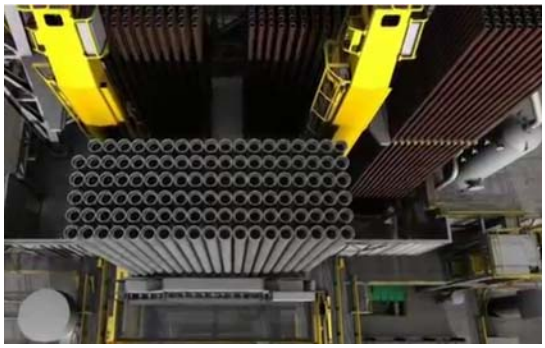
Offshore structures for oil and gas production

Prof. Milan Stanko (NTNU)

1

Components

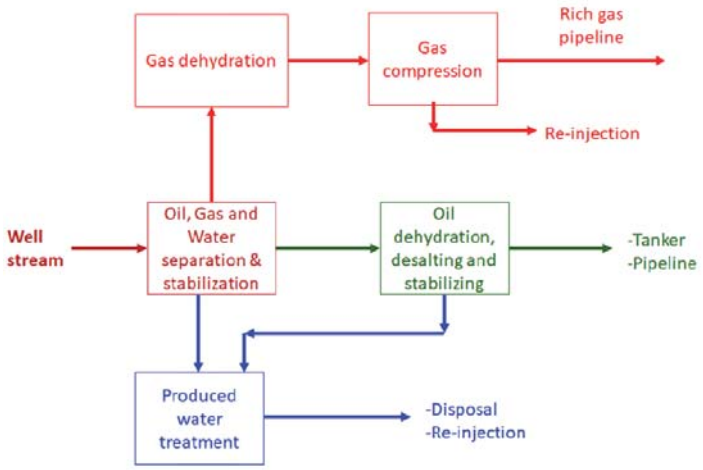
- Facilities for drilling and full intervention. This includes drilling tower, BOP, drilling floor, mud package, cementing pumps, storage deck for drill pipes and tubulars, drilling risers.



2

Components

- Facilities for light well intervention.
- Processing facilities: separator trains for primary oil, gas and water separation, gas processing train, water processing train.
- Gas injection system
- Gas compression units for pipeline transport
- Water injection system



3

Components

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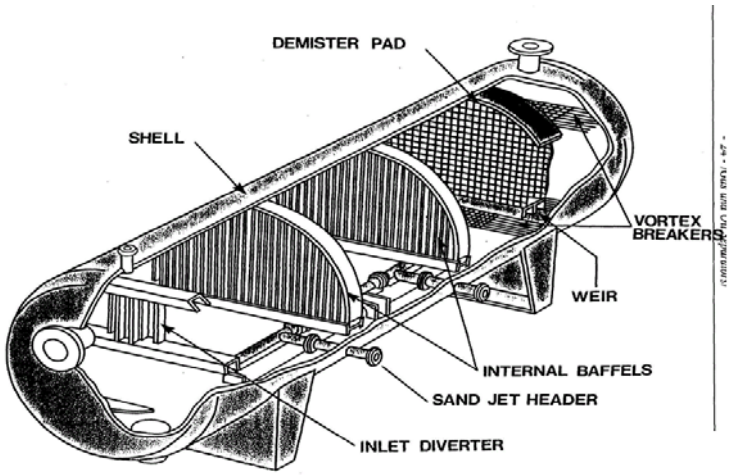

4

Components

- Living quarters
- Helideck.
- Power generation.
- Flare system.
- Utilities (hydraulic power fluid, compressed air, drinking water unit, air condition system, ventilation and heating system)

5

Components

- Bay for wellheads and X-mas trees
- Production manifolds
- Oil storage
- Facilities for oil offloading
- Control system
- Monitoring system
- System for storage, injection and recovery of production chemicals (wax, scale, hydrate or corrosion inhibitors)
- Repair workshop

6

Components

- Bay for wellheads and X-mas trees
- Production manifolds
- Oil storage
- Facilities for oil offloading
- Control system
- Monitoring system
- System for storage, injection and recovery of production chemicals (wax, scale, hydrate or corrosion inhibitors)
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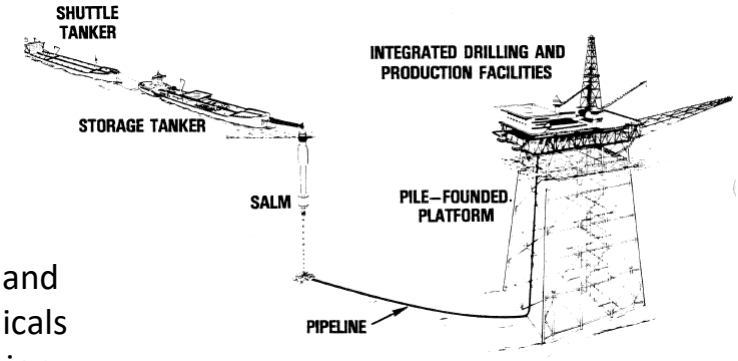
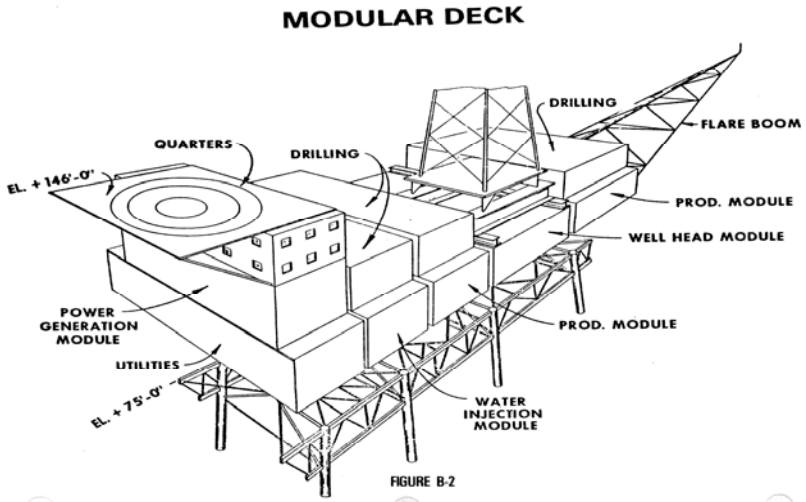


7

Components



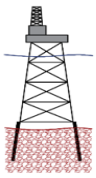
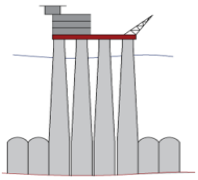
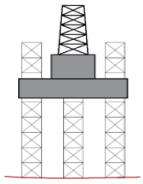
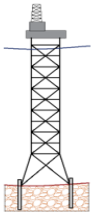
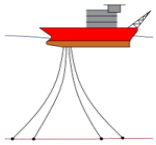
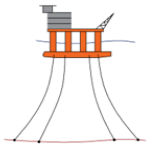
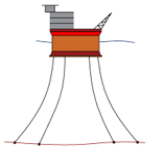
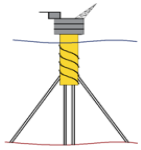
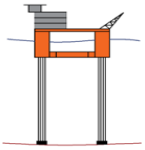
8

