Airborne Oil & Gas

# Free Hanging Composite Risers for Ultradeep Waters

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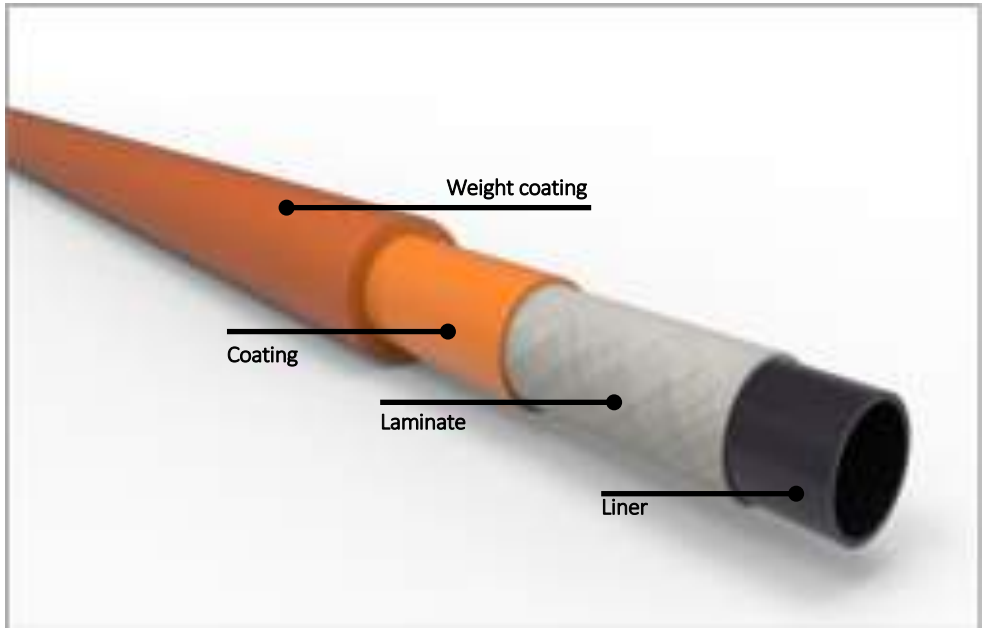
2018

# Agenda

- Introduction to Airborne
- TCP concept
- Design & Product Qualification
- Riser Development – Case Study



# The first and leading manufacturer of TCP

**First and leading manufacturer of TCP**
- Shareholders include Sumitomo Corporation, Subsea 7, Shell, Chevron and Saudi Aramco
- Headquartered in IJmuiden, The Netherlands
- Sales offices in Houston (USA) and Kuala Lumpur (Malaysia)
- ±100 personnel

**Champion in composite pipe for Upstream Oil & Gas**
- Largest track record in the world; field proven in subsea applications including Flowline, Jumper, Spool and Downline (well intervention)
- Qualified under DNV and manufactured under ISO 9001 and API Spec Q1 quality controlled conditions.

**TCP proven to reduce total installed cost and total life cycle cost**
- No corrosion, no inhibitor pumping, no related inspections
- Fast, lightweight and flexible
- Ability to terminate offshore

1999 – TCP concept developed by Airborne

Founding of Airborne Oil & Gas

2007 – First pilot line for continuous TCP manufacturing

2009 – Joint Industry Program launched to develop a deepwater riser concept and test feasibility

First commercial delivery of offshore downline

2010 – HPE steps in as investor

2012 – Full-scale production site for TCP in IJmuiden (Port of Amsterdam)

Airborne Oil & Gas independent company

2014 – Launch of the Recommended Practice for TCP: DNVGL-RP F119

2015 – Qualified in accordance with DNVGL-RP F119

Shell, Chevron and Evonik on board as strategic investors

Saudi Aramco Energy Ventures on board as strategic investor

2016 – Opening of regional offices in US & KL

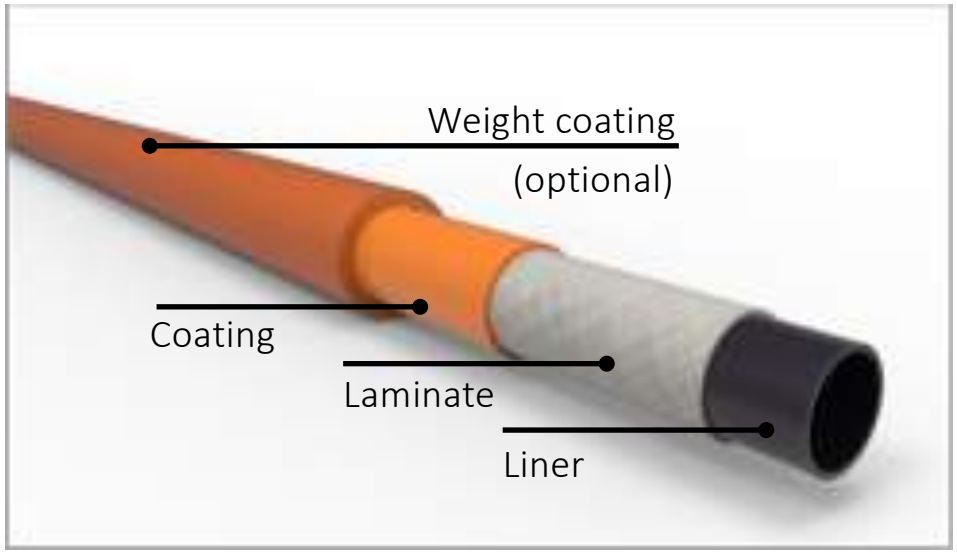
Track record on all products except TCP Riser

