Prelude Turret Topsides

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Prelude Turret Mooring System (TMS)

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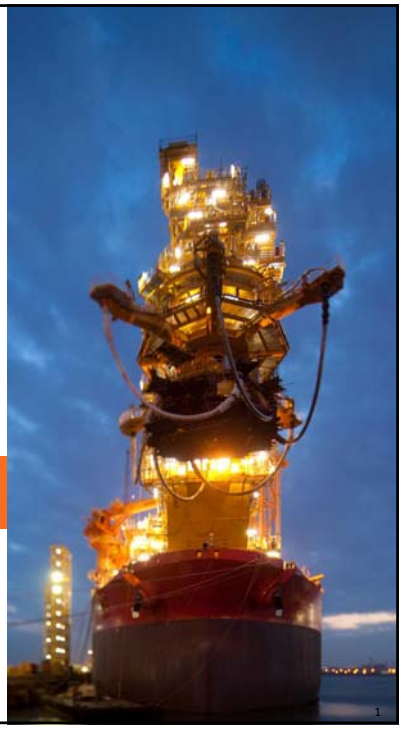

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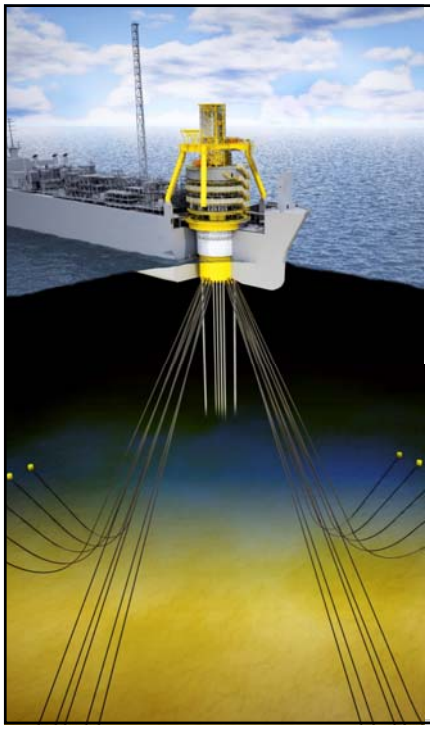
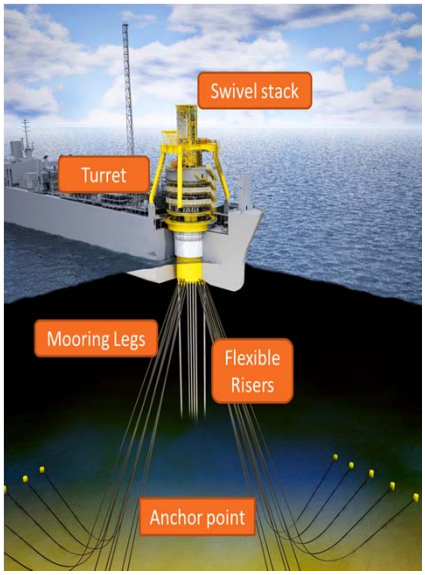
- Turret Mooring System Overview
- Prelude FLNG Project (*Shell video*)
- Prelude TMS specifics & pictures
- Focus on Prelude Turret Manifold & Fluid Transfer