Components – can be spread

https://www.akerbp.com/produksjon/valhall/

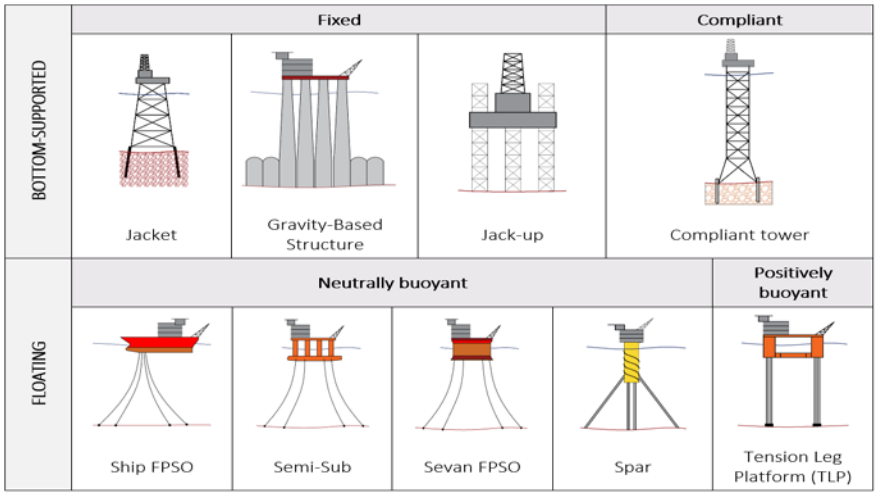
9

Types

BOTTOM-SUPPORTED	Fixed			Compliant	
	 Jacket	 Gravity-Based Structure	 Jack-up	 Compliant tower	
FLOATING	Neutrally buoyant				Positively buoyant
	 Ship FPSO	 Semi-Sub	 Sevan FPSO	 Spar	 Tension Leg Platform (TLP)

10

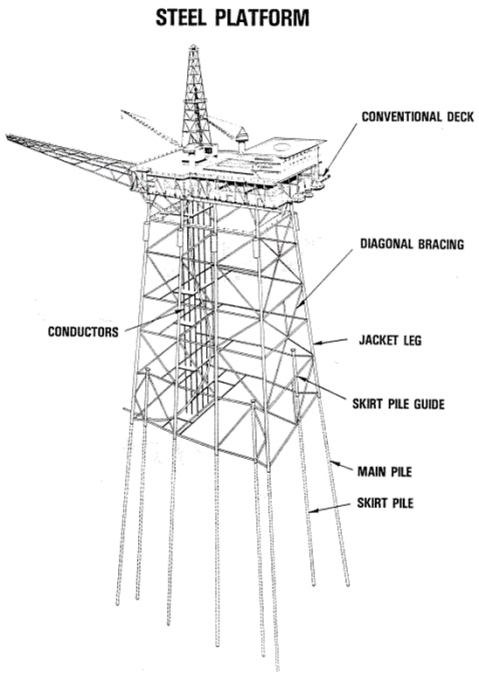
Types



- Have significant movement
- Are usually moored
- Buoyancy is controlled actively with ballast

