and for mud return conduit
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

Drill String Compensator

Slip Joint

Riser Tensioners

Riser

Riser tensioner
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

CONV. TENSIONING DEVICE

SPLIT TENSION RING

Source / illustrations: Cameron Drilling Products
Riser tensioning equipment

Tension : 16*100 kips
<= 7500 ’ riser
15 ppg in GOM conditions
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

…. In the moon pool

Telescoping joint (inner barrel)

Riser tensioning lines

Telescoping joint (main part – with suspension ring)
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

SPECIFIC RIG EQUIPMENT FOR FLOATERS

Subsea equipment
ROLE OF A DRILLING RISER - ROLE OF THE TELESCOPIC JOINT

**A drilling riser** connects the top of the BOP-stack to the drilling unit
- **mechanical role:**
  - to run or retrieve the BOP stack,
  - to guide the drillstring, the casings, the logging tools in the well,
  - to support BOP-hydraulic control lines, choke & kill lines, booster line, command lines (multiplex lines).

- **hydraulic role:**
  - to bring the drilling fluids up to surface; therefore, its participates to the hydraulic pressure balance of the well.

The drilling riser is kept under constant tension by means of riser tensioners.

**A telescopic joint** (top part of the riser) will allow vertical (heave) motions and provides a conduit for mud return.
OFFSHORE DRILLING WITH FLOATERS

(SS or DS)

A TYPICAL RISER JOINT
- 75 ft long (approx. 22m)
- weight in air: 22 t (with flotation modules)
- OD: 45 to 50 in (with flotation modules)
- Inside volume: 200 l per m

Source / illustrations: Part from Cameron Drilling Products
DRILLING RISER and OPERATIONAL LIMITS

Operational limits:

refer to tensionners capacity vs. water depth, mud weights, ...

refer to riser equipment/components: for example, for the ball joint ....

0 to 2°: drilling will continue;

between 2 and 5°: stop drilling, riser still connected;

between 5° and the maxi. for this equipment: riser must be disconnected.
SUBSEA ARRANGEMENT:

**Riser,**

A typical riser element
- 75 ft long,
- 21” OD x 7/8” wall
- 2 x 4 ½” ID choke and kill lines
- 1 x 4” ID booster line
- + hydraulic lines

**BOP stack**

Drilling wellhead

Source / illustrations: Cameron Drilling Products
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

Subsea BOP stack

Hydril BOPs

Weight : > 400 T in air
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

BOP rams

Shear rams

Variable bore rams

Source / Illustrations: Cameron

OFFSHORE DRILLING WITH FLOATERS (SS or DS)
BOP stack can be disconnected ....

-- either at the wellhead connector

-- or at the LMRP connector

At the wellhead connector:
- for example, to repair the BOP at surface, but in this case the well HAS TO BE secured (cement plugs, packers, ...).

At the LMRP connector
- in case the rig is drifting or an iceberg is approaching, but the drillstring has to be hanged-off on pipe rams first, or the DP have to be sheared in a process of an emergency procedure.
Subsea BOP STACK

LRMP
(Lower Riser Marine Package)

BOP

Kill line flexible

Choke line flexible

Annular BOP

Collet connector

Control pod

4 x rams type BOP

Choke line valves

Kill line valves

Well head
Operating the BOP ....

- Through multiplex (electro-hydraulic) system = normal operation,

Through EDS – Emergency Disconnect System = emergency
   it shears DP & unlatches the LMRP,

Through AMF – “Dead-man” (Auto. Mode Function)
   it shears DP, closes the well but does not disconnect the LMRP. Battery will allow to power up to five functions

Through ROV Panels - use of an ROV when normal operations is not available.
Operating the BOP (contd.)

- Through Automatic Disconnect System: automatically close the shear rams when the riser angle exceed a certain predetermined limit.

Through Autoshear System: to automatically close the shear rams When there is an unplanned disconnect of the LMRP

Through Acoustic System: system to activate a limited number of functions from the rig when no other communications are possible.

If a BOP failure occurs then HC influx will be uncontrolled leading/meaning to a blowout.
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

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OFFSHORE DRILLING WITH FLOATERS (SS or DS)

SUBSEA OPERATIONS ASSISTED BY ROV
ROV manipulators

Standard arrangement on Work ROV is 2 manipulators (1 “dextrous” and 1 “grabber”)
Manipulators are used to dock the ROV on sub-sea structures and manipulate:
• tooling (cutters, torque tool, brushes, HP jetting, hot stabs, sensors,...)
• Installation aids (rigging, buoys)
It can also be used to pick up objects (up to 100 kg at 2 m), pull ropes and cables, remove debris, etc.

