THE PAST, PRESENT & FUTURE (?) OF SUBSEA PIPE-IN-PIPE TECHNOLOGY

Back to the Future of Subsea

Subsea UK Conference, Woking
The First Edition of Herbert George (H.G.) Wells’ *The War Of the Worlds* was published in 1898.

- The novel has greatly influenced the work of many scientists.
- Robert H. Goddard, inspired by the book, invented both the liquid fuelled rocket and the multistage rocket.
- Goddard’s work directly led to the Apollo 11 Moon landing 71 years later.
AGENDA

- The Basics – in which we describe the basics of PiP technology
- The Past – in which we look at some previous designs that we may know
- The Present – in which we look at the current state of the art
- The Future (?) – in which we speculate wildly upon what may be to come
THE BASICS - Components

- Outer Pipe
- Insulation
- Inner Pipe

There may also be other components such as bulkheads, water stops or centralisers.
THE BASICS - Functionality

- **Inner Pipe** – contains produced fluid *(design: corrosion, internal pressure)*
  - Carbon Steel
  - Solid CRA
  - Clad CRA

- **Insulation** – maintains fluid temperature *(design: thermal conductivity, temp. resistance, ageing)*
  - Mineral wool / glass wool
  - Foamed cements
  - Polyurethane / polyurethane foams
  - Glass microsphere syntactic foams
  - Gels
  - Vacuum

- **Outer Pipe** – protects insulation, resists damage *(design: external pressure, impact / fishing)*
  - Rubber
  - High Density Polyethylene
  - Moulded Polyurethane
  - Spirally Crimped Steel
  - Steel Pipe
THE BASICS - Functionality

- Other Components

Centraliser

Water Stop

Bulkhead
THE BASICS – Some Examples
THE BASICS – Field Joints

- Field joint – joint between two pipe-in-pipe sections (design: corrosion, insulation, protection)
  - Steel Sliding Sleeve
  - Steel Half Shells
  - Screwed Connector

- Very important consideration
  - Installation
  - Operation
## THE BASICS – Design Considerations (compared to single pipe)

| ✓ Lower U-values possible | x Design Complexity |
| ✓ Suitable for deeper water depths | x Slower to fabricate and install |
| ✓ On-bottom stability improved | x More expensive |
| ✓ Pipeline end expansion reduced |
| ✓ Improved dropped object impact resistance |
| ✓ Improved fishing interaction behaviour |
| ✓ Improved global buckling behaviour |
THE PAST
THE PAST – Timeline of Selected Projects

- **1978**: Conoco Udan
- **1986**: Occidental San Miguel
- **1989**: Esso Bass Straits
- **1990**: CACT HZ26-1
- **1991**: Petronas Dulang
- **1992**: Nanhai West Weizhou 11-4
- **1994**: Total Dunbar
- **1997**: Statoil Gullfaks
- **1998**: Texaco Erskine
- **2000**: Shell ETAP
- **2008**: Shell Nakika
- **2012**: Total Islay
- **2014**: Shell Bonga NW
- **2017**: Total Kaombo
- **2020**: Petrobras Canapu
THE PAST – Early Designs

- Ring type bulkheads from sheet steel
- Polyurethane foam insulation
- Welded steel ring at field joint
- Early non proprietary systems
THE PAST – Snamprogetti DPIS

- Double Pipe Insulated System (DPIS)
- Polyurethane foam insulation
- Forged steel bulkhead (‘SJC’)
- Water tight joint
- Thermal load transfer
- Used on projects in late 1980’s / 1990s
THE PAST - ITP Interpipe

- Tulip connector at field joint
- Originally used glass fibre wool / mylar (polyester) film insulation
- Annulus also filled with inert gas under partial vacuum
- Has since been simplified by using Izoflex
- First used on Total Dunbar (1994)
- Large diameter 16” x 20” biggest
- Approx. 12 projects using S-lay / J-lay since
- Still active
THE PAST – BSC Hydrotherm

- Alumina silicate microspheres for insulation
- Supported and sealed with EPDM water stops
- Field joints of half shells filled with rock wool
THE PAST – Erskine Field Joint

Figure 1 Erskine Pipeline Hydrotherm System
THE PAST – Erskine Failure

- Field was shut-in on 23rd Dec
- On 8th Jan between 8-9 am pipeline pressure dropped twice, eventually to ambient
- Inspection found full-bore rupture had occurred 24.4km from Erskine
- Flow line had separated by 2 metres
- In addition to the failure point the carrier collar had failed at a further nine locations
- On start-up pipeline responded as intended with 13 evenly spaced buckles
- Peak stresses in buckle were underestimated and plasticity occurred in the carrier pipe
- On cooldown the pipeline was under high axial load, magnified by the stress concentrations of collar design
- Field joints were not designed for cyclic loads
- Only visual and MPI inspection of collar welds
- Pipeline was subject to low cycle high stress loading leading to collar failure, first failure could have occurred after 10 cycles
THE PAST – Erskine Replacement

- Logstor Ror pipe-in-pipe with PUF insulation
- Two welded steel half shell field joints with mineral wool mats
THE PAST – TechnipFMC Track Record

![Graph showing water depth and date for various regions.]

- **North Sea - UK**
- **North Sea - Norway**
- **Gulf of Mexico**
- **West of Africa**
- **Asia Pacific**
- **Brasil**
THE PAST – Notable Highlights

- Pipe-in pipe technology has a 40 year track record
- First reeled pipe-in-pipe - 1989 (Esso Bass Straits, Australia)
- First CRA inner pipe – 1997 (Statoil Gullfaks, North Sea)
- First reelable bulkhead – 2011 (BP Devenick, North Sea)
- First ETH pipe-in-pipe – 2012 (Total Islay, North Sea)
- Best insulated pipe-in-pipe - Total Dalia (U= 0.62 W/m².K – first use of aerogel)
- Deepest pipe-in-pipe – Shell Nakika (2115m)
THE PRESENT
THE PRESENT – Ever More Challenging Conditions

- Higher Pressures – linepipe material requirements, design
- Higher Temperatures – insulation materials
- Deeper Water Depths – linepipe material requirements, flow assurance
- Active heating - design
- More competitive market place – cost!
THE PRESENT – Fenja Field Development

- 12” x 18” Pipe-in-Pipe Production Pipeline
- 333 barg and 120 deg C design conditions
- Carbon steel, mechanically lined pipe (UNS31603)
- May be either BuBi® or GluBi®
- Electrical Trace Heating (ETH) with FO monitoring
- To be installed on seabed in a snake lay configuration
THE PRESENT – Fenja Field Development
THE PRESENT – Fenja Field Development

Glued mechanically lined pipe that can be laid by the reel-lay process, without using inner pressure or increasing the wall thickness of the corrosion-resistant liner: the GluBi® pipe.
THE FUTURE (?)
THE FUTURE (?)

NEW MATERIALS
THE FUTURE (?)

SMART SENSORS
THE FUTURE (?)
THE FUTURE (?)

NEW MATERIALS  SMART SENSORS  CONNECTED
THE FUTURE (?)

Jennifer Parker: Dr. Brown, I brought this note back from the future and - now it's erased.

Doc: Of course it's erased!

Jennifer Parker: But what does that mean?

Doc: It means your future hasn't been written yet. No one's has. Your future is whatever you make it. So make it a good one, both of you.
THANK YOU

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