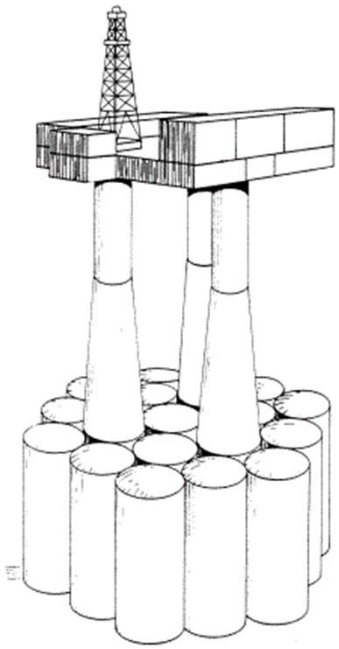
11

Jacket



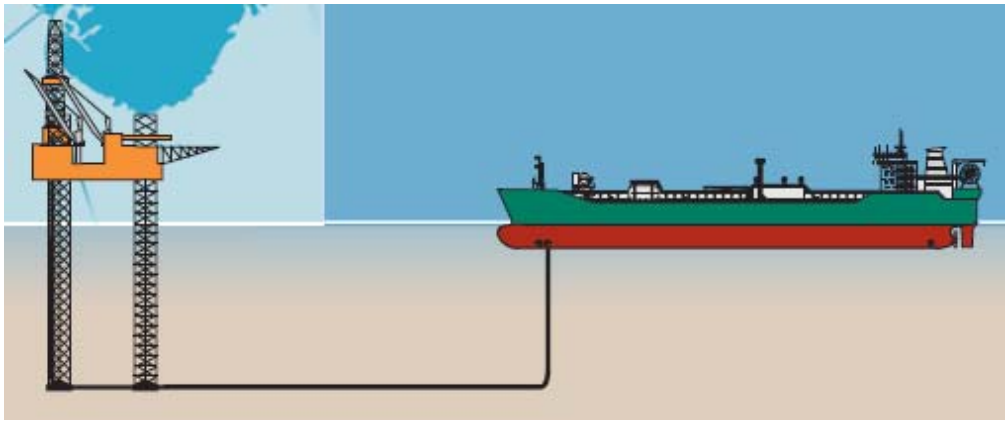
12

GBS



13

JACKUP



Taken from Volve PDO

14

FPSO

15

FPSO - Comment about swivel

16

FPSO - Swivel

https://www.youtube.com/watch?v=70XwYmmZFWs

17

FPSO - Swivel

https://www.youtube.com/watch?v=Sfjay0Rt3hU

https://www.youtube.com/watch?v=cCiUggjUhY0

18

FPSO - Swivel

https://www.youtube.com/watch?v=HbJh1ar0u1s

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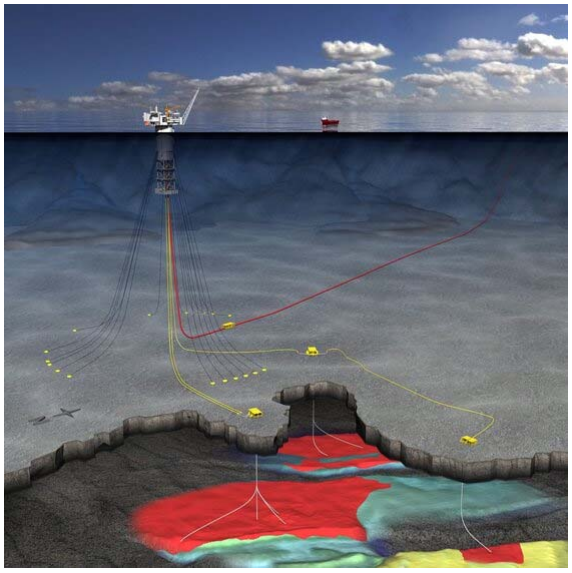
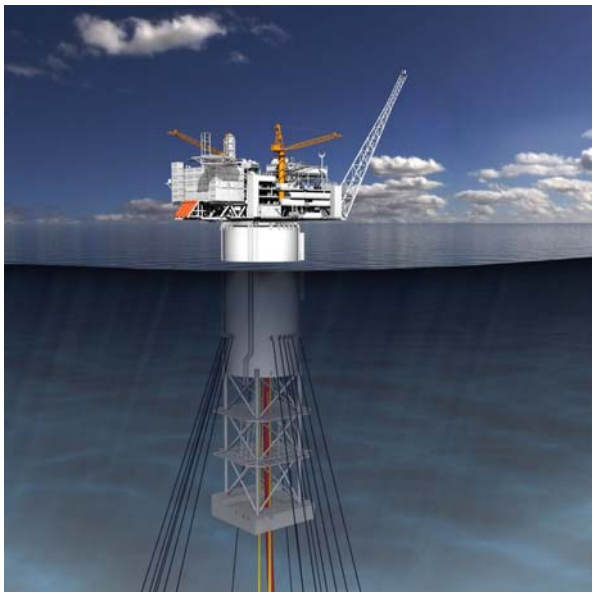
SPAR



https://www.tu.no/artikler/industri-kvaerner-sikrer-enda-et-aasta-hansteen-oppdrag/225940



https://www.tu.no/artikler/industri-kvaerner-sikrer-enda-et-aasta-hansteen-oppdrag/225940