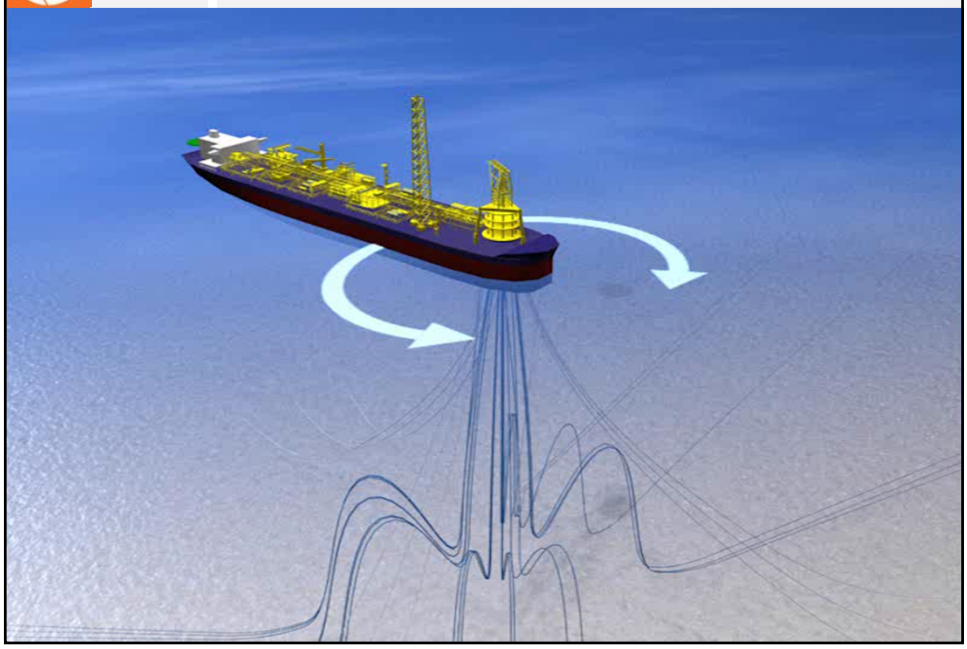
Turret Mooring System (TMS) Overview

Turret Mooring System - Main Components

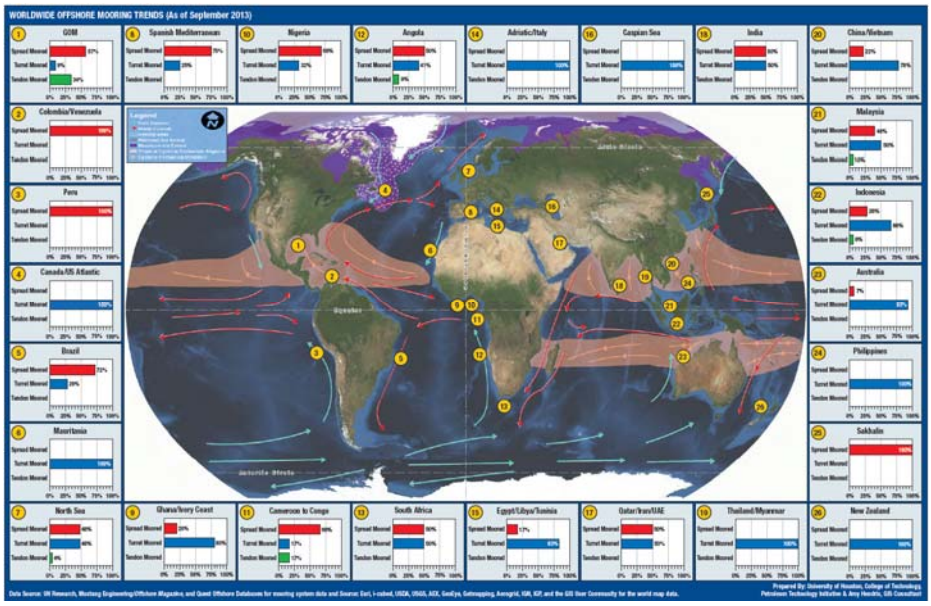
- Geostationary turret connected to mooring lines and supporting risers
- Weathervaning facility
- Bearing system- structural interface
- Swivel stack – fluid and power interface



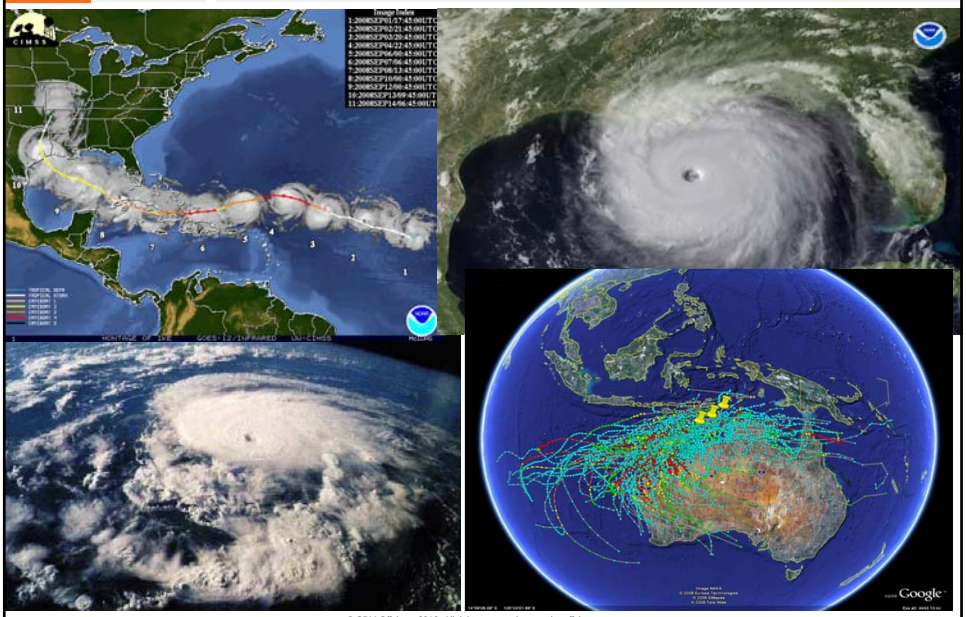
Weathervaning Systems



Mooring Type - World Overview



Tropical Storms: Hurricanes, Cyclones, Typhoons

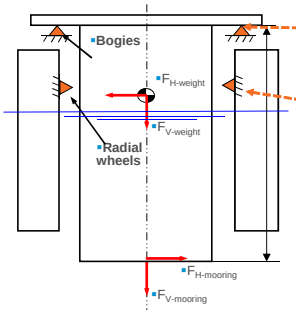


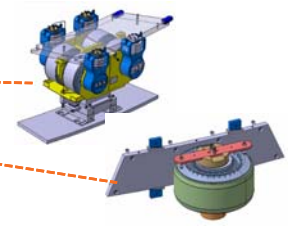
SBM Turret Design Philosophy: Safety & Reliability

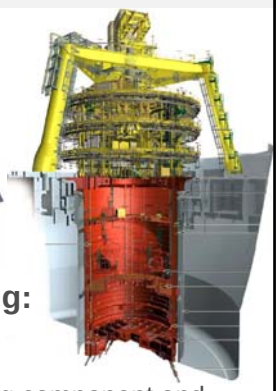
- Safety:
  - Passive mooring system (designed to work in 'black ship' scenario)
  - 'Fail Safe' approach
  - Minimize Risks
    - Minimize Risk of gas leak (reduce number of flanges before ESDV)
    - Minimize Consequence of potential gas leak (riser connection at main deck)
    - Minimize Entrapped inventory
  - Passive Fire Protection system
- Reliability
  - Ability to inspect/change-out/repair components while in operation
    - Axial Bogies & Radial Wheels (for very demanding project conditions)
    - SBM swivel & stack design
  - Stringent Design & Procurement Requirements based on wealth of experience
    - Shell DEP (Design Engineering Practices)
    - SBM GTS (Group Technical Standard)

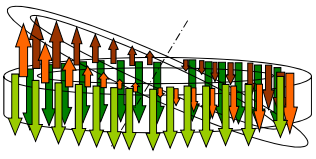
Bogie bearing system design

Generic Bogie Video









Loads on bogie bearing:

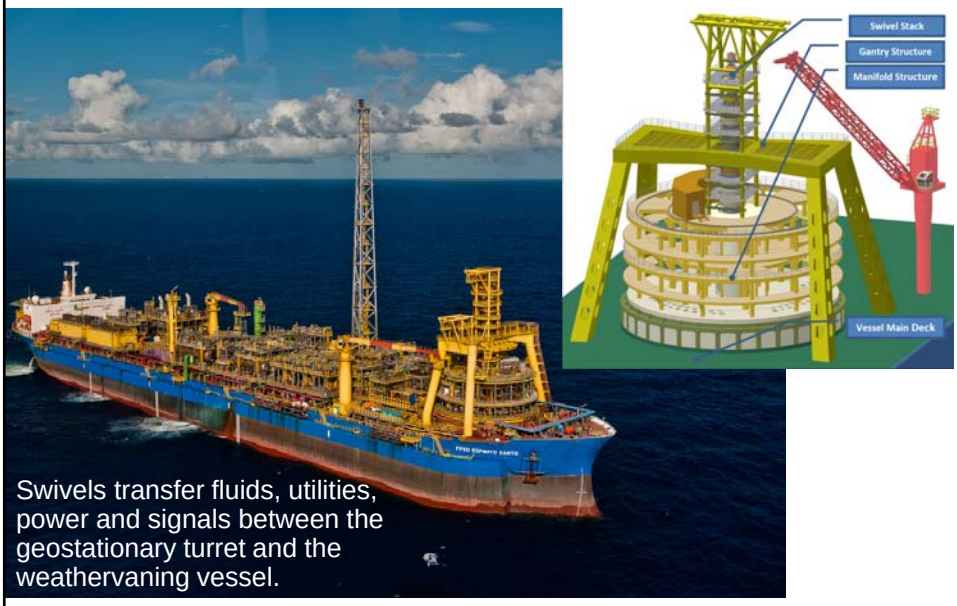
- **Vertical loads:**

(gravity, riser, vertical mooring component and overturning moment) distributed evenly over all axial bogies

- **Horizontal loads:**

(accelerations, horizontal mooring component and vessel motions loads) resisted by radial wheels in contact

Swivel Overview

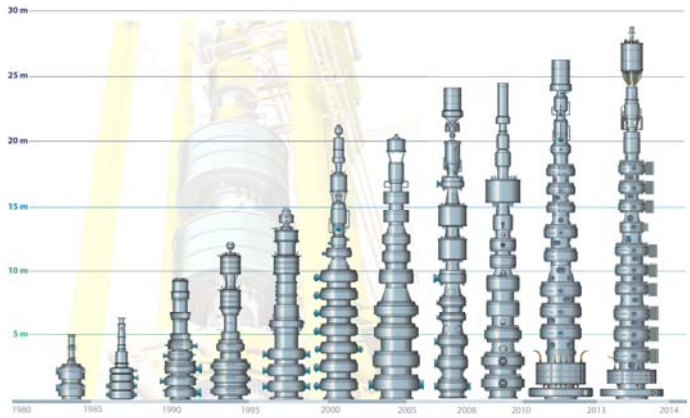


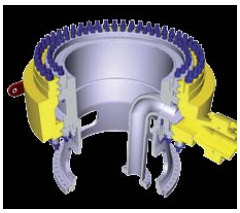
Swivels transfer fluids, utilities, power and signals between the geostationary turret and the weathervaning vessel.

Swivel Overview

- Fluid Swivels for oil, water and gas (Pipe Swivels)
- Fluid Swivels for oil, water and gas (Toroidal Swivels)
- Utility Swivels for transfer of chemicals, hydraulics, air/gas, firewater and vents
- Electrical and Optical Swivels for the transfer of power and signals / information

Turret Mooring key components: Swivels





Swivel video

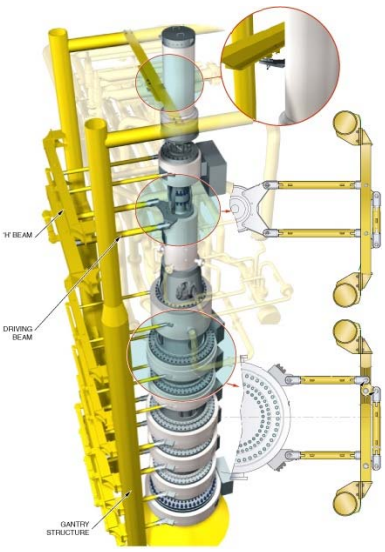
Since 1977, SBM has delivered 70+ Swivel stacks, representing:

- 300+ Production swivels from 4 to 532 bar
- 40 + Utility swivels from 5 to 517 bar
- 63 + Electric swivels from 3.5 kW to 30 MW

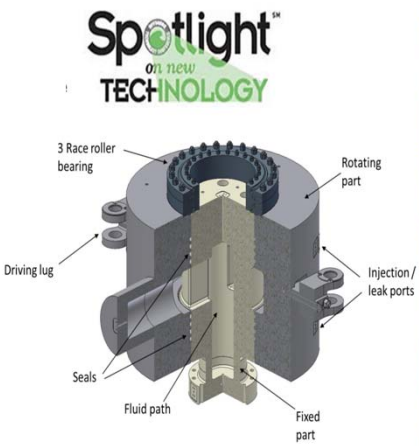
→**1/3 of swivel stacks in production worldwide**

Swivel Stack Driving system

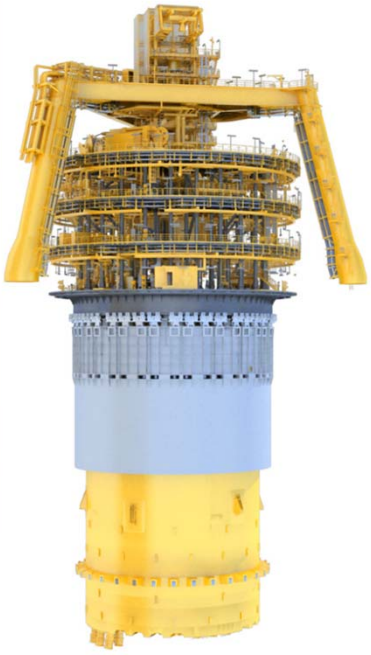
- Each swivel is fitted with a passive mechanical device that connects the rotating part to the rotating Vessel.
- The only degree of freedom that is restrained is the rotation about the vertical axis. The swivel stack remains free to translate in all 3 directions.
- Designed to withstand the friction loads generated by the different seals sliding on their respective seal running surfaces as well as the environmental loads.
- Easy access for maintenance.