“dextrous” Manipulator, 7 functions or 7 DoF, (Degrees of Freedom), identical to human arm

“Grabber” type manipulator, 5 functions, mainly used for docking the vehicle on structures, and for heavy lifting

Source: TPA  A.O. tenelle
** Поэтому не копировать **

** ОФФШОРНАЯ ДРЕССИРОВКА С ФЛОТАМИ (SS или DS) **

**ОБОРУДОВАНИЕ СЕМЬИ ВОЗДУШНОЕ **...

**ДЛЯ ОПЕРАЦИЙ IMR* **

(* Оценка, поддержание, ремонт)

**Один пример работы, выполненной с помощью ROV**

**ROV — АУВ** ----> **SWIMMER**

**(Подводное обслуживание с минимальным окружением ROV)**

Концепт изобретен компаней CYBERNETIX в 1997 году

* (Автономная подводная машина)
ROV --- AUV --- SWIMMER

ROV: (Remote Operated Vehicle) for underwater works; widely used in support of offshore drilling activities; rental daily rate: (approx) 4000 $/d)
- main system components: TMS (Tether Management System) + tether (= ombilical) + ROV (Remote Operated Vehicle).

AUV: (Autonomous Underwater Vehicle) for survey works (video inspection, …) on pipelines

SWIMMER: R&D development stage
- for underwater surveys + works
- main system components: docking station (to “park” AUV + ROV) + AUV (to support the ROV) + ROV linked to the AUV with a tether)
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RIGS ON LOCATION and STATION KEEPING

When on location different system of station-keeping ...

Reference point = the drilling wellhead

--- > Inland barges are set on sea-bed bottom,

--- > Jack-up are pinned on the sea bed (spud cans and legs),

--- > Tenders are “conventionally” moored,

--- > SS, DS are either:

- “conventionally” moored (mooring lines, anchors)
- operated in DP mode (thrusters, propellers)
ANCHORING PATTERN

for a semi-submersible

WD on location: 115m
Chain length out: 1200m
RIGS ON LOCATION and STATION KEEPING PERFORMANCES

Reference point = the drilling wellhead

**BUT** ... a DP mode will

- facilitate re-entries (drilling bits, conductor pipe, ...)
- facilitate BOP or riser reconnection
- safe access when sea-bed are occupied with pipe-lines, umbilicals, ...
- facilitate leaving a location in case of emergency: blowout (surface gas),
  of typhoons, of iceberg drifting, ....
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

**SUMMARY**

- **INTRODUCTION**

- **ENVIRONMENTAL DATA ACQUISITION**

- **OPERATIONS**

  - RIG BEHAVIOUR vs. ENVIRONMENTAL CONDITIONS

  - RIG DRILLING EQUIPMENT

    - HEAVE MOTION COMPENSATORS

    - SUBSEA BOP

    - DRILLING RISER

    - ROV

  - RIG STATION KEEPING

  - RIG MOVING

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PLATFORM RIGS, MODU --- MOVING TO/OFF LOCATION

For Platform rigs  === >  Platform cranes or crane-barges are used
For Tender rigs  === >  Crane of the Tender rig  are usually used

For Jack-Up  === >  Cantilever are skidded over the wellhead platform
                  === >  “Skid-off” method over the wellhead platform

For floaters and Jack-Up

  === >  field move with tug(s) (floater without own propulsion)
  === >  ocean tow (long distance) === > on heavy ship-lift carriers
Conventional semi-submersible
(deballasted conditions)

In transit: “dry tow”
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

SS « Polyarnaya Zvezda »

In transit: “self” moving

Loading for dry tow
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A DRILLING WELLHEAD .... WHAT FOR ?

Main functions
- to suspend casing strings (typically 3 or 4),
- to suspend a production tubing,
- to seal the different annulus (at wellhead level) = safety barrier
  and,
- to provide access to the different annulus,
- to support the BOP (while drilling),
- to support the X-mas tree (producing well).