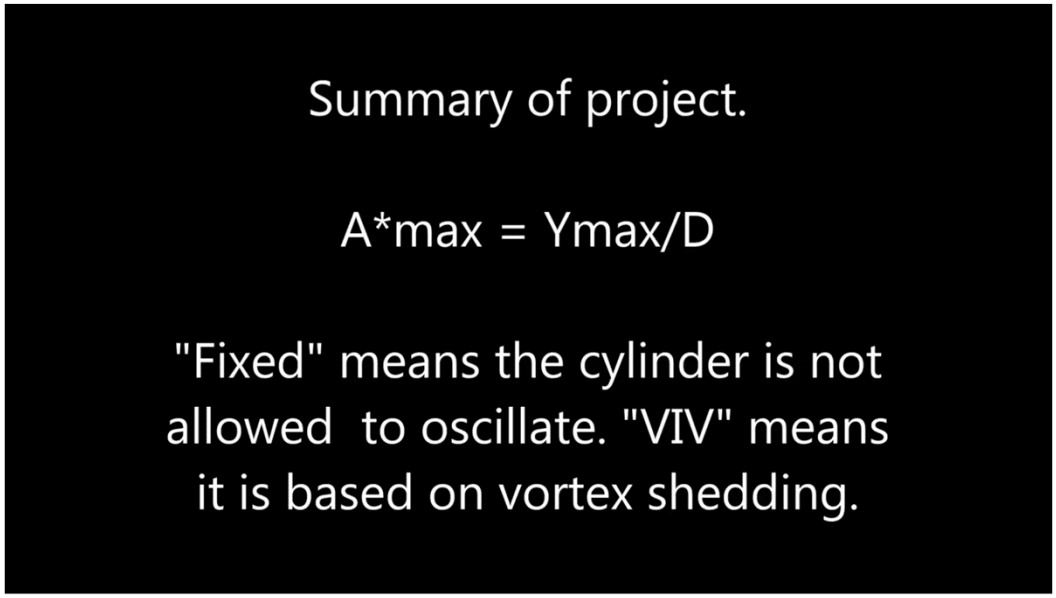
20

SPAR – Vortex induced vibrations

https://www.youtube.com/watch?v=_Hbbkd2d3H8&feature=youtu.be

21

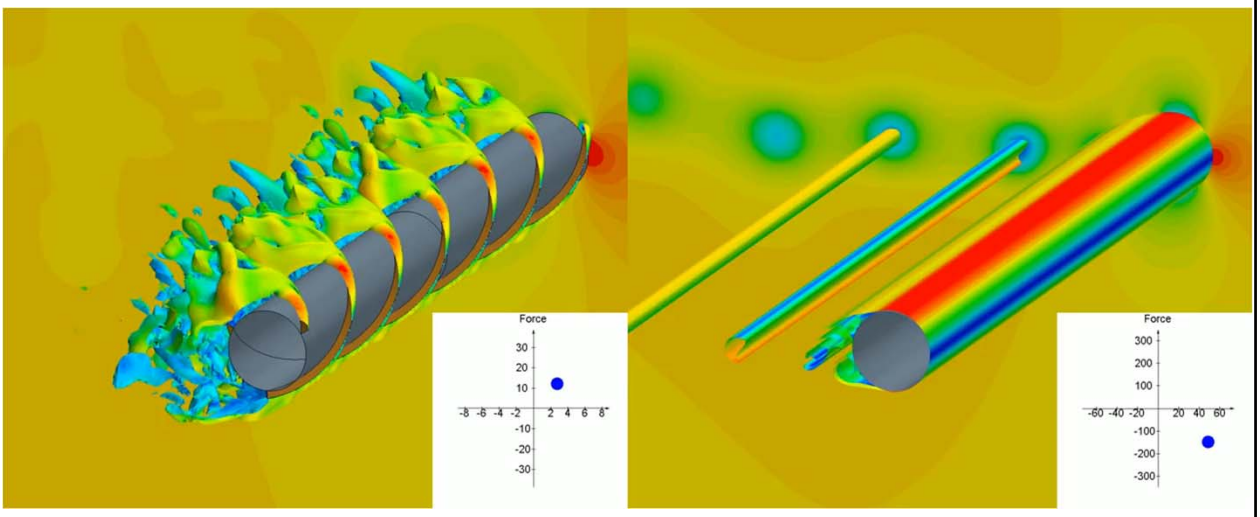
SPAR – Vortex induced vibrations



https://www.youtube.com/watch?v=24tBX_UD3fM

22

SPAR – Effect of helical strakes



https://www.youtube.com/watch?v=W-zXwPT2r14

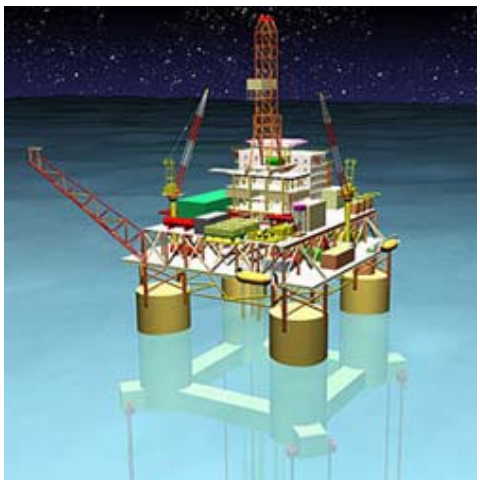
23

SEVAN FPSO

https://www.upstreamonline.com/epaper/sevan-fpso-selected-for-bream/1-1-1160389

24

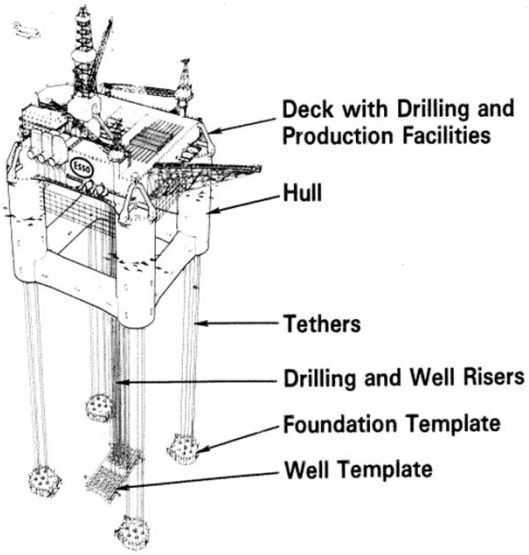
Tension leg platform



https://www.rigzone.com/training/insight.asp?insight_id=305&c_id=

25

Tension leg platform

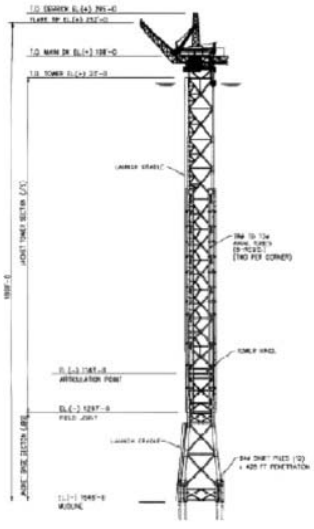


26

Comment about Tension leg platform

27

Compliant tower



https://www.sciencedirect.com/science/article/pii/S0951833914000148

28

Semi-Sub

https://www.oedigital.com/news/453987-jack-st-malo-flows-for-chevron

https://www.bairdmaritime.com/work-boat-world/offshore-world/offshore-extraction-and-processing/offshore-drilling/awilco-orders-second-semi-submersible-drilling-rig-from-keppel-fels/

29

Some selection criteria for offshore structures

- Water depth
- Type of X-mas tree
  - Well intervention needs
    - Tubing replacement
    - Completion modifications
    - Artificial lift (ESP)
  - Infill drilling needs
  - Reservoir spread and structure
- Need for oil/condensate storage
- Marine loads Oceanographic environment
  - Wind, waves, current

30

Some selection criteria for offshore structures

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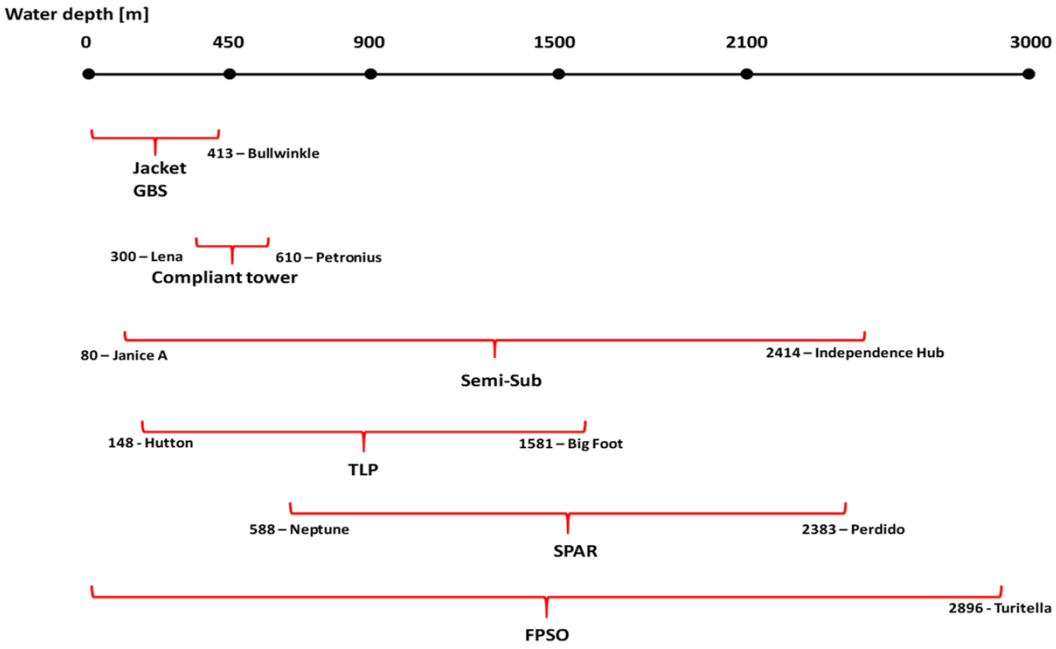
31

Water depth



32

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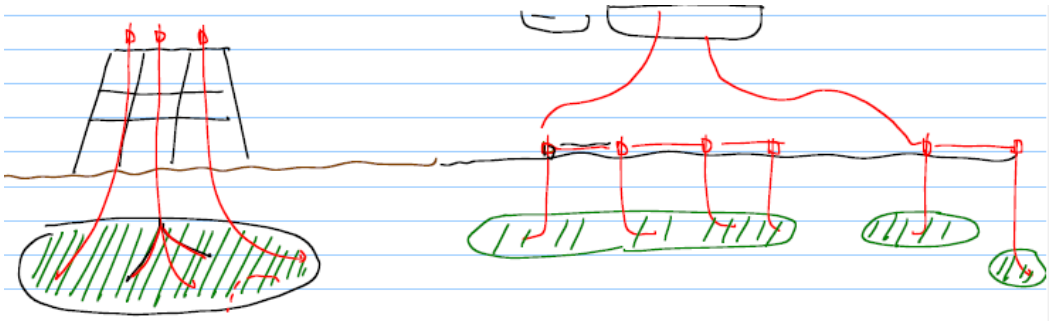
  - Wind, waves, current

33

Reservoir spread and structure

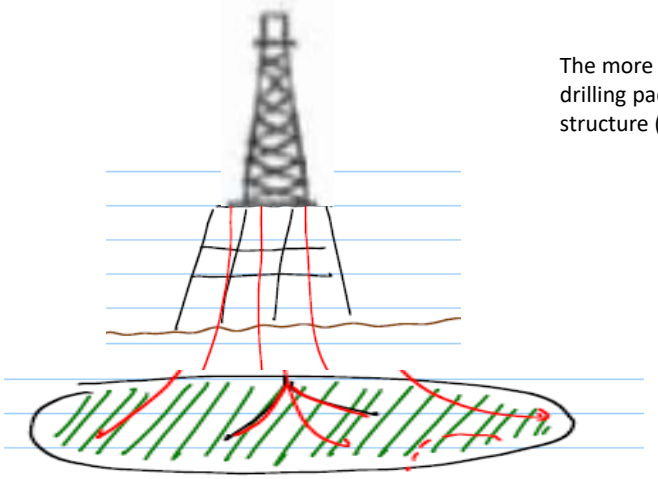


- Long deviated wells ($$$)
- Wells are drilled from one location, no need to spend mobilization time ($$)
- Production startup must be delayed until all wells are drilled

