Subsea hot taps provide a potential solution for lower cost access the pipeline/flowline arterial network. An appraisal of the relative merits and risks of grouted, mechanical and welded assemblies.

Jamie McCallum
Overview

- Generic Technology Overview
- Technology Suppliers
- Hot Tap Technologies
- Benefits
- Barriers
- Concluding Remarks
- Recommended Further Work
- Appendix
Generic Technology Overview

- **Hot Tapping**
  - Making connections to a host pipeline, or other pressure vessel, whilst the pipeline or vessel remains in service.
  - Involves technology to make orifice into pressure envelope of host while maintaining environmental isolation.

- **Used for:**
  - Tie-ins to existing export lines.
  - Flowline reconfiguration as part of field optimisation.
  - Plugging operations for abandonment.
  - Rerouting pipeline prior to replacement of damaged section.

- **Current North Sea approach:**
  - Hyperbaric welding (using divers)
  - Hyperbaric welding (Statoil remote pipeline repair system)
  - Pre-installed tees (Statoil Ormen Lange)
Benefits

- Continuous system operation
  - Hot tapping allows pipeline extensions to be added to the main pipeline whilst the pipeline remains in service avoiding costly shutdowns and service interruptions.
  - Live pipelines can be worked on without leakage of the product to the atmosphere.
  - Can connect to existing pipeline as opposed to closing off the system, cutting and replacing a section of the pipeline.
Technology Suppliers

Include:

• Welded Tees
  - Statoil – Remote Pipeline Repair System

• Grouted Tees
  - Subsea 7 – Subsea Grouted Tee
  - Namco Solutions

• Mechanical Tees
  - Oceaneering – Smart Tap
  - QCS – Quali-Tee Tap Fitting
  - STATS Group – BISEP

• Hot Tapping Machines
  - TD Williamson
  - Furmanite
  - Hydratight
  - Claxton

• Tee Design
  - Clear Well Subsea
Mechanical Tee

- Overview
  - Typically three part assembly with split fitting bolted together around the pipe and seals at either end. Available in a large range of sizes customisable to the customers needs, one supplier quoted up to 30” OD with 10-20” OD of pipe off the hot tap outlet.
  - Design offers both sealing and mechanical load transfer in one go.
  - Technology is constantly evolving with new seal and gripping technologies.
  - Installation is straight forward and eliminates hyperbaric welding.
  - Use divers at depths of around 3-180m but can also be installed using ROVs.
  - Limitations include issues with ovality, operating temperature, the need to remove all insulations and coatings and concerns over the longevity of elastomeric seals.

Example of Oceaneering design below.
Mechanical Tee

- Technological Maturity
  - TRL Level 9
  - Over 700 installed, mainly in the Gulf of Mexico, at a rate of around 20 a year.

- Time to Market
  - Already on the market.
  - Stock can be ready available with company for quick procurement.

- Qualification
  - None required – already on the market.

- Costs
  - Installation cost savings expected from removing the need to perform hyperbaric welding.
  - Simple installation operation taking 4-5 days.
  - Able to go to multiple suppliers for best deal.
  - Some suppliers can offer full package including preparatory works and inspection.
Subsea Grouted Tee

- Overview
  - Epoxy filled hot tap fitting which has been previously used onshore by British Gas.
  - Uses a single piece saddle seal around opening as opposed to bolted tee sealing mechanisms.
  - Eliminates requirement for hyperbaric welding.
  - Potential for off the shelf application reducing lead times.
  - Weight advantages over mechanical tees.
  - Suitable for any depth.
  - More tolerant of pipeline geometry i.e. ovality.
  - Offers metallurgical independence between main pipeline and connection.

Image from Subsea 7.
Subsea Grouted Tee

- Technological Maturity
  - TRL Level 7
  - Subsea trials performed successfully but yet to be used in subsea operations.
  - Over 130 successful land based applications

- Time to Market
  - Within 12 months of concept selection.

- Qualification
  - Further qualification of grout mix required prior to first use.

- Costs
  - Installation cost savings expected from removing the need to perform hyperbaric welding.
  - For large diameter pipes – greater than 26” – grouted tees may be more cost effective than mechanical tees. However there will be other substantial costs associated with subsea grouting spread, installation and curing times etc.
internal welded tee

- overview of scope
  - a remote-controlled hot tap operation where a robot welds a T-piece on to the pipeline. When that has been done, a remote-controlled drilling machine drills holes in the producing pipeline.
  - the pipe’s protection is removed using a 1200 bar pressure washer. Before the T-section is lowered and bolted in place.
  - the welding robot then arrives and blows the branch pipe on the T-section dry using argon gas. The area is then dried and heated using induction-based heating coils.
  - the robot welds an internal seal weld between the inside of the branch pipe and the pipe to be hot-tapped before isolating the pipeline.
  - the tapping machine is lowered for drilling, extracting the drill and coupon through the valve.
  - https://www.youtube.com/watch?v=UnsWCobs-Ww

- technological maturity
  - TRL Level 9 – operation successfully performed by Statoil on Asgard field.

- time to market
  - on the market exclusively with Statoil.

