FPSO Training Course

Radisson Blu Boulogne Hotel, Paris ~ December 2016

Session 3.1 - Turrets and Swivels

Ian Parsons – Crondall Energy

Agenda

- Key technologies - Turrets and swivels
- Types of turret
- Interface with sub-sea
- CALM buoys
- Swivels

Key technologies – turrets and swivels

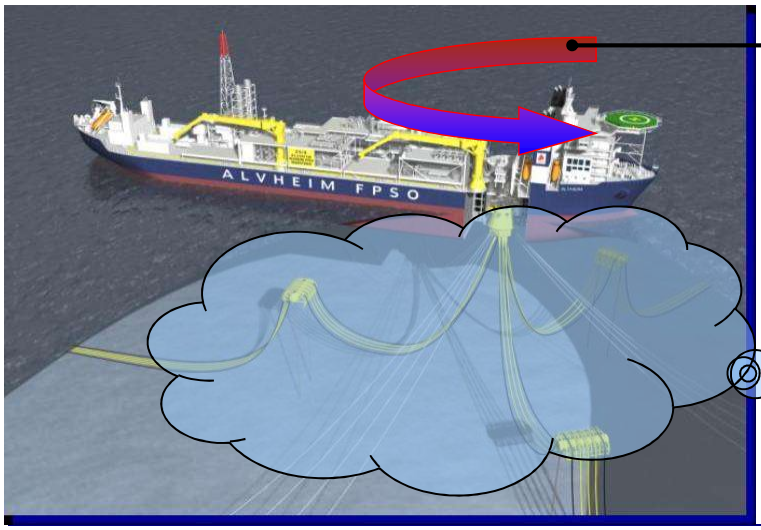
Key Technologies

- Development of turret and swivel systems which allow ***n x 360 degrees*** rotation have been the key technologies which have allowed FPSOs to be used in all met-ocean environments
- Turrets allow vessels to weathervane – that is, to take up a position which aligns it with the dominant forces of wave, wind and current
- **<u>Weathervaning</u>** has the effect of minimising environmental loads on the station keeping system, and minimises the most sensitive vessel motions – generally for mono-hulls – ***roll.***

Key Technologies

- Turret provides connection to mooring lines, transfer of mooring loads to the hull and mechanical support for the risers and umbilicals
- Swivel systems allow the transfer of:
  - Production fluids from the sub-sea equipment to the vessel
  - Export fluids from the vessel to the sub-sea infrastructure
  - Well/sub-sea management/control fluids e.g. methanol
  - Electrical signals for control and monitoring
  - Electrical power for driving sub-sea/down hole equipment e.g. ESPs

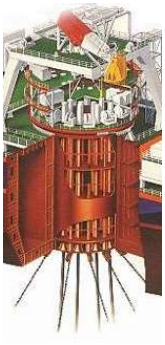
Weathervaning FPSOs



FPSO rotates around turret and fluid swivel

Mooring and risers fixed to sea bed and are "geostationary"

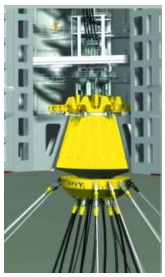
Turret Systems



Internal Turret

External Turret

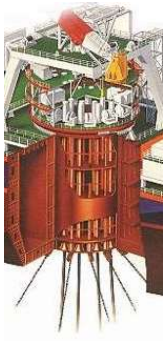
External Disconnectable Turret



Internal Disconectable Turret

Yoke Tower

Which Turret?