2017 – Subsea 7 on board as strategic investor

World's first flowline for hydrocarbon service (Petronas, Malaysia)

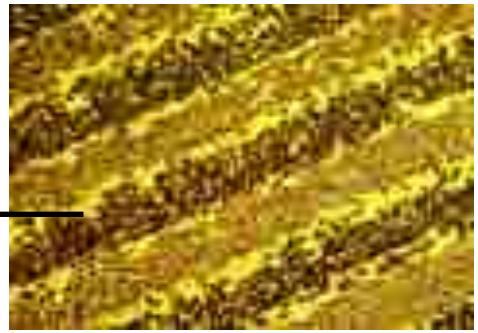
2018 – Sumitomo Corporation on board as strategic investor

# Simplicity by design: TCP concept



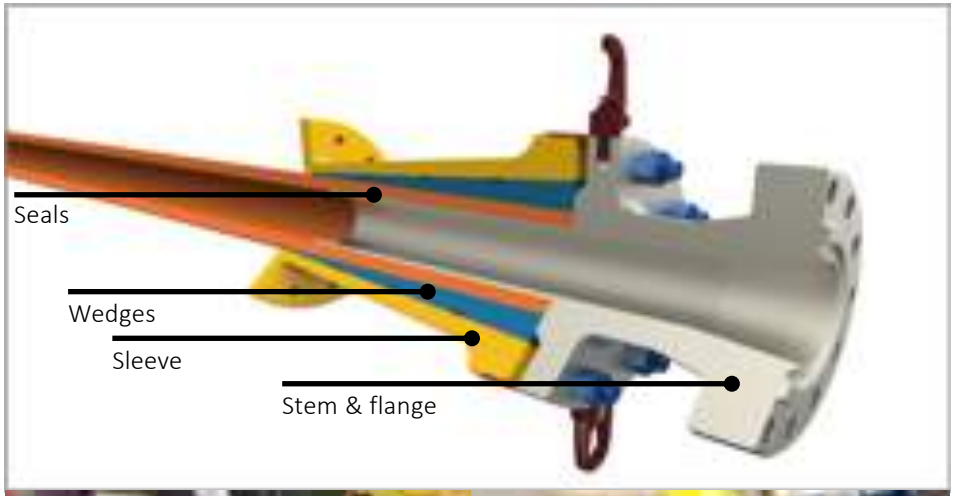

- Solid pipe structure: bonded
- Fit for purpose polymer: liner, matrix & coating
- Glass or carbon fibres fully embedded (true composite)
- Optional weight coating for on-bottom stability

➢ No corrosion
➢ Flexible
➢ Light weight



A plastic liner is over-wound with polymer impregnated fibre tapes and melt fused using Airborne Oil & Gas propriety production technology to form a single walled structure
Monolithic wall reduces permeation and allows for high pressure applications including gas service

# Simplicity by design: TCP concept




- Terminated within hours
- Fully qualified and field proven
- Can be fitted with bend restrictors, bend stiffeners and clump weights (TCP Downline)
- Various flange options available (API, ANSI, etc)
- Various material options available (carbon steel, CRA etc)

The TCP can be terminated in the field, both onshore and offshore. This allows for flexibility in tie-in as well as pulling through J-tubes without end-fitting
The liner is reamed prior to stem insert, maximising bore dimensions
CRA options include weld inlays