- Shorter, vertical wells ($)
- The drilling rig must be mobilized often which costs money ($$$)
- Production can start in ramp up mode (if topside is in place)

34

Reservoir spread and structure



The more spread - requires a bigger and more costly drilling package – more weight on the structure, bigger structure ($$$)

35

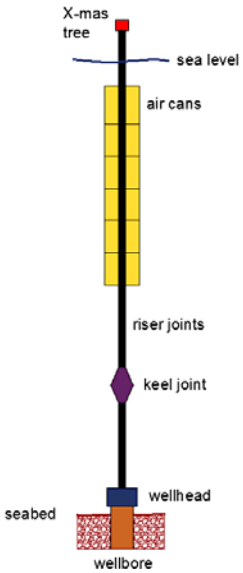
Transfer of well weight to soil and to offshore structure

36

Transfer of well weight to soil and to offshore structure

37

Support system for dry X-mas trees – deep water



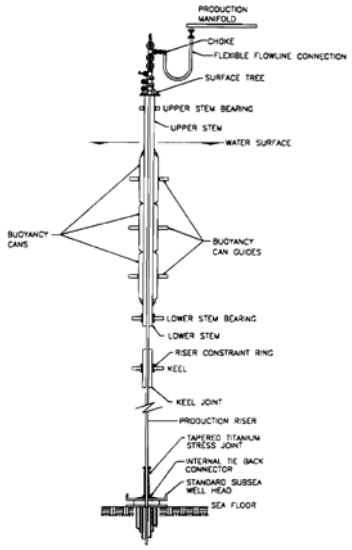


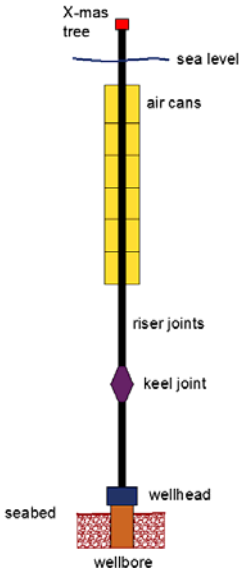
Figure 6 - Well System

OTC 8382

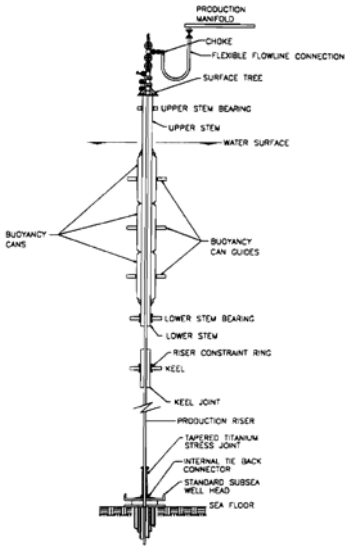
Neptune Project: Spar History and Design Considerations
R.S. Glanville, J.E. Halkyard, R.L. Davies, A. Steen, F. Fimm, Deep Oil Technology, Inc.

38

Support system for dry X-mas trees – deep water



Real State on offshore structure is critical, not more slots than what is needed!



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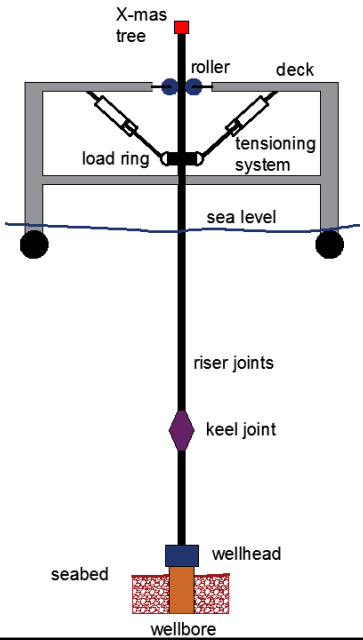

40

Some selection criteria for offshore structures

- Water depth
- **Type of X-mas tree**
  - Well intervention needs
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    - Completion modifications
    - Artificial lift (ESP)
  - Infill drilling needs
  - Reservoir spread and structure
- Need for oil/condensate storage
- Marine loads – Oceanographic environment
  - Wind, waves, current

Only floating structures SPAR, TLPs and Semi-subs have "small" movement ranges suitable for dry X-mas trees

41

Possibility for jackets without drilling package

https://www.youtube.com/watch?v=-vJmAvqn6dU

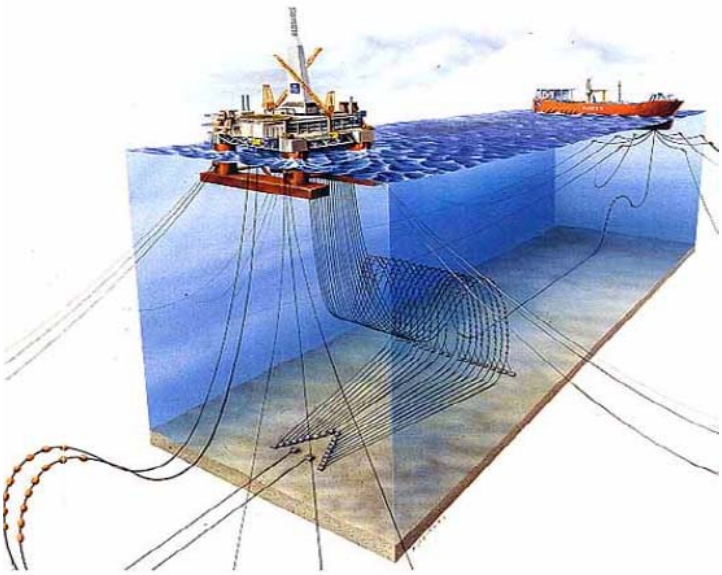
42

Possibility for jackets without drilling package

https://www.offshoreenergytoday.com/offshore-safety-watchdog-to-investigate-maersk-invincible-incident/