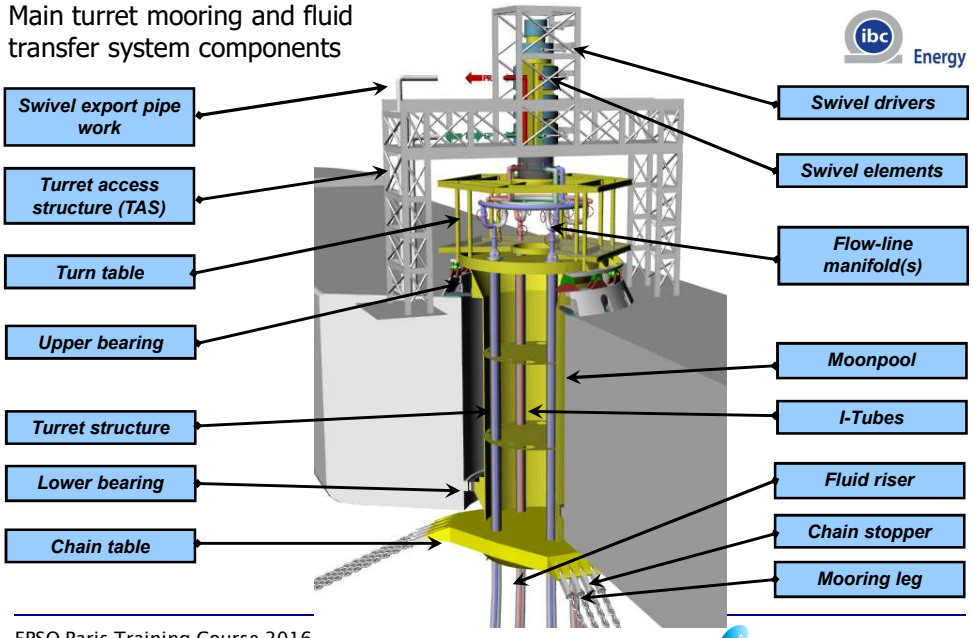
Internal turrets:
- Harsh environment
- Large number of risers (~25-75)
- Large amount of equipment
- Water depth above ~70+m

External turret:
- Moderate environments
- Small number of risers (up to 25)
- Small amount of equipment
- Water depth between ~50 – 1000m

Yoke system:
- Small water depths (<50m)
- Large or small number of risers
- Moderate environment