# TCP Products that bring value to the industry

## Onshore

### TCP Light

**Key Proposition**

- No corrosion
- High pressure, sour
- Crude & gas service

**Key Applications**

- Onshore
- Flowline
- Well jumpers

## Subsea Risers Flowlines (SURF)

### Flowlines & Spools

**Key Proposition**

- No corrosion
- Lower total installed cost
- Lowest total cost of ownership

**Key Applications**

- In-field flowlines
- Spools & well jumpers
- Gas, water & HC service

### Risers

**Key Proposition**

- 50% weight reduction
- Lower riser cost
- Lower installation cost

**Key Applications**

- Deepwater
- Corrosive environments
- Gas, water & HC service

## Subsea Well Intervention (SWI)

### Dynamic Jumpers & Hoses

**Key Proposition**

- Collapse resistant 3000 m
- Smooth bore
- Flexible

### Downlines

**Key Proposition**

- High flowrates
- Lower cost per intervention
- Long service life

**Key Applications**

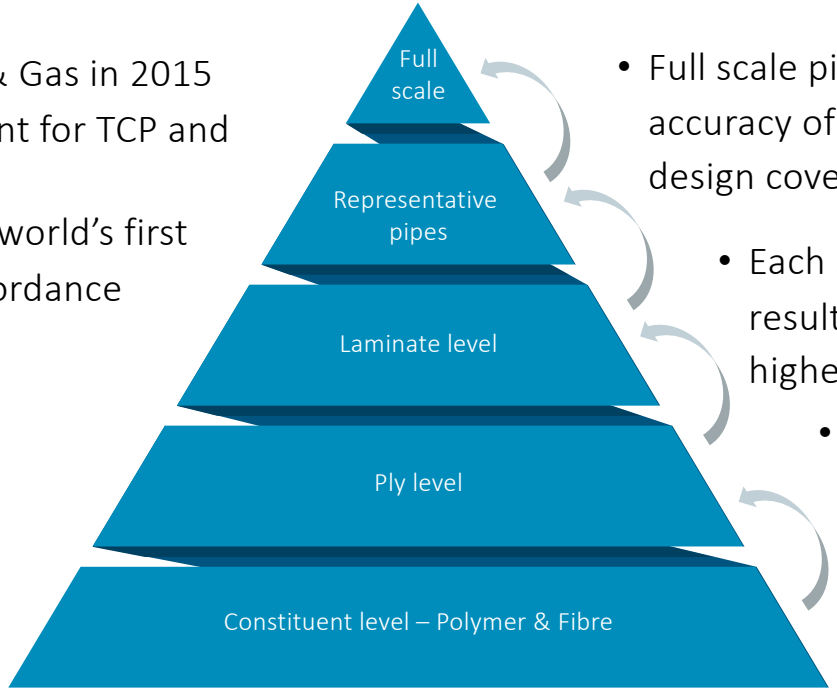
- Light well intervention
- Plug & Abandonment
- Pipeline pre-commissioning

# Shaping the environment to accept new technology

## DNVGL-RP F119 Standard

- Initiated by Airborne Oil & Gas in 2015
- Standard specifically meant for TCP and offshore use
- Airborne Oil & Gas is the world's first company qualified in accordance with it

## DNVGL-RP F119 Qualification approach




- Full scale pipes are tested on critical load cases to prove the accuracy of the design predictions, hence proving that the design covers all single and combined load cases well
- Each step includes validation, proving that the results from the lower level can be used for the higher level
- Material performance is measured and tested with infield conditions of fluid, temperature etc
- Tested material performance is translated to validate a model based on fibre and polymer

# Leading to broad qualification status with leading operators

## DNV Qualifications


## Product & client

**Jumper Spools**

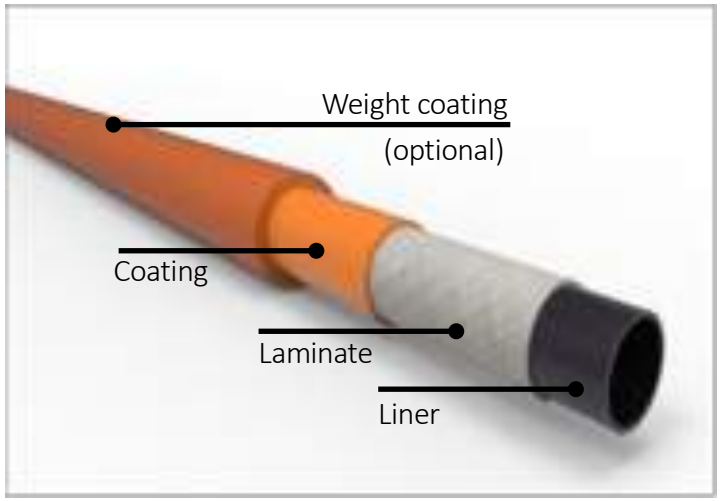
**Flowlines**

**Dynamic jumpers**

**Downlines**

*: In progress

# Simple & fit for purpose: TCP




- Solid pipe structure: bonded
- Single polymer: liner, matrix & coating
- Glass or carbon fibres fully embedded (true composite)
- Optional weight coating for on-bottom stability