Very High Pressure Swivels



ASME Woelfel Award of Merit 2014



Prelude FLNG Project

OFFSHORE

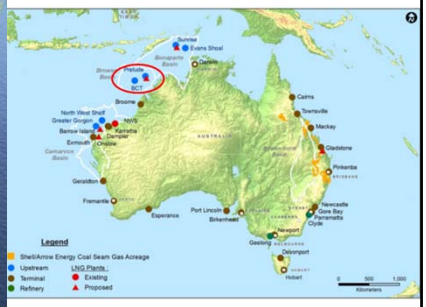
SHELL video

https://www.youtube.com/watch?v=0oIOLqu8TtU

Prelude TMS Specifics

SHELL Prelude FLNG

- Turret moored floating LNG facility with liquefaction capacity of 5.3 mtpa
- LNG (3.6 mtpa), condensate (1.3 mtpa) and LPG (0.4 mtpa)
- Facilities for exporting by Side by Side mooring
- On station for 25 years – 475 km North-East of Broome in Western Australia
- 250m WD – Cyclonic area – 10,000 years event



Shell Prelude FLNG - Copyright Shell - Presented with permission of Shell

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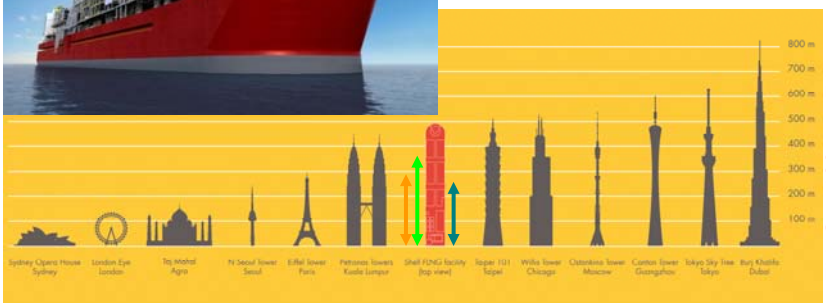
SHELL Prelude FLNG



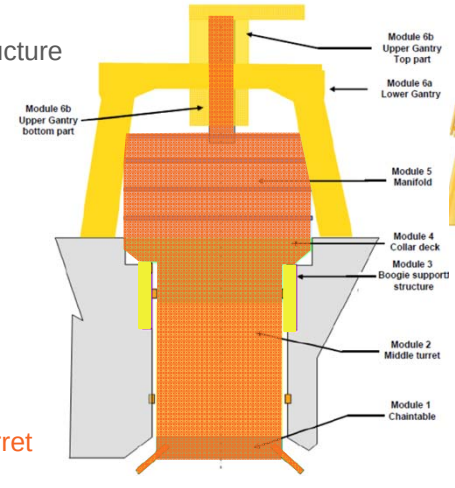
FLNG ~ 488 m x 74 m
VLCC ~ 330 mx 55 m
Suezmax ~ 285 m x 45 m
Aframax ~ 245 m x 34 m

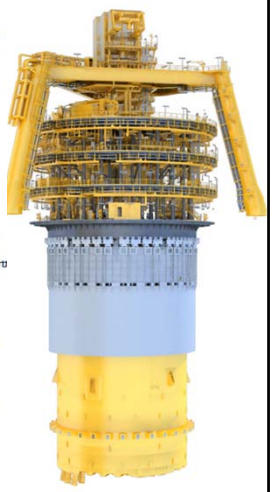
FLNG => permanently moored while exposed to cyclones
Designed for 10,000 yrs Cyclonic conditions

Prelude TMS – Overview – Fixed vs Rotating

Rotating part : ■
- Bogie Support Structure
- Swivel outer part
- Gantry
- *(Vessel)*

Fixed part : ■
- Mooring lines
- Chaintable & Lower Turret
- Collar deck
- Manifold
- Swivel inner part

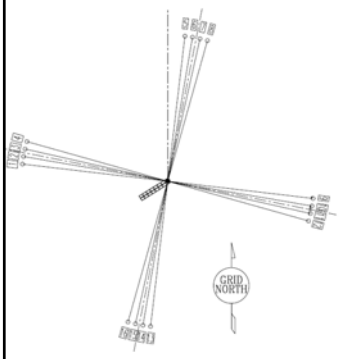


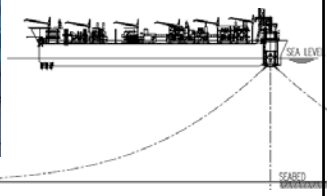


Prelude TMS – Mooring

- Largest-ever-built :
  - 4x4 arrangement
  - 175mm R4 chains
    + 162mm∅ wires
    (MBL= 25.2 MN)

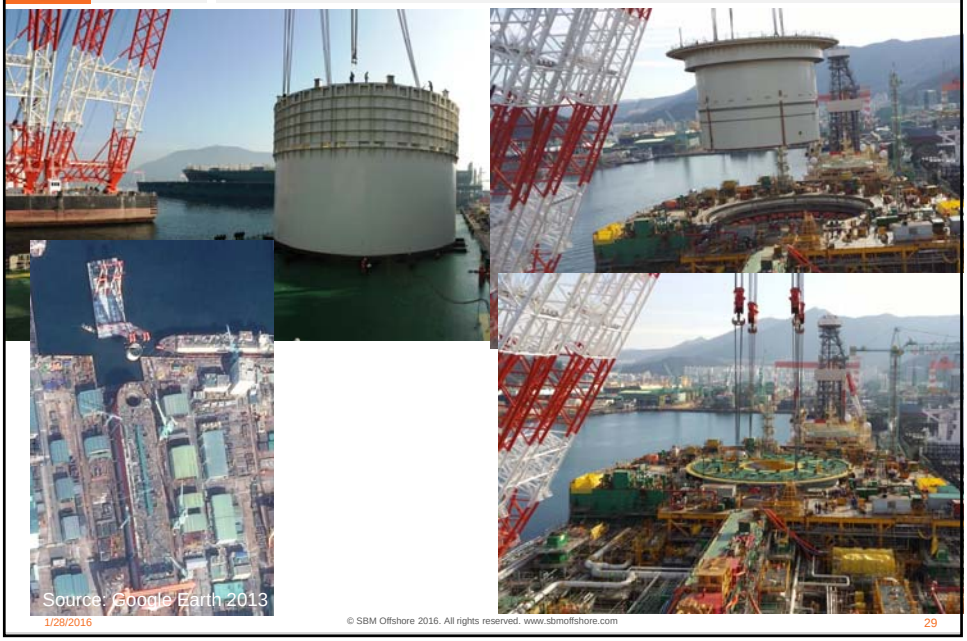
(total = 17kms / 10.400tons of chains)