43

Njord: subsea wells with well intervention possibility



44

Layout of subsea systems – template wells

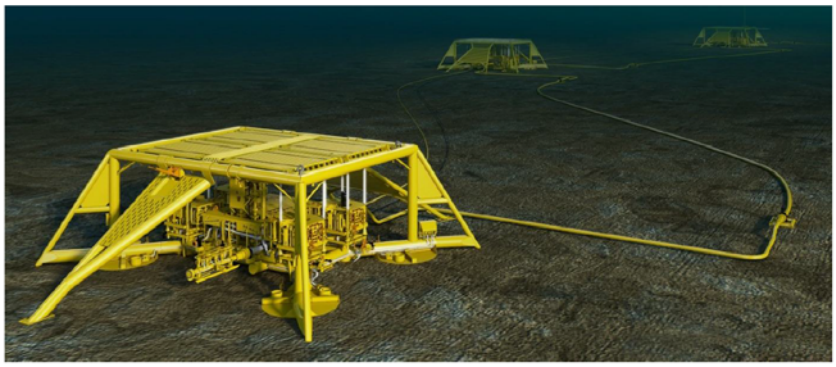
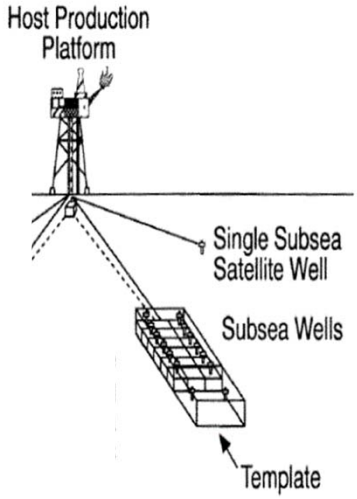


Figure 3.3 Typical NCS tie-back solution (Image: Statoil ASA)

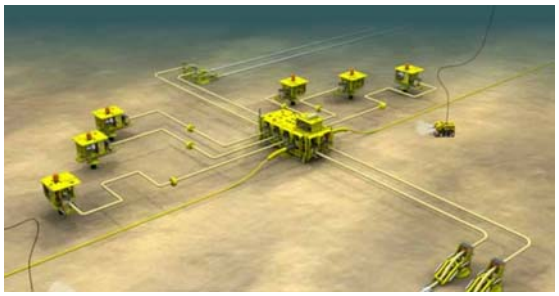
45

Layout of subsea systems – template wells



46

Satellite wells



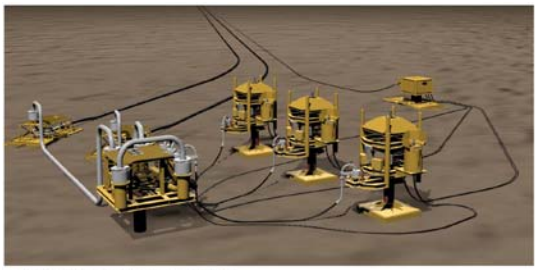
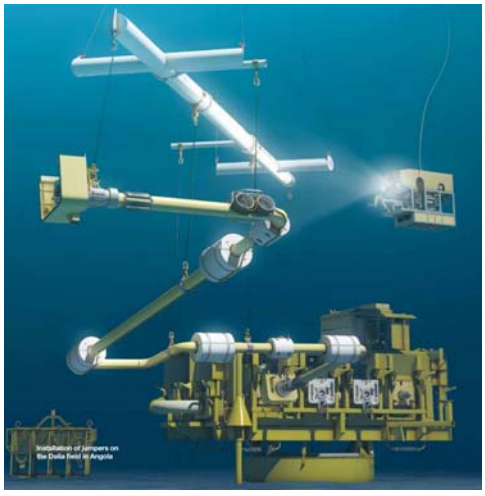
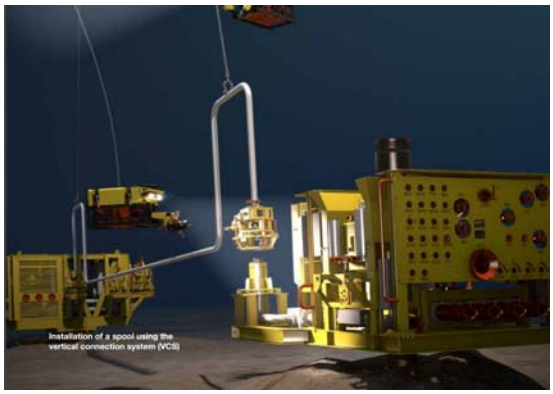


Figure 3.4 Typical GOM subsea tie-back

47

Jumpers for satellite wells (if close)

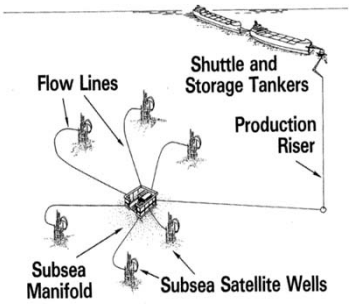




48

Template wells vs satellite wells – similar dilemma to dry versus wet X-mas tree

Figure 3.3 Typical NCS tie-back solution (Image: Statoil ASA)



- Long deviated wells
- Wells are drilled from one location, no need to spend rig mobilization time
- Less subsea equipment

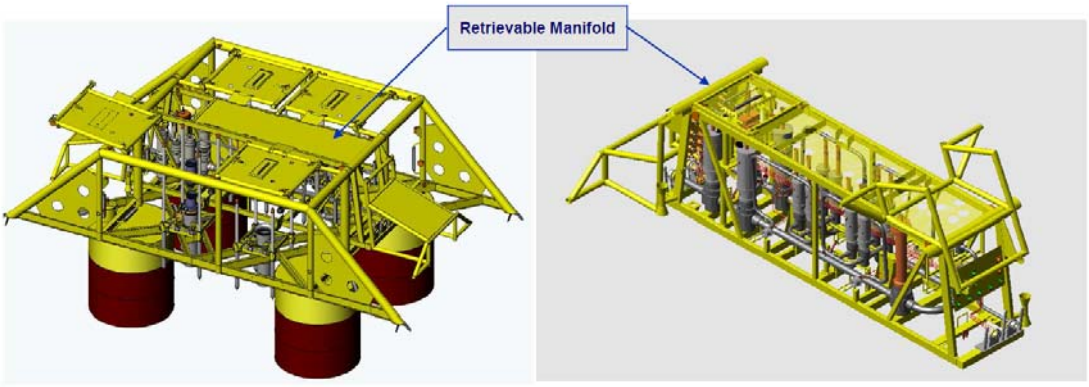
- Shorter, vertical wells
- The drilling rig must be mobilized often which costs money
- More flowlines, pipelines. Manifolds are required