  - ➢ No corrosion
  - ➢ Flexible
  - ➢ Light weight

Fit for purpose materials, optimized for each application



# Track record

| Delivery | TCP Description | Application | Client | End user / project |
|---|---|---|---|---|
| 2011 | 2 x 4.5” downlines, 800m | Trenching | AGR, Flexlife | Chevron |
| 2012 | 3” downline, 2500m + reeler | Pipeline pre-comm | Saipem | Guara & Lula, Sapinhoa |
| 2015 | 2.5” downline, 1600m | Pipeline pre-comm | IKM /Subsea7 | Statoil Astaa Hansteen |
| 2015 | 2x 2”, 10ksi dynamic jumpers | P&A | Wild Well Control | Marubeni |
| 2015 | 1“ static high pressure spools | Methanol injection | Chevron | Alder |
| 2016 | 2.5”, 10 ksi dynamic jumpers | Acid stimulation | OneSubsea | Various |
| 2016 | 3“ downline, 1500m + spread | Acid stimulation | Shell | SNEPCo Bonga |
| 2017 | 6” jumper spool qualification | Spool, water injection | Total | Zinia |
| 2017* | 5.2” 10 ksi jumper spool qualification | Spool, water injection | Shell | Perdido |
| 2017 | 2” 10 ksi dynamic jumpers | Acid stimulation | Enpro / GE Oil & Gas | Tullow Oil Ghana |
| 2017 | 2” 5 ksi gas lift jumper | Gas lift | Anasuria | Anasuria |
| 2017 | 6” flowline, 550m | Hydrocarbon production | Petronas Carigali | SKO West Lutong |
| 2018* | 6” 100 bar TCP Light, 1500m | Onshore, crude | Saudi Aramco | Saudi Aramco |
| 2018* | 6” 7500 psi TCP Light, sour gas | Onshore well jumper | Saudi Aramco | Saudi Aramco |
| 2018* | 2.5” 7500 psi TCP Jumper Spool | Crude oil | Genesis | Genesis |

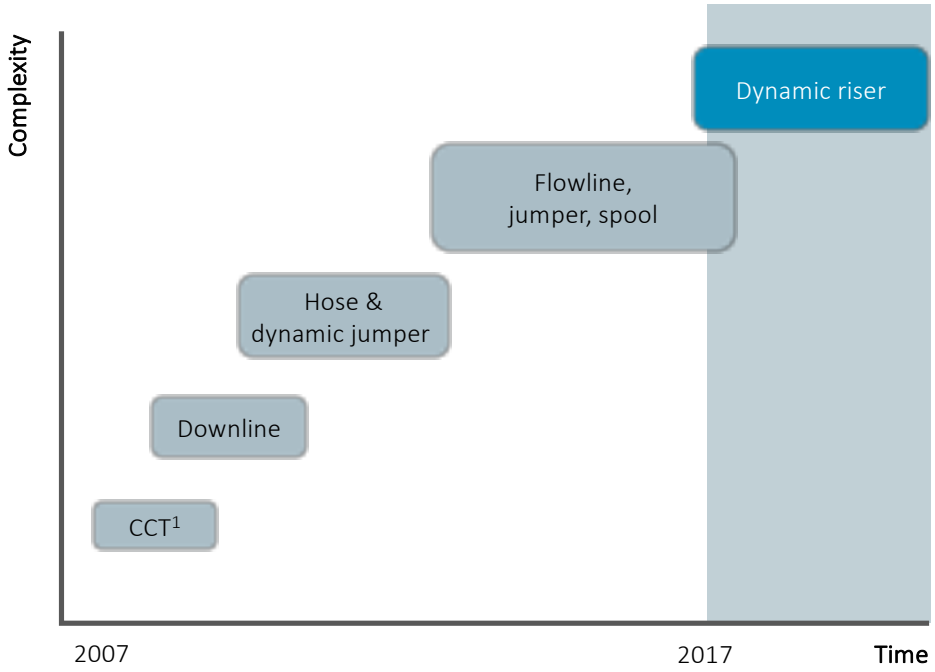
*: in execution

# 6.0in Flowline / 550m /Hydrocarbon production / Petronas

- TCP riser pull through I-tube onshore
  - I-tube marginally larger than TCP OD
  - Controlled environment
  - TCP terminated on-site
- TCP flowline prepared onshore
  - Tow-out to location using low-cost tug boats