Prelude Lower Turret Integration

Prelude BSS & Collar Deck Integration



Prelude Manifold & Gantry Integration

Prelude Turret Manifold & Fluid Transfer

OFFSHORE

Prelude Turret Manifold

Gas Flow & Safety Systems

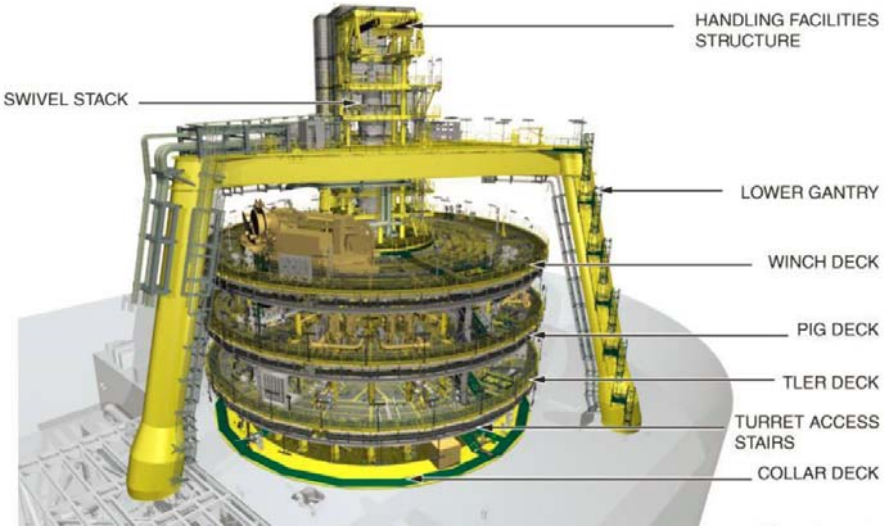
OFFSHORE

Prelude TMS – Fluid Transfer System

- From Subsea…

Prelude TMS – Fluid Transfer System

- …to Topsides (via Turret Manifold)



Turret Production Gas Flow

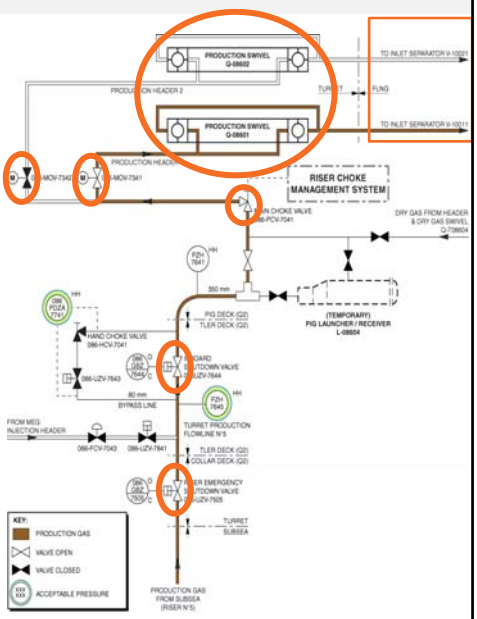
- Normal Operation

❑ Transfer from riser to manifolds

- Individual lines provided with :
  - o Riser ESDV
  - o Inboard Process SDV
  - o Main Choke valve
  - o Bypass

❑ Manifolding through 2 productions headers

- With Turret Motorized Operated diverter valves
- Via production swivel to get from Fixed Turret to Rotating Topsides
- To 2 separators onboard FLNG Topsides

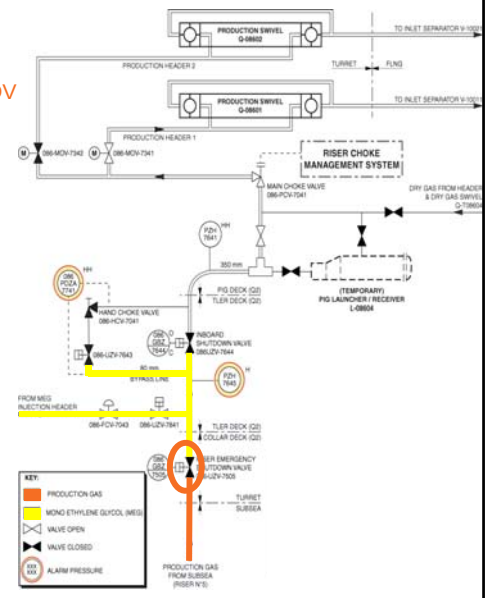


Turret Production Gas Flow

- Start-Up

➢ 1st step : Pressure equalization across ESDV

- MEG injection in pipe section between riser ESDV and PSDV
- Ensure safe riser ESDV (ball valve) opening