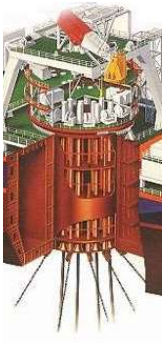
Main turret components

Main turret mooring and fluid transfer system components



Types of turret

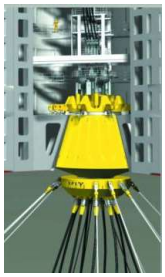
Turret Systems



Internal Turret

External Turret

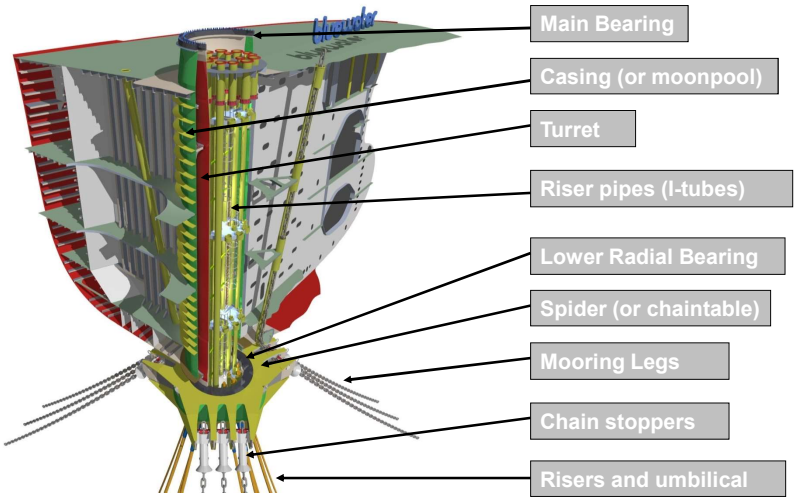
External Disconnectable Turret



Internal Disconectable Turret

Yoke Tower

Internal Turrets



Images courtesy of Bluewater

Internal Turrets

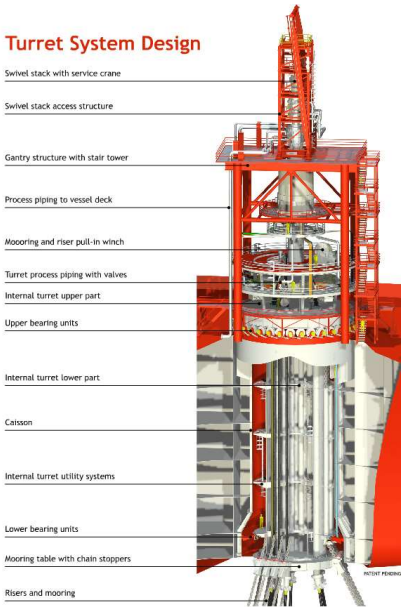


Image courtesy of Framo as

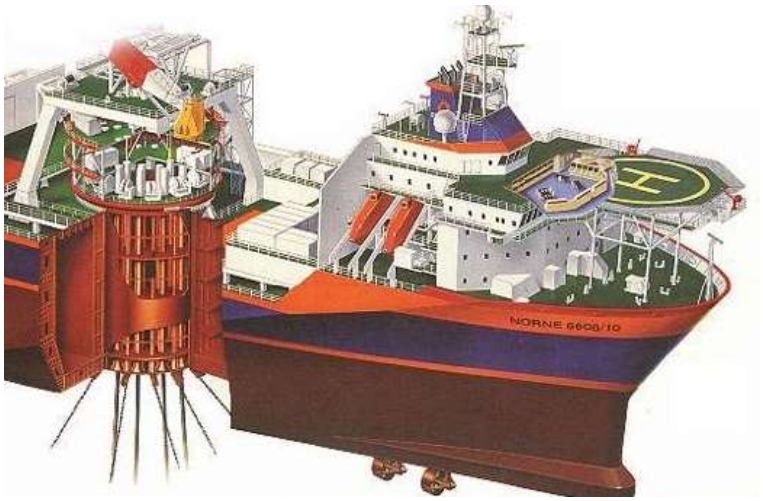
Internal Turrets

Images courtesy of SBM

Internal Turrets

Images courtesy of SBM

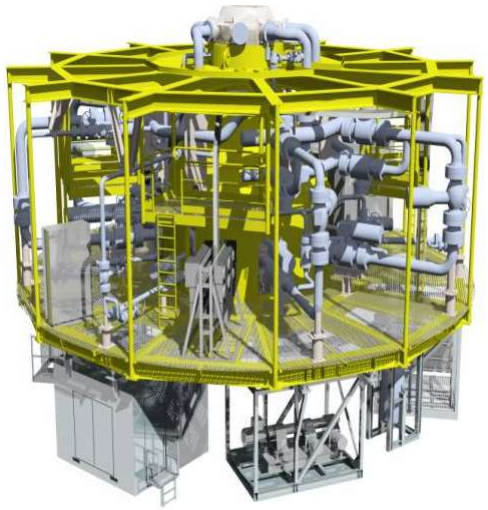
Internal turret



Internal Turrets? Turntable - Typical Lay-out

Typical turntable equipment:

- Subsea control hydraulic power pack
- Subsea chemical injection
- Pipe headers
- Control valves and safety valves
- Riser maintenance equipment (pig launchers/receivers)
- Riser and mooring pull in Winch

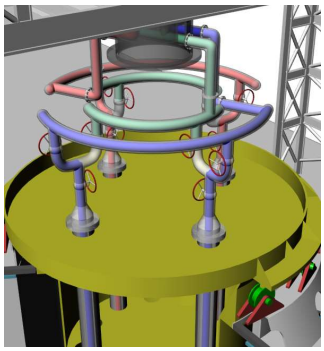


Images courtesy of Bluewater

Internal Turrets? Turntable

One of the primary function of the turntable is manifolding:

- 'Combining multiple flow lines to one or more swivel paths, and creating the flexibility to add or interconnect other flow paths'



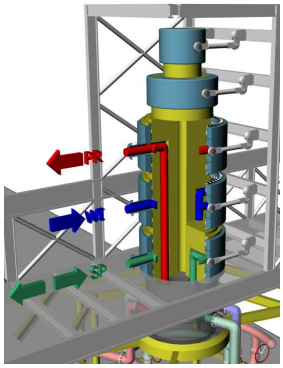


Image courtesy of BP Norge

External turrets - FPSO Fluminense Brazil

- 800 m water depth
- 357,000 dwt tanker conversion
- 1.2 million bbls storage

Images courtesy of Modec/Sofec

External turrets - Cuulong MV9 FPSO

- 46 m water depth
- 151,000 dwt tanker conversion
- 1.0 million bbls storage

Images courtesy of Modec/Sofec

Disconnectable Turret Systems

Why a disconnectable system?