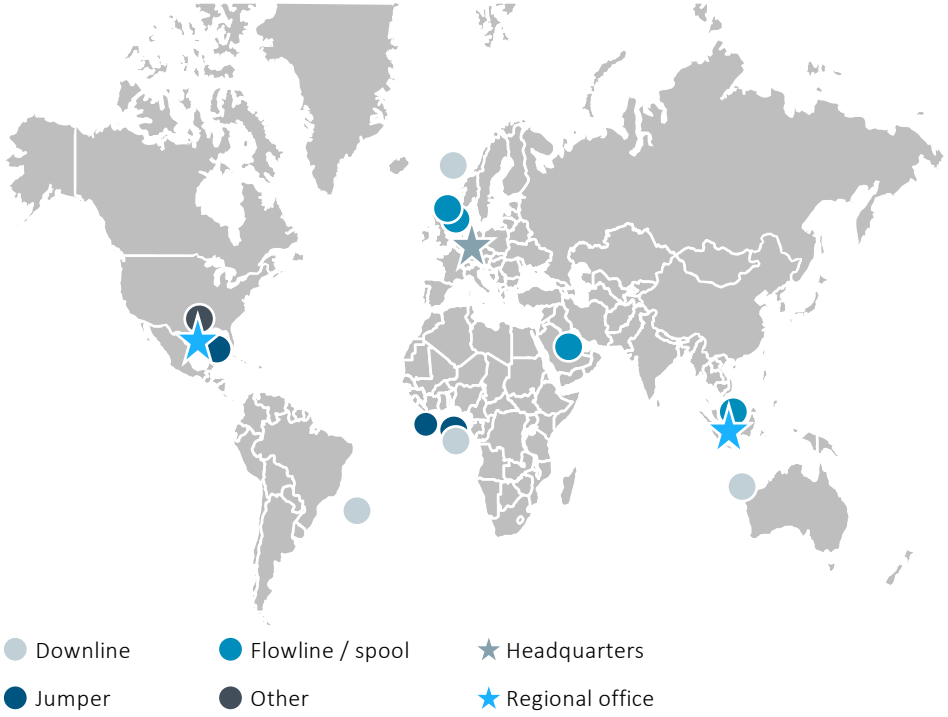
# Building field track record: staircase approach

## Staircase




1. CCT – Composite Coiled Tubing

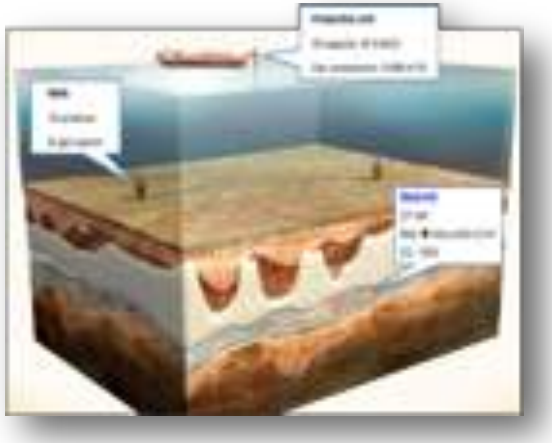
## Key completed and ongoing projects



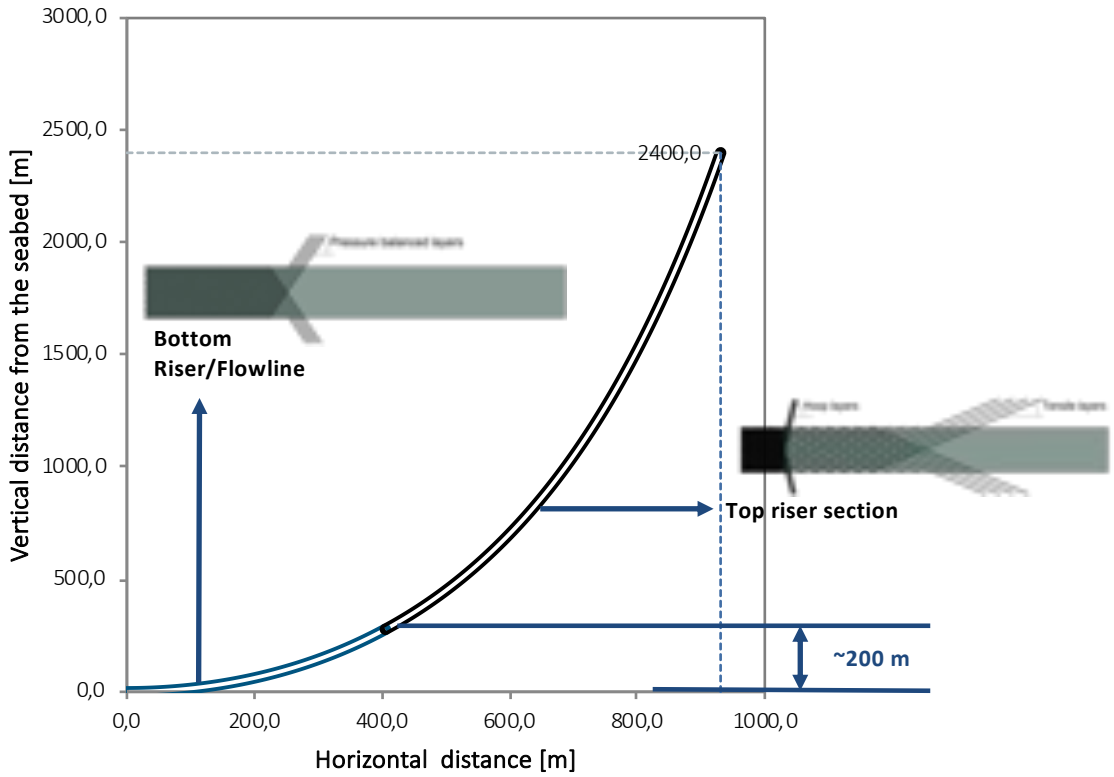
# Riser Development: Case Study

- 6.0in WAG line for pre-salt Brazil
- Main Goal: To achieve Free Hanging Catenary at 2400 m WD
- FPSO Cidade de Sao Paulo (Spread Moored)