Turret Production Gas Flow

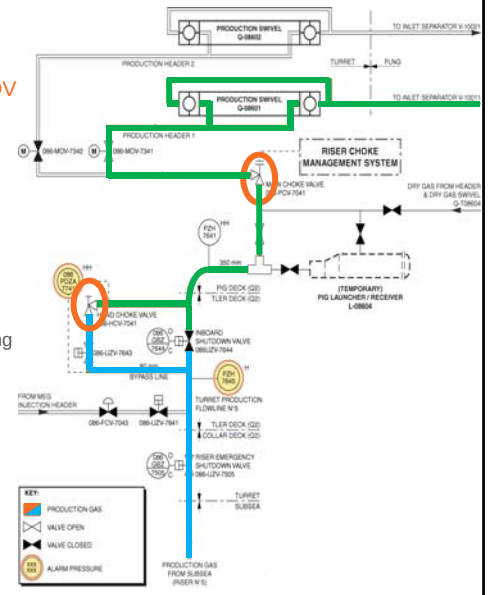
Start-Up

➢ 1st step : Pressure equalization across ESDV

- MEG injection in pipe section between riser ESDV and PSDV
- Ensure safe riser ESDV (ball valve) opening

➢ 2nd step : Lower riser pressure

- Main choke valve opened
- PSDV bypass line used to lower the riser pressure below pressure trip setting
- & hence ensure a safe step 3



Turret Production Gas Flow

Start-Up

➢ 1st step : Pressure equalization across ESDV

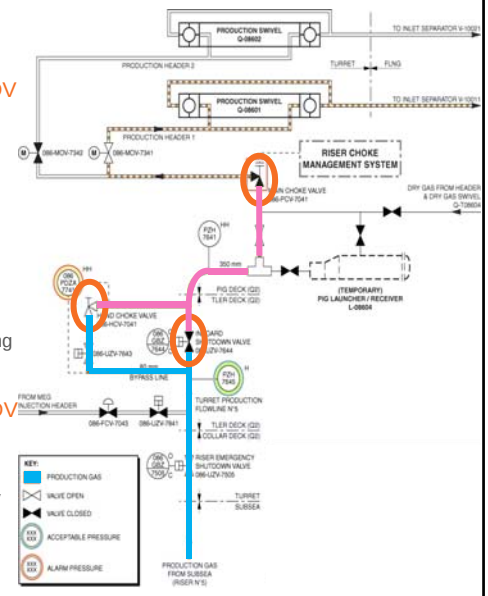
- MEG injection in pipe section between riser ESDV and PSDV
- Ensure safe riser ESDV (ball valve) opening

➢ 2nd step : Lower riser pressure

- Main choke valve opened
- PSDV bypass line used to lower the riser pressure below pressure trip setting
- & hence ensure a safe step 3

➢ 3rd step : Pressure equalization across PSDV

- Main choke valve closed
- PSDV bypass line opened to equalize pressure across PSDV
- Ensure safe PSDV (ball valve) opening



Turret Production Gas Flow

Start-Up

➢ 1st step : Pressure equalization across ESDV

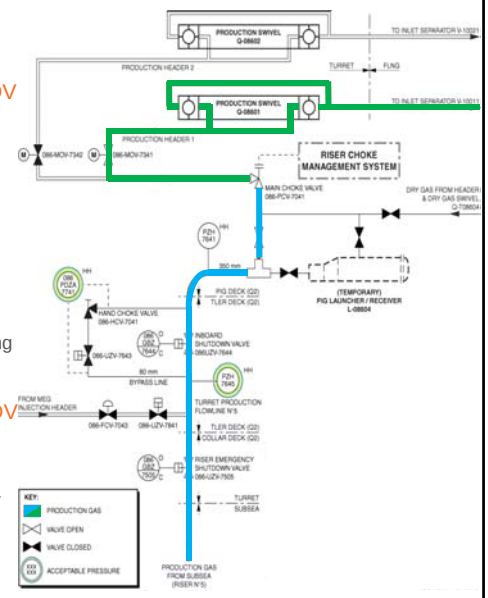
- MEG injection in pipe section between riser ESDV and PSDV
- Ensure safe riser ESDV (ball valve) opening

➢ 2nd step : Lower riser pressure

- Main choke valve opened
- PSDV bypass line used to lower the riser pressure below pressure trip setting
- & hence ensure a safe step 3

➢ 3rd step : Pressure equalization across PSDV

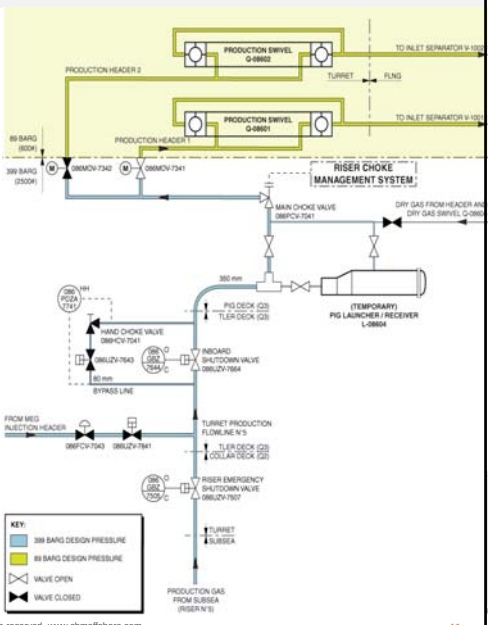
- Main choke valve closed
- PSDV bypass line opened to equalize pressure across PSDV
- Ensure safe PSDV (ball valve) opening …and start-up



Turret Production Gas Flow

=> Pressure Rating Break
2500 # / 600 #

- Production piping lines u/s (and including) MOVs
  - ➢ rated to 399 barg
- Production headers, swivels and d/s piping line to Topsides
  - ➢ rated to 89 barg