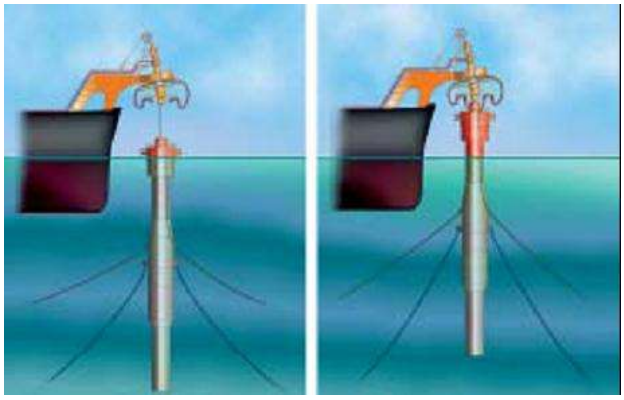
- Weather driven: disconnect for cyclones, hurricanes or ice;
- Pre installation of mooring lines and risers attached to the buoy:
  - Schedules of subsea installation and FPSO installation disconnected -> less risk;
  - Smaller weather window required since installation time is reduced.

Why we disconnect for cyclones!

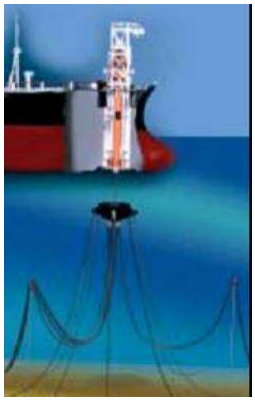
Somebody asked about green water……?

Disconnectable systems
SBM's External and Internal solutions

External or Riser Turret Mooring



Internal turret with disconnectable buoy



Images courtesy of SBM

The Riser Turret Mooring (RTM)

- Enfield
  Location W Shelf Australia
- Water depth: 600m
- Vessel size: 150,000 Dwt

Images courtesy of SBM

Enfield RTM – during RTM connection

Images courtesy of SBM

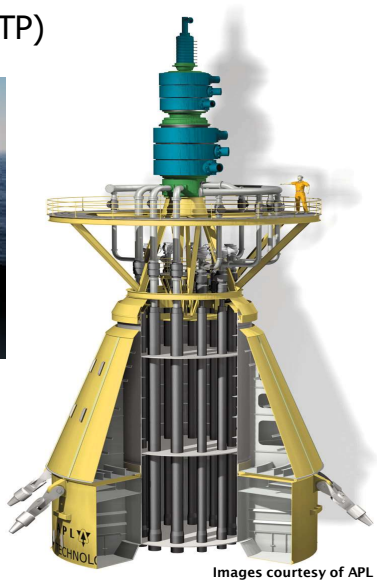
Images courtesy of SBM

Enfield RTM – during RTM connection

Images courtesy of SBM

Submerged Turret Production (STP)

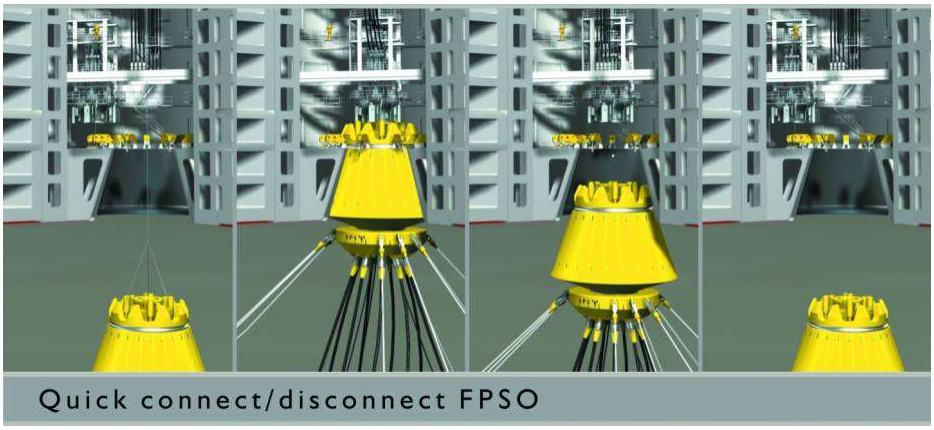
Images courtesy of BW Offshore



Images courtesy of APL

- APL system;
- Compact system;
- Swivel located in hull or on deck;