| Parameter description | Specification | |
|---|---|---|
| Temperature | -20°C to 60°C | |
| Design Life | 30 years | |
| MAOP | 620 barg | |
| Water depth | 2400 m | |
| Location | Pre-Salt Brazil | |
| Fluids | Water | |
| | $CO_2$ | < 90% |
| | $H_2S$ | < 100 ppm |



# Riser Development: Case Study




- TOP Riser optimized for high tension.
- BOTTOM Riser optimized to comply with high curvature.
- BOTTOM Riser is the same as flowline since fatigue is not driving cross section design.



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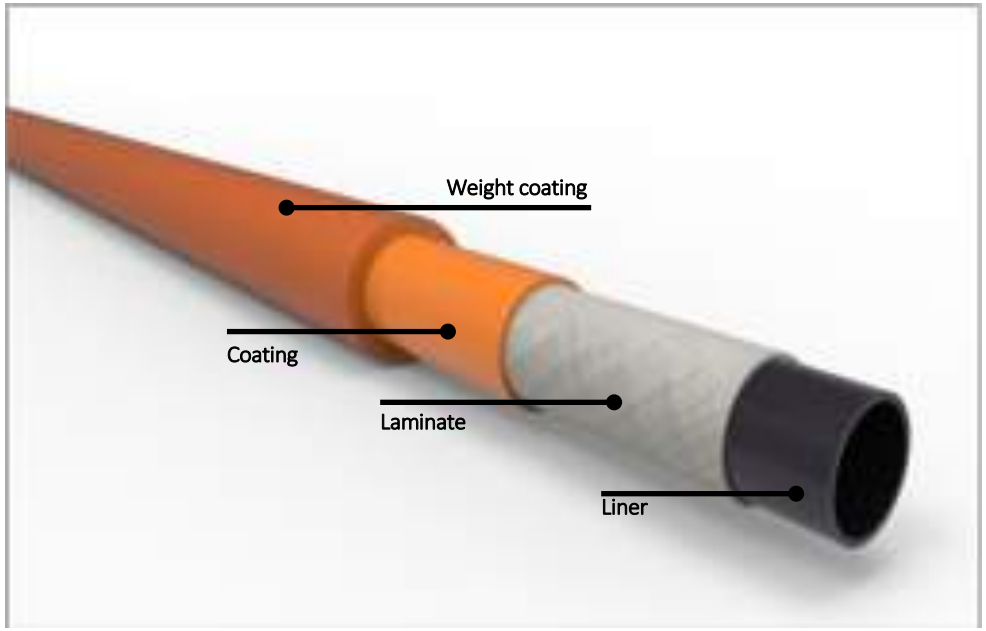
# Riser Development: Weight coating technology

- System must be stable when filled with water and gas:
  - ✓ Preliminary global analysis shows that 20 kg/m submerged weight (filled with light fluid) is sufficient to reach an stable configuration in free hanging;
- Heavy Coating Technology:
  - ✓ AOG technology of heavy coating allows system optimization achieving a stable configuration while minimizing top tension loads;



# Riser Development: Weight coating technology

**Heavy Compound:**

- Untreated natural mineral
- Very low chemical reactivity
- Used in automotive and cosmetics parts
- Density of 5.2 g/cm$^3$

**Weight coating compound:**

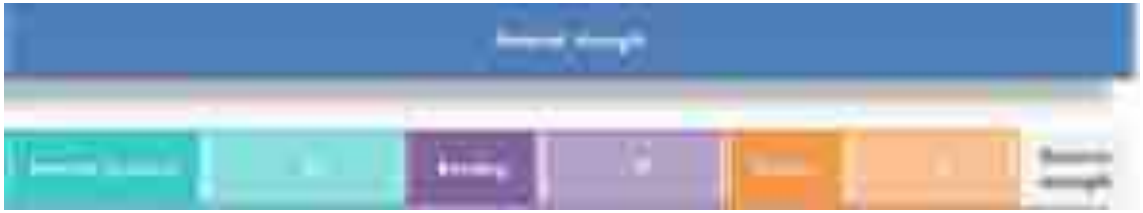
- Polyethylene (PE) as base polymer (other polymers may be possible in the future)
- Density max 2.6 g/cm$^3$ in PE (40% volume)
- Can be processed in extruder with proper tooling