Turret Production Gas Flow

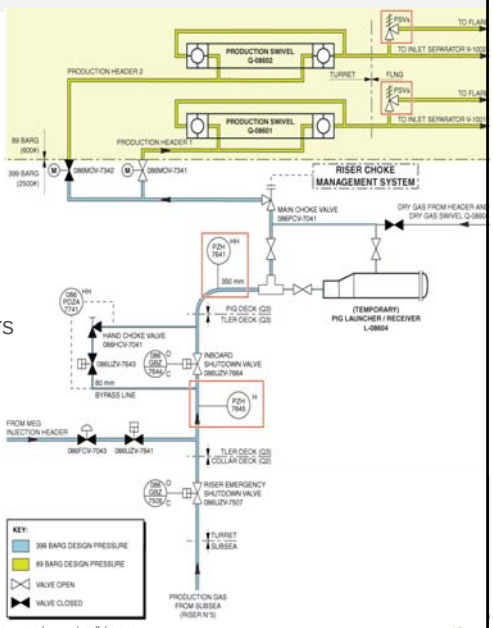
- Overpressure protection

- High pressure Trip
  u/s main Choke valve

- 2oo3 High pressure trip
  d/s main Choke valve

- PSVs located on Topsides
  i.e. d/s swivels on lines to separators

Follow-up actions:
- Close PSDV
- Close Bypass PSDV
- Close Meg injection SDV
- Close riser ESDV

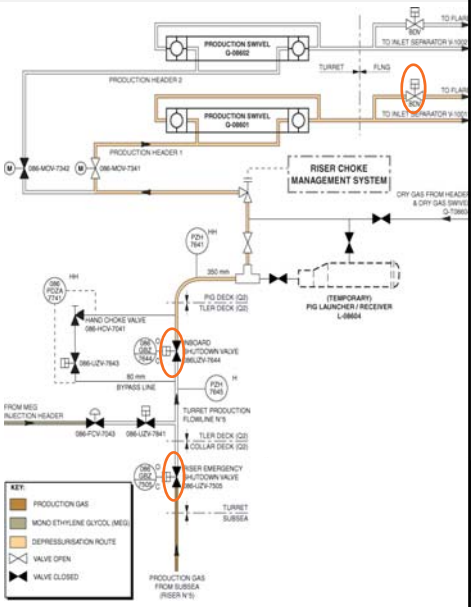


Turret Production Gas Flow

- Shutdown

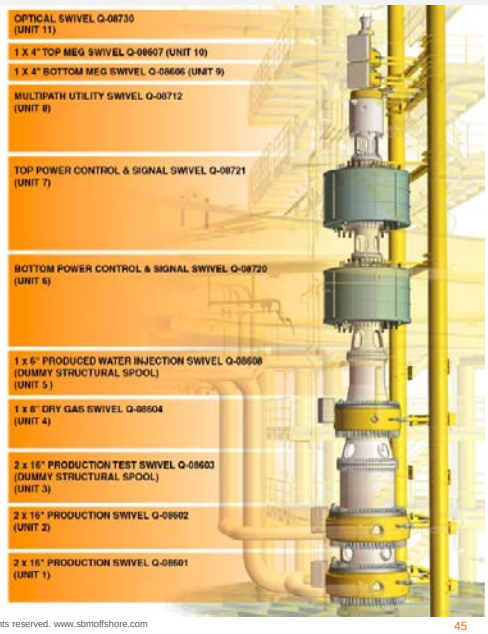
In case of Emergency Shutdown
ESD 2
(confirmed F&G detection)

- Subsea shutdown initiation
- Close Turret PSDV
- Close Turret riser ESDV
- Automatic blowdown of inventory
  from Turret SDV to Topsides
  (Blowdown valve located on Topsides)



Prelude TMS – Fluid Transfer System

- Prelude Swivel Stack
  - Height: 19.6 Meters
  - Diam. Max.: 3 Meters
  - Weight Approx.: 140 Tons

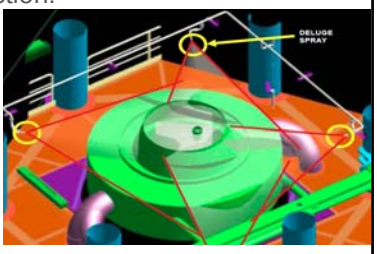


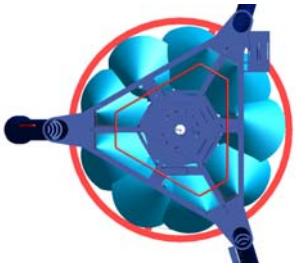
Prelude Turret Manifold

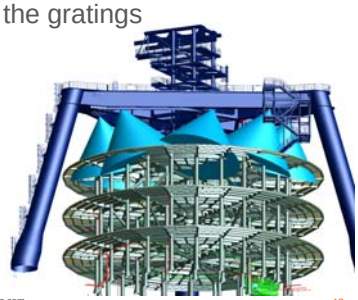
Other Safety Systems

Active & Passive Fire Protection

- Deluge water is used for the active fire protection:
  - Dedicated water spray deluge system protecting swivel stack
  - Deluge nozzles located under Gantry Deck to protect Manifold decks by **cooling** via cascading effect through the gratings

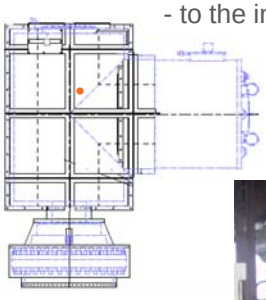






Active & Passive Fire Protection

- Passive Fire Protection
  - protecting Production piping lines
    - from the riser head
    - to the inboard PSDV



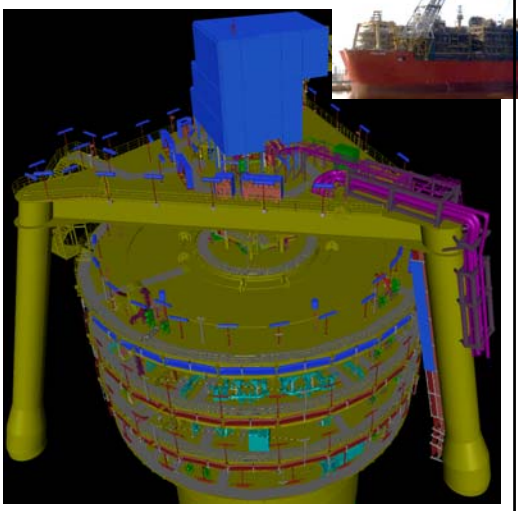
PFP SS enclosure

PFP flexible jackets

Heat Shielding

- Flare tips located close to Turret & 136m above Collar deck level

- Flaring :
  - not part of normal operating conditions;
  - however, may occur in emergency conditions *(& also process upset conditions like start-up*).
- Heat shielding required to reduce impact from radiation :
  - on personnel, considering time to escape *(>1.6 /6.3kW/m²*)
  - on equipment *(>12 /22 kW/m²*)