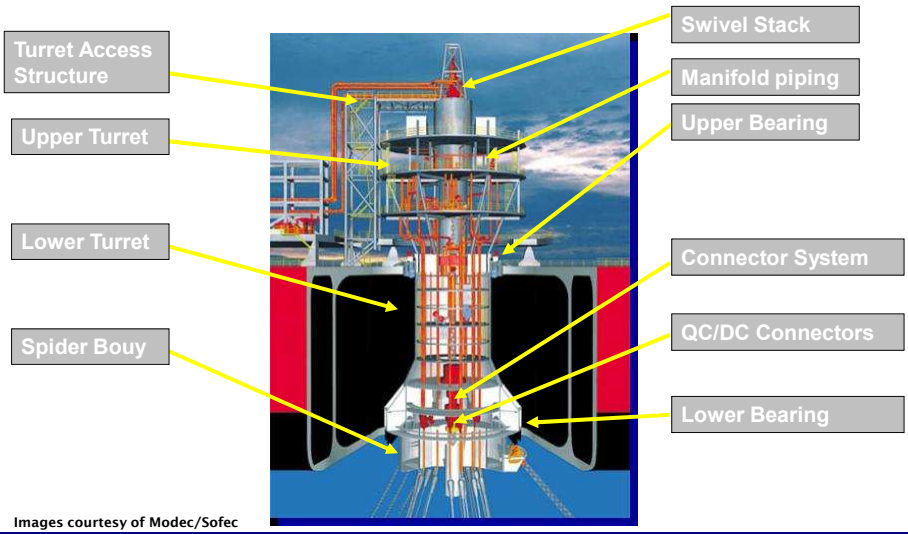
Disconnectable internal turret system
APL's STP system



Images courtesy of APL

APL Mooring system

Disconnectable systems –Terra Nova (Sofec)



Images courtesy of Modec/Sofec

Yoke Mooring

CNOOC Bohai Bay QHD32-6 FPSO (China)

- 20 m water depth
- New-build vessel
- 1.0 million bbls storage

Kome Kribi FSO w/ Tower Yoke Mooring System

- 34 m water depth
- Converted tanker
- 2.3 million bbls storage

Images courtesy of Modec/Sofec

Yoke Mooring

CNOOC Bohai Peng Lo FPSO (China)

- 28 m water depth
- New-build vessel
- 390.000 Dwt

Images courtesy of Bluewater

Interface with sub-sea

Interface with sub-sea equipment

- Turret and swivel provide the main interface between the FPSO and the subsea system
- Subsea system consists of flow lines, umbilical and mooring lines.

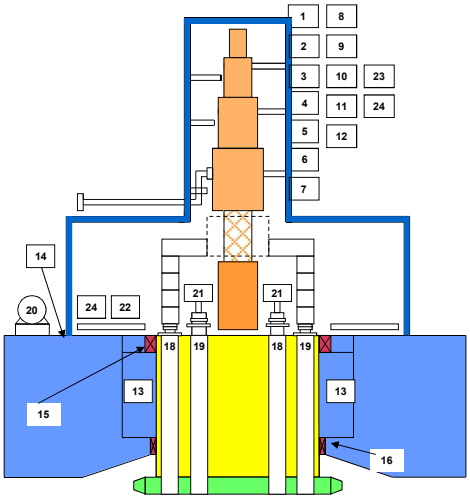
Risers are provided for:

- Reservoir fluids
- Water injection
- Gas injection
- Gas lift
- Gas export/import
- Oil export

Umbilical are provided for:

- Signal transfer from the well head
- Well head control
- Chemical injection into well

Turret and sub-sea interfaces



Process:
1 - Product
2 - water injection
3 - Gas injection
4 - Gas lift
5 - Gas export/import
6 - Oil export
7 - Drain system

Utilities:
8 - Plant Air
9 - Fresh water
10 - Hydraulics
11 - Deluge
12 - Chemical injection

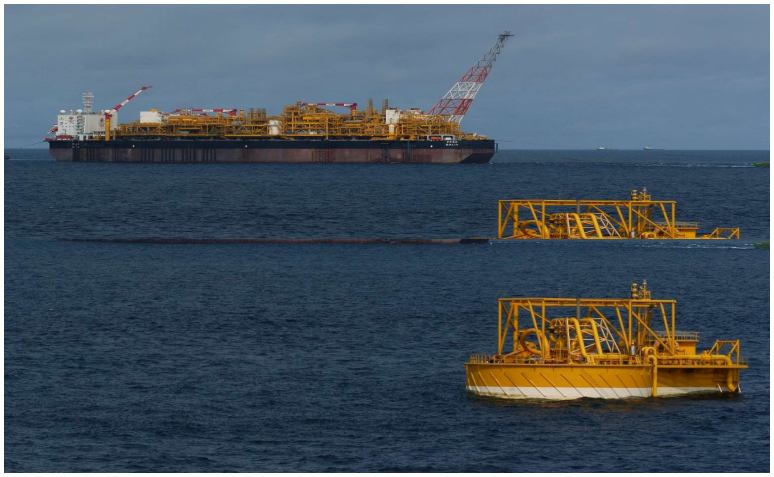
Structural:
13 - Hull structural integration
14 - Turret access structure supports
15 - Top bearing
16 - Lower bearing