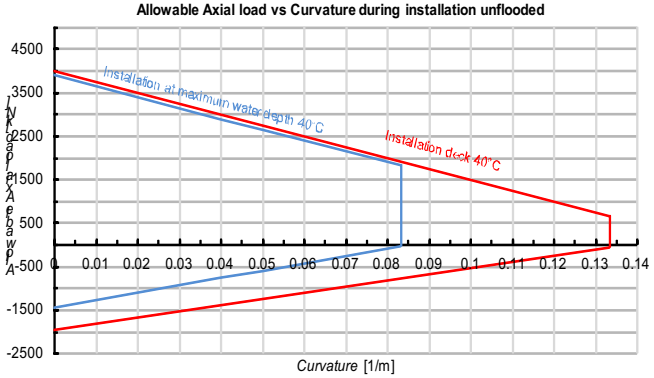
# Riser Development: TCP Datasheet

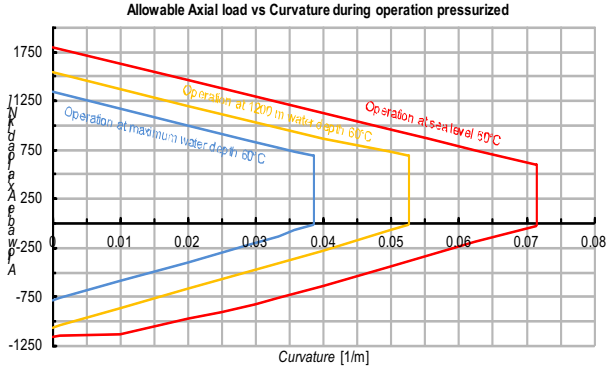
| Pipe Characteristics | Unit | Top Riser | Bottom Riser / Flowline |
|---|---|---|---|
| OD without heavy coating | [mm] | 213 | 236 |
| *OD with heavy coating* | *[mm]* | *243* | *244* |
| Bending stiffness at 60ºC | [$kNm^2$] | 900 | 225 |
| MAOP (internal top) | [barg] | 620 | 620 |
| MBR storage | [m] | 7.5 | 3.5 |
| Tensile capacity (installation) | [kN] | 4000 | 560 |
| Tensile capacity (operational) | [kN] | 1800 | 485 |
| Mass, in water, water filled | [kg/m] | 34.8 | 25.8 |
| Mass, in water, light fluid filled | [kg/m] | 20 | 10 |

# Riser Development: TCP Datasheet

- **Bonded structure:** Axial strength, internal pressure and bend radius are all related;
  - Best way to represent pipe capacity is to produce performance envelopes for the different scenarios (Installation/Operation);
    - Pipe capacity already considering DNV safety factors;
    - Red curve applies to sea level (no EP);
    - Blue curve applies to seabed level (EP contribution);