Location,
The well head is located on ground level (onshore), at the wellbay level (drilling on platform) or at the seabed (offshore).
TYPICAL SUBSEA HP WELLHEAD STACK-UP
TYPICAL SUBSEA HP WELLHEAD HOUSING

A 18 ¾” wellhead housing

Source/Illustrations: TOTAL
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

TYPICAL SUBSEA HP- WELLHEAD

Casing Hangers

HP Housing

LP Housing

Conductor Pipe

20" Casing

14" or 13-3/8" Casing

10-3/4" or 9-5/8" Casing

7.5/8" or 7" Casing

Seal Assemblies

Source / Illustrations: Cameron
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

P & A -- Subsea wellhead recovery
Rig move on location
Running WH
Running BOP and riser
Drilling

OFFSHORE DRILLING WITH FLOATERS (SS or DS)
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

**OFFSHORE WELL CONSTRUCTION - TYPICAL SEQUENCE OF OPERATION:**

- Drilling 36” hole (no mud return in surface)
- Run 30” CP (*) (Install temporary guide base for very soft formation only)
- Drilling 26” hole
  
  . no mud return in surface or
  
  . with mud return for special application (use of pin-connector & riser)
- Run 18 ¾ “ HP - wellhead housing with the permanent guide base attached
- Run BOP and marine riser
- Drill 17 ½” hole - Run 13 3/8” intermediate casing
- Drill 12 ¾” hole - Run 9 5/8” intermediate casing
- Drill 8 ½” hole - Run 7” production casing or liner
- Well test (DST)
- Well completion (= run X-tree) or T&A or P&A

( * CP can be set by jetting process)
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OFFSHORE DRILLING WITH FLOATERS (SS or DS)

DRILL STEM TEST (DST) PERFORMED FROM FLOTATORS *

* Semi-submersibles or drillships

Source / illustrations: Cameron Subsea Systems
Typical assembly
(onshore)

Surface testing wellhead
Rig floor

Subsurface Safety Test Tree

DST string (DP, tubing)

Reverse circul. tool

Test valve
Pressure recorder
Safety joint

packer

Perforated tail-pipe
Pressure recorder

Typical assembly
(offshore – floating supports)

Sea bed

Sea bed

casing

Cased or Uncased hole

OFFSHORE DRILLING WITH FLOATERS (SS or DS)
SSTT
Subsea Completion Test Tree *
(*™ Schlumberger)

Provide wellbore access, dual barrier well control and fast acting means to shut-in a well and disconnect the test string at BOP level in the event of an emergency.

Such SSTT devices support operations performed from anchored or Dypo floaters in water depths ranging from shallow to ultra deep.

Such devices can have slickline, wireline, CT cutting capability.
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

SSTT POSITION IN BOP STACK

*Disconnection level*
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

SURFACE TEST EQUIPMENT LAYOUT
(OFFSHORE SET UP)

Source / illustration: IFP – ENSPM
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

WELL TESTING FROM A SEMI-SUBMERSIBLE
OFFSHORE DRILLING WITH FLOATERS (SS or DS)

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### OFFSHORE DRILLING WITH FLOATERS (SS or DS)

<table>
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<tr>
<th>Rig Type</th>
<th>Rig rental costs (approx.)</th>
<th>Operational daily costs (approx.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land rig</td>
<td>30 to 45 K$ / d</td>
<td>65 000 $/d</td>
</tr>
<tr>
<td>Drilling barge</td>
<td>45 to 100 K$ / d</td>
<td>130 000 $/d</td>
</tr>
<tr>
<td>Tender rig (conventional)</td>
<td>50 to 120 K$ / d</td>
<td>160 000 $/d</td>
</tr>
<tr>
<td>Jack-Up (300 ft)</td>
<td>100 to 250 K$ / d</td>
<td>170 to 425 000 $/d</td>
</tr>
<tr>
<td>Semi-submersible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5000 &lt; WD &lt; 7500 ft)</td>
<td>200 to 250 K$ / d</td>
<td>380 to 475 000 $/d</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(5000 &lt; WD &lt; 7500 ft)</td>
<td>300 + K$ / d</td>
<td>570 000 $/d</td>
</tr>
<tr>
<td>(7500 &lt; WD &lt; 10 000 ft)</td>
<td>+ / - 700 K$ / d</td>
<td>1 200 000 $/d</td>
</tr>
</tbody>
</table>

Figures vary with type of contract (short/long term), market conditions, geographical area....
Slides were prepared for presentation and information to Students of Schools and Universities only.

References

Slides presented were prepared with illustrations from the following referenced documents:

- API Standards and Recommended Practices,
- Neal J. Adams, Drilling Engineering, PennWell Books, Tulsa, Oklahoma, 1985,
- (Halliburton) - Petroleum Well Construction – J Willey & Sons
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- Miscellaneous documentation from TOTAL Drilling Division
- Halliburton Completion Services
- Miscellaneous books from IFP
- Leading Edge Advantage Ltd (Under Balance Drilling).
- Miscellaneous documentation from web-sites: O&GJ, World Oil, SPE
- Transocean, Saipem, Pride Drilling Contractors
- Baker Hughes, Schlumberger, Weatherford, Wild Well Control Service Companies
- Cameron, Hydril, Companies.