Subsea:
18 - Riser and umbilical sizes
19 - Number of riser and umbilical
20 - Riser pull in winch capacity
21 - Umbilical termination units
22 - Subsea control cabinets

Electrical & Controls:
23 - Power supply
24 – Controls

CALM Buoys

CALM buoys



Images courtesy of NOV/APL

CALM buoy operation

Images courtesy of NOV/APL

CALM buoy construction

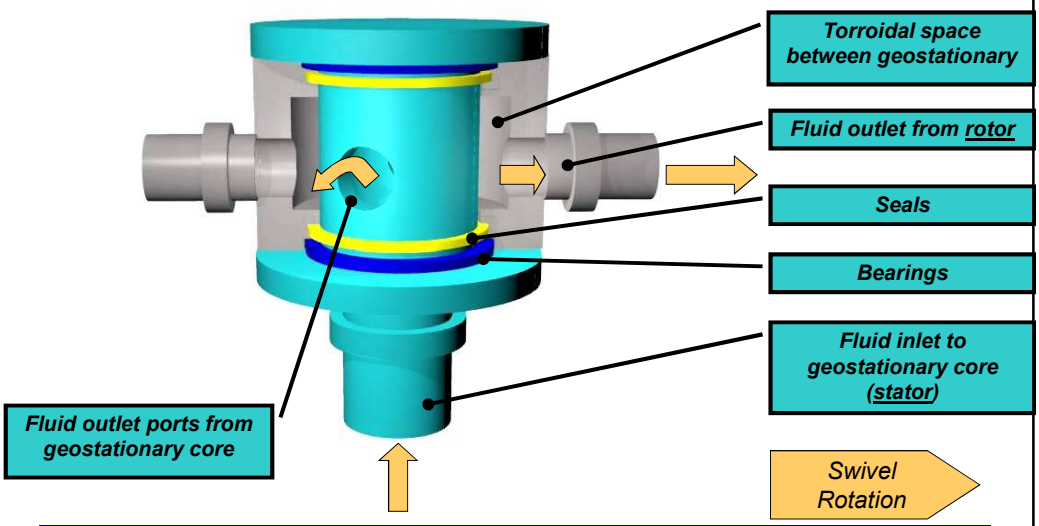
Images courtesy of NOV/APL

Swivel systems

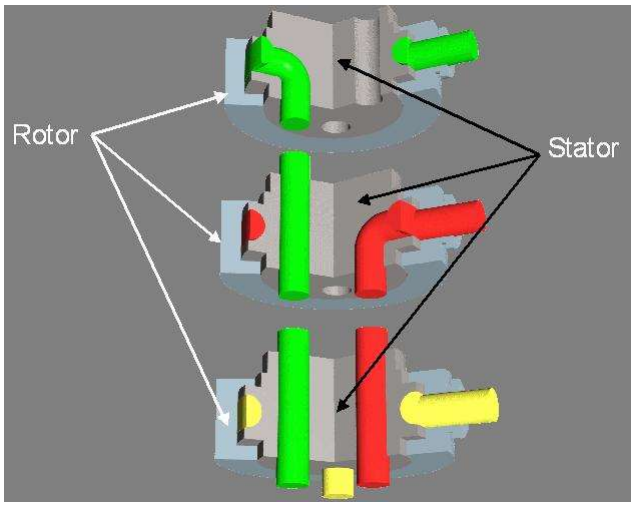
Swivel systems

- Swivel systems allow the transfer of:
  - Production fluids from the sub-sea equipment to the vessel;
  - Export fluids from the vessel to the sub-sea infrastructure;
  - Well/sub-sea management/control fluids e.g. methanol;
  - Electrical signals for control and monitoring;
  - Electrical power for driving sub-sea/down hole equipment e.g. ESPs.
- Swivel systems allow n x 360 degrees rotation
- Fluid swivel manufacturers are pushing back the boundaries of pressure and temperature to limits of around:
  - ~525 barg;
  - ~130c; (Source: SBM)
  - For utility swivels (small diameter hydraulic and electrical & electro/optical) see vendors such as Focal

Simplified swivel (single path)