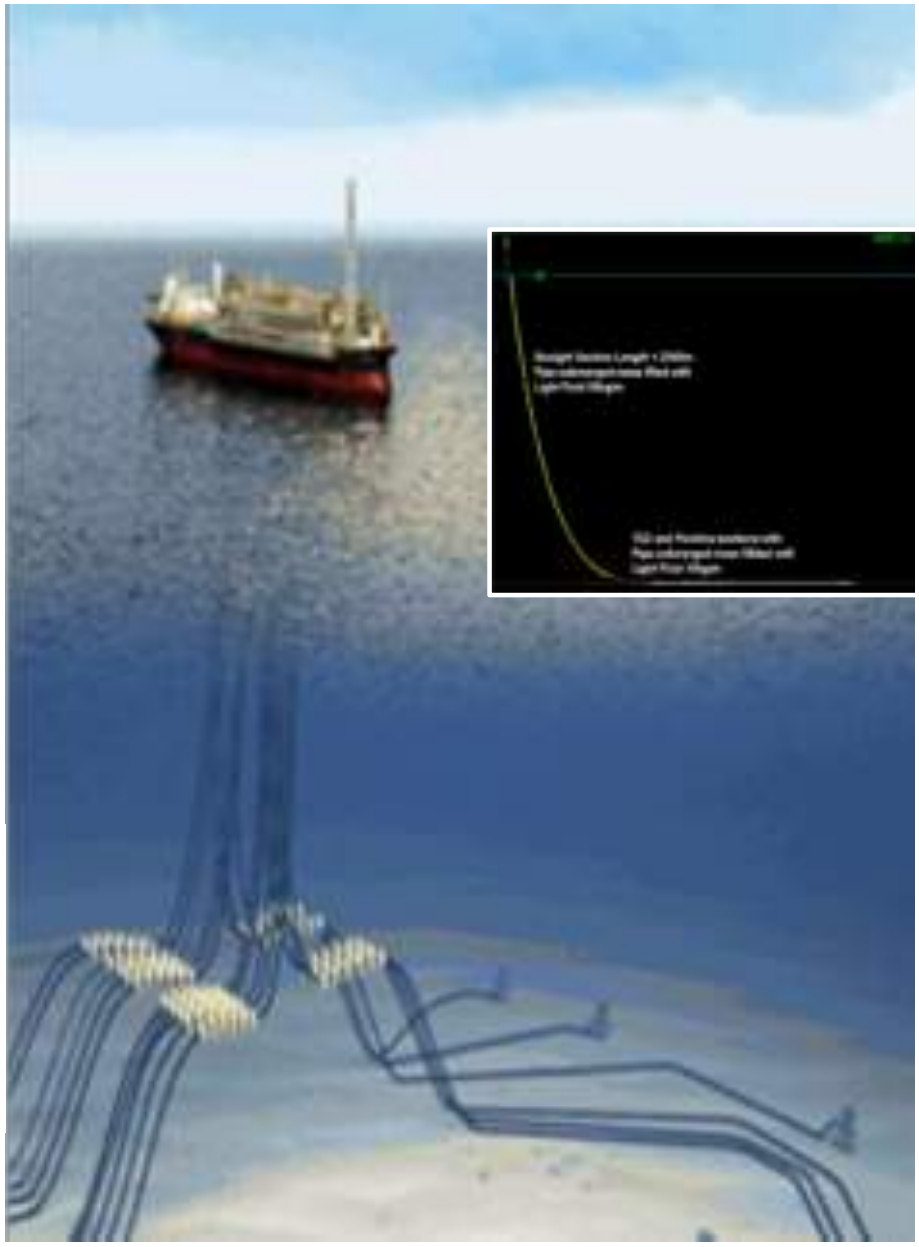


# Riser development: Conclusions

**Detailed engineering shows feasibility**

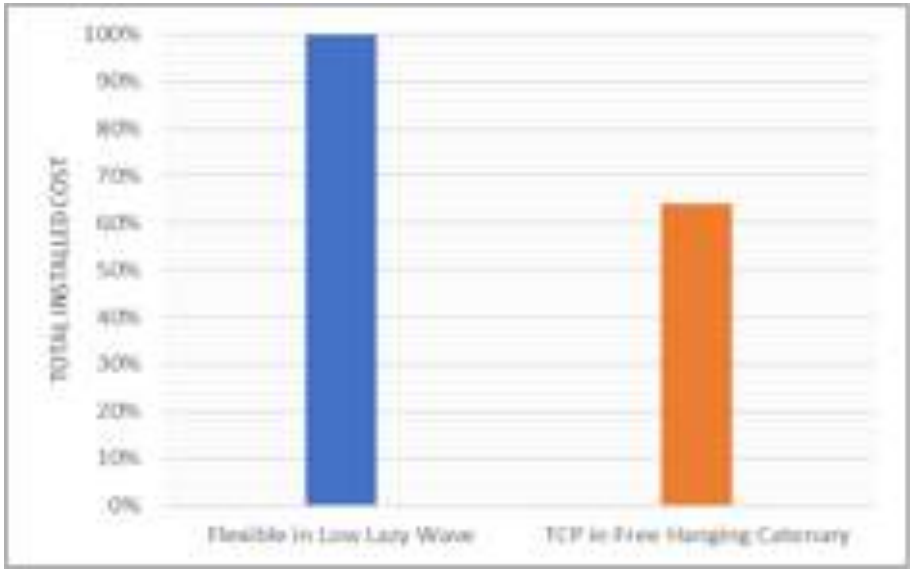
- In-place global analysis performed considering pre-salt environmental conditions and FPSO Cidade de Sao Paulo shows feasible in-place configuration;
- Installation assessment performed by SURF contractor shows feasible installation of TCPs;
- Preliminary assessment of TCP fatigue life shows large margin of safety



# Riser development: Conclusions

TCP Riser reduces significantly total installation cost

- Free hanging configuration removes all buoyancy elements
- Reduced length per riser
- Less riser sections, reduced installation time
- Total cost saving per riser USD 6-8m




Further knock-on effects unlock potential cost saving on future FPSO's thanks to 50% lower top tension

- Lower loading on riser balcony
- Lower loading on mooring system
- More pay-load capacity for FPSO (gas handling etc)

# Highlights of the presentation

## Design approach based on new standard for TCP

- DNVGL RP F119, issued Q4 2015
- Understanding and predicting TCP behavior
- Generic, knowledge based approach

## Several Applications

- Downlines, Jumpers & Flowlines, Risers

## Fit-for-purpose materials

- Glass or Carbon Fibre
- PE,PA12 or PVDF

## Composite riser developments

- Final step on staircase
- Heavy coating technology

## Case Study – Pre-salt Brazil

- Significant cost reduction when FHC can be achieved
- Significantly reduced top-side tension

Airborne Oil & Gas

# Thank you very much!

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