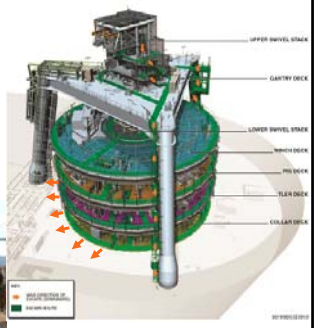


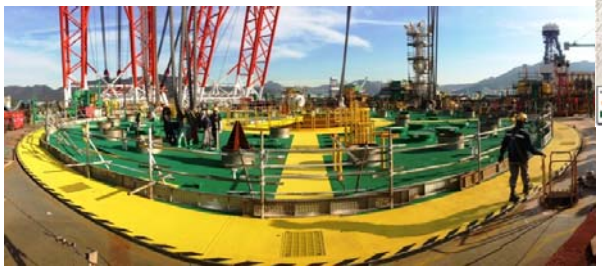
Personnel Safety

- Personnel protection provided for all piping normally operating above 70°C in areas where piping is exposed to personnel

Personnel Safety – Access & Escape

- Turret Collar deck @same elevation than Forecastle deck & Vessel Process Deck Level A
  - easy Access/Escape routes from Turret area to reach primary or secondary muster point





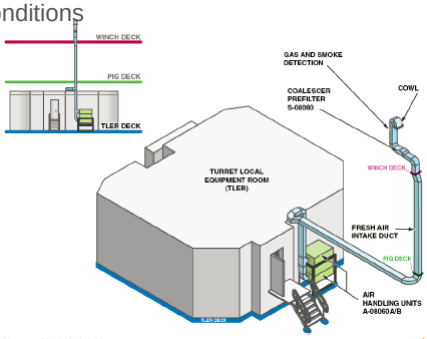
- Between the Turret fixed and rotating parts:
  - anti-entrapment devices strategically positioned to prevent hand/limb/foot entrapment whilst the vessel weathervanes around the Turret
  - suitable marking with painted colored stripes and appropriate warning

TLER: Safety & Reliability Motivations

Turret Local Equipment Room (TLER) :

- workable area… but normally un-manned (& not considered as temporary refuge)
- pressurized room housing the non-"Ex rated" E&I&T equipment

- provided with entrance air lock + with HVAC system able to:
  - maintain acceptable working inside conditions for equipment & personnel
  - prevent ingress of gas & smoke by maintaining >50Pa higher TLER pressure
  - isolate the TLER under shutdown conditions



Control & Safeguarding

Achieved from CCR through PAS (*Process Automation System*):

- DCS (*Distributed Control System*) - controlling facility systems by normal monitoring, control and advance warning of abnormal parameters.
- IPS (*Instrumented Protection Systems*) - safeguarding systems against parameters extreme excursions and catastrophic events by initiating appropriate shutdown actions.
- FGS (*Fire and Gas System*) - detecting smoke, fire or gas leaks and providing advance warning or initiating appropriate shutdown & fire protection actions.

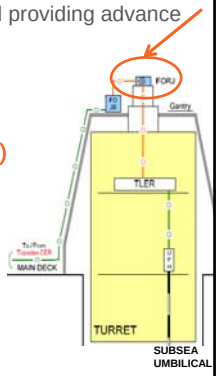
➢ **via Optical Swivel:**

✓ Topsides / Turret interface data communication by redundant FO networks Control & Safety (CN/SISnet)

✓ ⊕ FLNG / Shore principal link (Fitzroy project) enabling collaborative work from SHELL's PERTH offices

➢ **via LV swivel**

✓ Topside-Turret shutdown ESD2 also provided hard-wired as a secondary back-up



+ PA/GA (*Public Address/General Alarm system*) - alerting personnel of a potential hazard and transmitting instructions to the personnel on board.

Prelude Turret Manifold

Other Reliability Systems

Flow Assurance

- Typical hydrate management strategy :
  - MEG injection
    - not expected during the normal operation
    - intermittent use during start-up and shutdown
    (*directly in Turret prod. piping lines or subsea via umbilical*)
- Other chemicals (*paraffin inhibitor - pour point depressant - scale inhibitor*) against wax/scale formation injected subsea via umbilical

Flow Assurance

- Pig launchers & receivers
  - dry gas motive fluid for pigging
  - 3D bends on piggable piping
  - isolation DBB valves from main production line
  - returned fluids back to gas production lines
  - collected condensates directed to closed drains

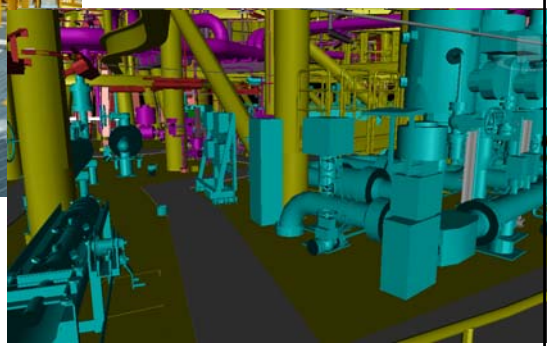
Prelude Base Case vs Future Scope

- TMS is already considering later stage/future fields tie-in to Prelude
- Design basis = Plug and Play philosophy

- Key features :
  - minimize production shutdown during future Offshore integration,
  - maximize symmetries and therefore increase the flexibility,
  - minimize leak sources,
  - limit offshore hot-work (*like: already planned bolted solutions for supports*),
  - space allocation, equipment pre-sized for future,…

Prelude Base Case vs Future Scope

- TMS is already considering later stage/future fields tie-in to Prelude
- Design basis = Plug and Play philosophy



Thank you

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OFFSHORE

Q&A