Multiple paths can be stacked



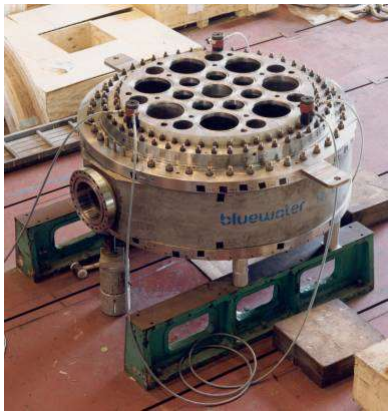
Images courtesy of Bluewater

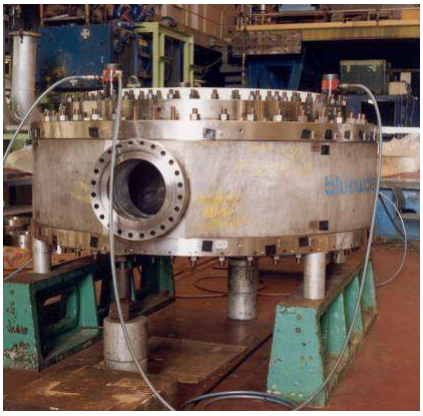
Seal materials

- Generally seal material is polytetrafluoroethylene (PTFE);
- High melting point (327°C) and an excellent chemical resistance;
- The main reason to use PTFE for dynamic seals, is its low coefficient of friction and the absence of stick-slip phenomenon;
- Disadvantage of PTFE is its tendency to creep, particularly at high pressures and temperatures;
- The design of swivel seal arrangements is dominated by this tendency to creep, i.e. minimisation of extrusion gap

Ref OTC Paper # 7178

Swivel stack modules





Images courtesy of Bluewater

Ancillary Support Systems

- Silt Barrier / Seal Energisation System
- Leakage Recovery System
- Torque Drive System
- Condition Monitoring System

Images courtesy of Scana

P37 Swivel stack

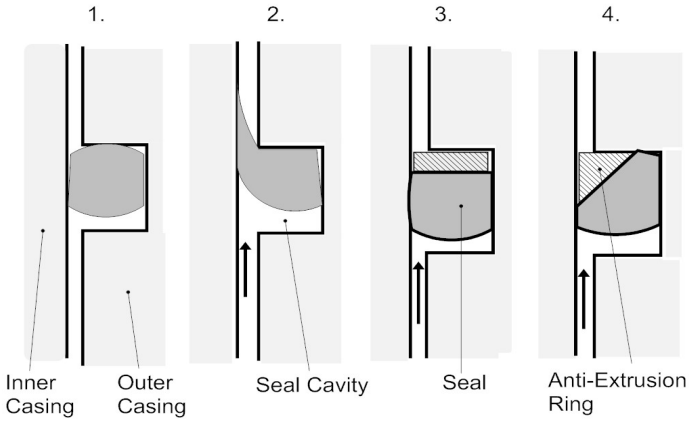
Thankyou for your time!