49

The production manifold

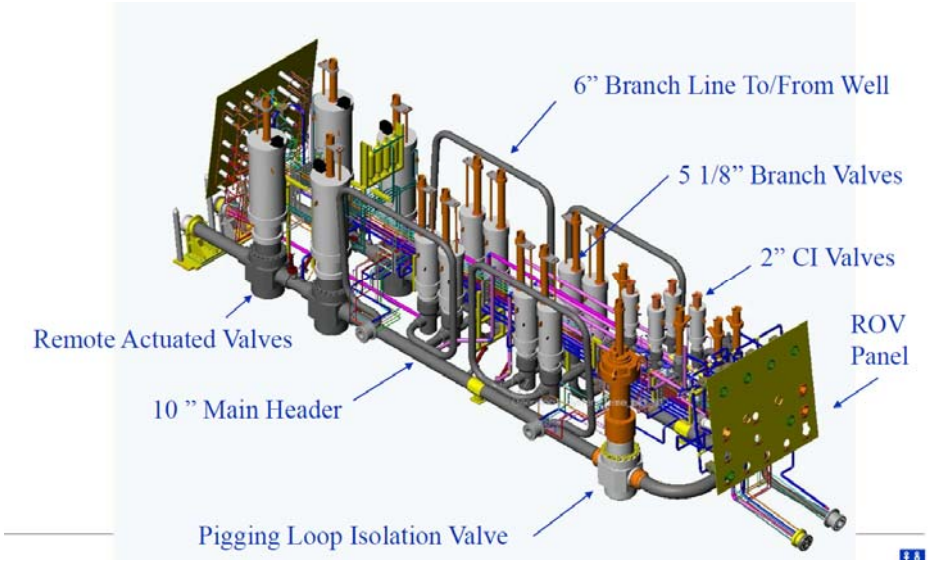
50

4 well template – the production manifold



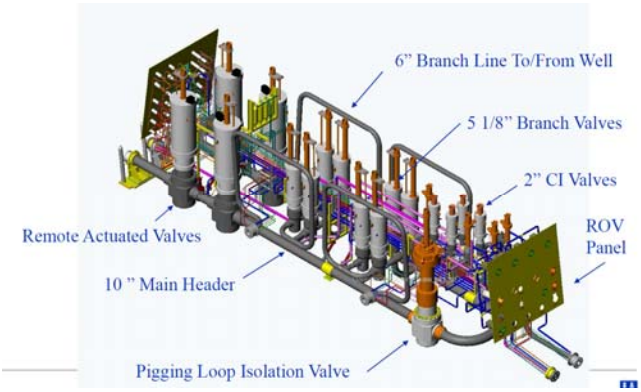
51

The manifold



52

The manifold – reality vs sketch



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4 well template – weight transfer

54

Metering - onshore

55

Metering onshore – test separator

56

Metering subsea – test line

57

Metering subsea – multiphase meter

58

Metering requirements affect field layout - Brazil

RESOLUÇÃO CONJUNTA ANP/INMETRO Nº 1, DE 10.6.2013 - DOU 12.6.2013 – RETIFICADA DOU 17.6.2013

7.2.7. Testes de poços

7.2.7.1. Nos casos em que os resultados dos testes de poços sejam utilizados somente para apropriação da produção aos poços, cada poço em produção deve ser testado com um intervalo entre testes sucessivos não superior a noventa dias, ou sempre que houver mudanças nas condições usuais de operação ou quando forem detectadas variações na produção.

7.2.7.2. Quando os resultados dos testes de poços forem utilizados para apropriação da produção a um campo, em casos de medição fiscal compartilhada, cada poço em produção deve ser testado em intervalos não superiores a quarenta e dois dias, ou sempre que houver mudanças nas condições usuais de operação ou quando forem detectadas variações na produção.

7.2.7.4. Devem ser utilizados separadores de testes ou tanques de testes nos testes de poços. Outros métodos de testes, utilizando novas tecnologias, devem ser previamente aprovados pela ANP.

http://www.anp.gov.br/wwwanp/?dw=66648

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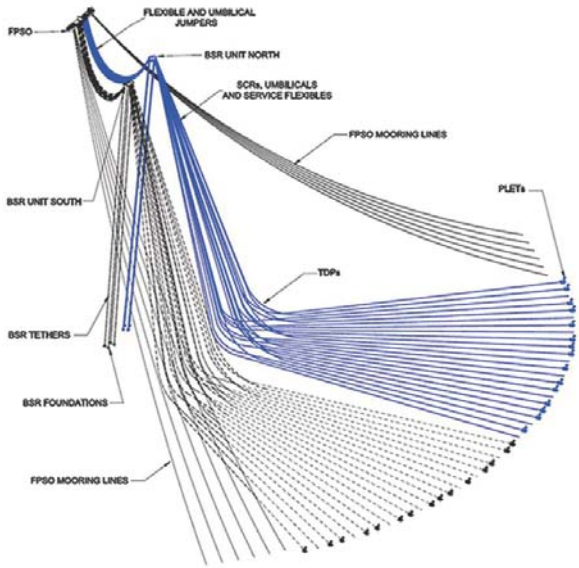
Metering requirements - Brazil

$$$



https://www.marinetechnologynews.com/news/reviewing-sapinho-system-564661

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Metering requirements - Norway

http://www.npd.no/Global/Engelsk/5-Rules-and-regulations/NPD-regulations/Maaleforskriften_e.pdf

REGULATIONS RELATING TO MEASUREMENT OF PETROLEUM FOR FISCAL PURPOSES AND FOR CALCULATION OF CO_2-TAX (THE MEASUREMENT REGULATIONS)

Multiphase measurement

Multiphase measurement may be used if traditional single phase measurement of hydrocarbons is not possible for financial reasons. The multiphase meter can then be used as a fiscal meter.

The following elements shall be satisfactorily documented to allow use of a concept based on multiphase measurement, cf. Chapter VII and Section 18:

- The operator shall present a concept to the Norwegian Petroleum Directorate for comments and formal processing well before submitting the Plan for Development and Operation (PDO). An estimate of the expected measurement uncertainty shall be presented, combined with financial figures for the risk of loss between production licenses (cf. NORSOK I-105), Annex C).
- The main principles of the operations and maintenance philosophy shall be described.
- Possibility to calibrate meters against test separator or other reference.
- Redundancy in sensors and robustness in the design of the measurement concept.
- Relevant PVT (equation of state) model and representative sampling opportunity to be able to perform a sound PVT calculation.
- Design of inlet pipes to ensure similar conditions if multiple meters are used in parallel.
- Flexibility in the system for handling varying GVF (gas volume fraction).
- The planned method for condition monitoring and/or planned calibration interval shall be described.
- The planned method and interval for sampling and updating PVT data shall be described.

When the multiphase meters are part of the fiscal measurement system, they shall be treated as other fiscal measurement equipment and the administrative requirements which apply pursuant to these Regulations shall therefore be fulfilled.

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Pigging requirements

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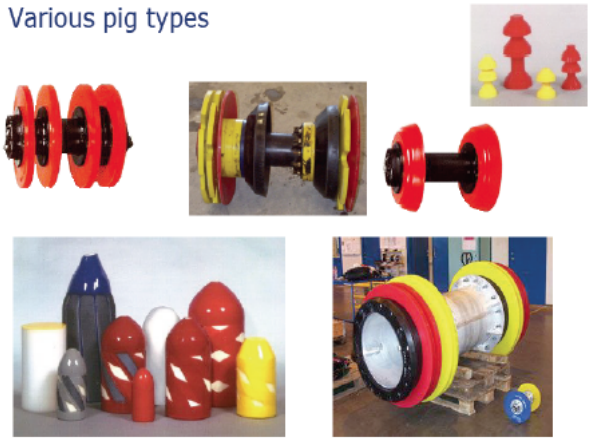
Pigs

Various pig types



Wax plug-North Sea line pigging

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Pigging loop and subsea pig launcher

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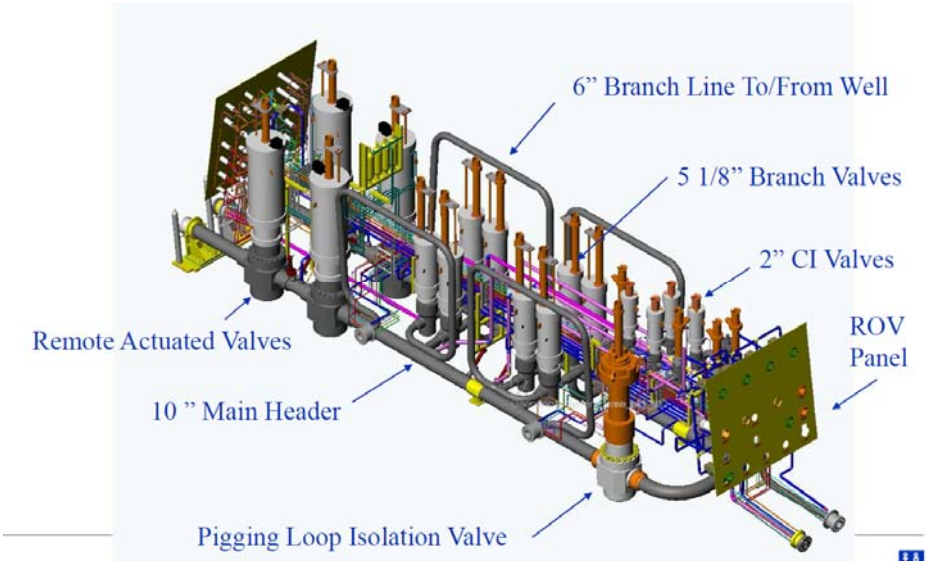
The pigging valve



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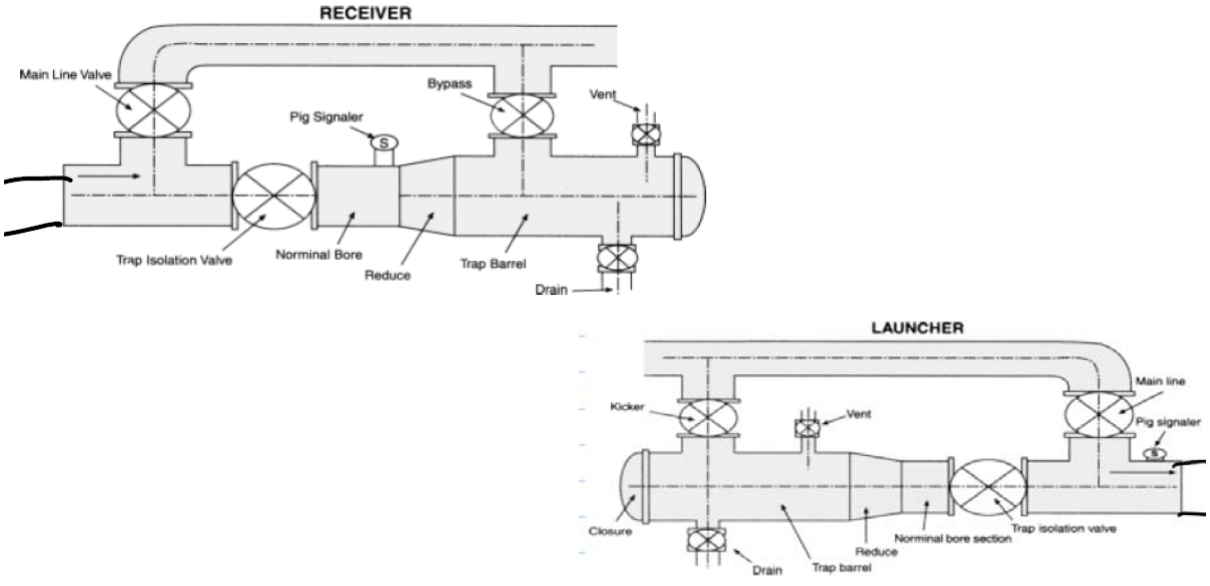
Pig launcher and receiver



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Pigging - video

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Summary table

	Dry X-mas trees	Wet X-mas trees
Deep water (1700 m+)		X
Reservoir is “spread” or multiple reservoirs		X
Frequent well intervention	X	
Flow assurance concerns	X	
Plans for infill drilling (and coping with reservoir uncertainty)*	X	X
Progressive production startup		X
	Jacket, GBS, SPAR, TLP	ALL

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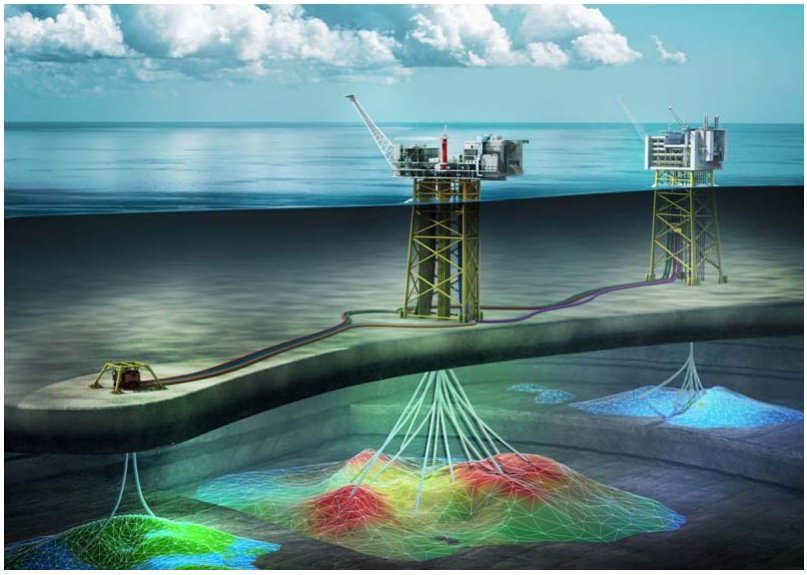
Combinations can be used



https://www.akerbp.com/en/our-assets/production/ivar-aasen/the-development-solution/

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Some selection criteria for offshore structures

- Water depth
- Type of X-mas tree
  - Well intervention needs
    - Tubing replacement
    - Completion modifications
    - Artificial lift (ESP)
  - Infill drilling needs
  - Reservoir spread and structure
- **Need for oil/condensate storage**
- Marine loads – Oceanographic environment
  - Wind, waves, current

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Need for liquid storage

No or limited storage	Steel Jackets, Semi-subs, TLPs, Spars[20]
Medium - Large storage (up to 2.5000.000 STB)	FPSOs, GBS

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Other selection criteria for offshore structures

- Previous experience
- Riser issues
- Topside upgrade flexibility
- Manufacturing workshop availability
- Maturity of technology
- Maintenance and OPEX

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