Images courtesy of Bluewater

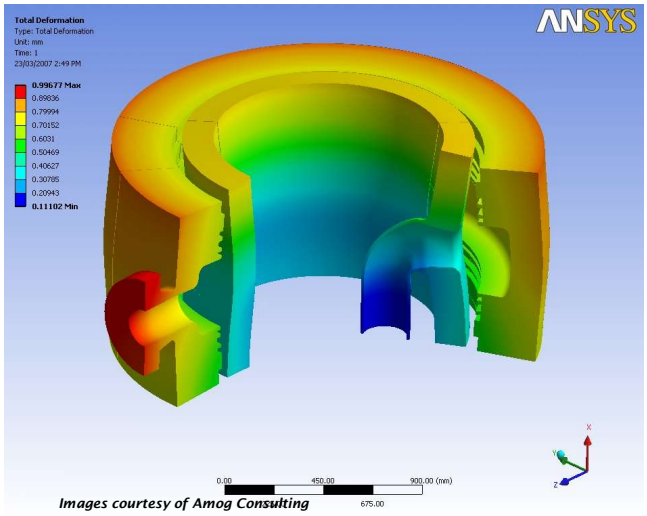
Additional material

A common seal failure mode

Seal material extrusion

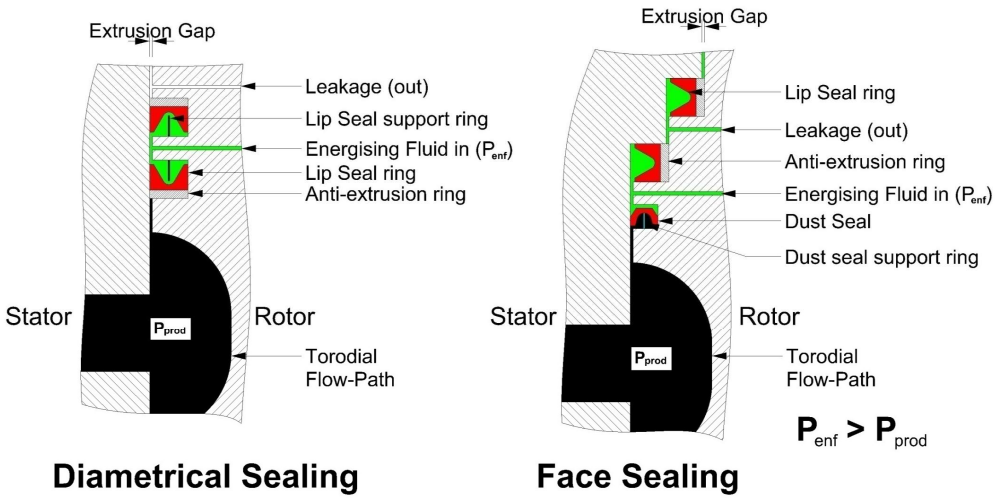


Swivel deflections

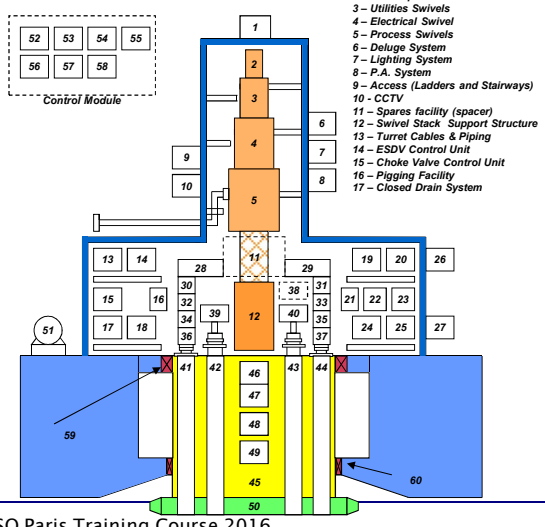


Images courtesy of Amog Consulting

Typical Swivel Sealing Systems



Turret and fluid transfer systems & interfaces



1 – Swivel Stack Hoist
2 – Fibre Optic Swivel
3 – Utilities Swivels
4 – Electrical Swivel
5 – Process Swivels
6 – Deluge System
7 – Lighting System
8 – P.A. System
9 – Access (Ladders and Stairways)
10 - CCTV
11 – Spares facility (spacer)
12 – Swivel Stack Support Structure
13 – Turret Cables & Piping
14 – ESDV Control Unit
15 – Choke Valve Control Unit
16 – Pigging Facility
17 – Closed Drain System

18 – Telephone/Comms Aids
19 - Turret Remote I.O.
20 – Distribution Panels (Chemicals)
21 – Pigging Facility
22 – Plant Air
23 - Lighting
24 – Small Power Distribution & Control
25 – Anchor Load Cell/Sensors J.B
26 – Fire & Gas Sensors
27 – Barrier Oil Tubing & Cabling
28 – Inlet Manifold
29 – Inlet Manifold
30 – MPFM Spool
31 – MPFM Spool
32 – Choke Valves
33 – Choke Valves
34 – Instrument Injection/Sampling
35 – Instrument Injection/Sampling
36 – ESDV's
37 – ESDV's
38 – Power Umbilical J.B
39 – F.O Umbilical J.B
40 – Control Umbilical J.B
41 - Riser
42 – Umbilical
43 - Umbilical
44 - Riser
45 – Turret Structure
46 – Ventilation System
47 – Open Drain System
48 – Bilge Pumps
49 – Anchor Load Sensors
50 – Chain Table
51 – Pull-in Winch
52 – Anchor Load Monitors
53 – ESDV H.P.U
54 – Barrier Oil H.P.U
55 – Auxiliary H.P.U
56 – Auxiliary Systems Module
57 – Auxiliary Control Panel
58 – Swivel Control Panel
59 – Top bearing
60 – Lower bearing

Acknowledgements

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