- qualification
  - code compliance of fillet weld around branch rather than full penetration was a potential issue however use on Asgard suggest this was able to be overcome.

- costs
  - Asgard operation took 10 days compared with 3 months had the pipeline been required to be shutdown.
Barriers

- General Hot Tap Issues
  - Limited in where they can be used within a pipeline. Location needs to be carefully considered due to potential need to excavate host pipe, remove coatings, perform pipeline condition survey etc.
  - In many cases there will be a need for some form of protection or overtrawlable structure to protect the hot tap tee, valve(s) etc.
  - Potential issues associated with pipeline integrity.
  - Pressure and temperature limitations
  - Suitability of host pipeline (size, capacity, residual life etc.). If tapping into small pipes you might want to cut a large orifice and tee might not work. Flowlines seldom have much ullage available – the volume of fluid produced does not decline all that much even as the field declines. Ability to flow both legs without backout of other leg – i.e do the pressures match and is there sufficient ullage.
  - Inherent risk to the host pipeline if operation does not go as planned.
  - Compatibility of unprocessed fluid to unprocessed fluid.
  - Metering difficulties.
Barriers

• **Mechanical Tee**
  - Private ownership of assets where main risk is production loss, hot tapping increases risk to host pipeline.
  - Industry resistance to use of elastomer seals for permanent North Sea applications in the past. As system relies on bolt preload and has non-metallic seals it is often perceived as an inferior product. This is despite a significant track record of use in the Gulf of Mexico.

• **Subsea Grouted Tee**
  - No track record subsea, successful trial but not been used in field.
  - Further testing and qualification of grout mix required.
  - Installation can take longer than for mechanical tees due to grout curing period.
  - Temperature limitations on current grout range (-50 to 100deg C).
  - Single source availability.

• **Internal Welded Tee**
  - Code compliance of fillet weld around branch rather than full penetration weld a potential issue.
  - Single source availability.
Concluding Remarks

- Mechanical hot tap tees are a field proven technology for processed fluids which could be used as a solution for small pool tie backs.

- Both Mechanical and Grouted hot tap tees are likely to offer cost savings compared with welded hot tap tees by removing the need to perform hyperbaric welding.

- Mechanical tees are a more freely available solution when compared with grouted and remotely welded tees as the rights to those technologies are each held by single companies.

<table>
<thead>
<tr>
<th></th>
<th>Welded</th>
<th>Mechanical</th>
<th>Grouted</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pros</strong></td>
<td>Significant subsea track record in North Sea.</td>
<td>Track record subsea in the Gulf of Mexico.</td>
<td>Eliminates need for hyperbaric welding. More tolerant of pipeline geometry. Offers metallurgical independence between main pipeline and connection.</td>
</tr>
<tr>
<td></td>
<td>Least complex design.</td>
<td>Eliminates need for hyperbaric welding.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reliable and proven pressure containment seal method.</td>
<td>Quicker, cheaper installation.</td>
<td></td>
</tr>
<tr>
<td><strong>Cons</strong></td>
<td>Complex installation with welding habitat required.</td>
<td>Industry resistance to use of elastomer seals.</td>
<td>No track record subsea. Further testing and qualification required. Longer installation than mechanical Single source availability.</td>
</tr>
</tbody>
</table>

www.nsri.co.uk
Recommendation for Further Work

• Review mapping of small pool locations and surrounding infrastructure. Identify how many pools could utilise hot taps as a potential solution to tie into existing network. This would determine the potential demand and therefore whether it is worth investigating further. Initially looking at proximity to architecture it may be necessary to look at cluster specific applications to determine potential for multiple installations in one offshore trip.

• Identify order of magnitude installed costs for each of the different hot tap types based on a common set of inputs. This would give a better idea of the likely cost of each type to see if mechanical or grouted tees are likely to have truly significant cost benefits.

• Facilitation may be required to promote cooperation between operators to use hot taps as a solution.

• Get operators engaged with suppliers of hot tap tees to promote the technologies and alleviate any concerns they may have.

• Investigate if there are any known failures of mechanical hot tap systems elsewhere in the world e.g. Gulf of Mexico.
Acknowledgements

- Keith Evans – Clear Well Subsea
- Dan Vu – Namco Solutions
- Brian Todd – Oceaneering
- Eric Kiltie – Universal Pegasus International
Appendix

- Hyperlinks
    - https://www.youtube.com/watch?v=eA-xzPB9Dug
  - http://www.furmanite.co.uk/products/hot-tapping/
Appendix

- Papers
  - IOPF2011-6002
  - SPE 124676
  - Remotely Controlled Hyperbaric Welding of Subsea Pipelines

- Presentations
  - Clear Well Subsea – Subsea Hot Taps an Enabling Technology
  - Clear Well Subsea – Hot Tapping – A Small Field Enabling Technology
  - Statoil – Remote Hot Tap on Asgard
  - Subsea 7 – Hot Tapping Technology Subsea Grouted Tee

- Meetings
  - Keith Evans – Clear Well Subsea
  - Dan Vu – Namco Solutions
  - Brian Todd - Oceaneering
NSRI- the focal point for Subsea Research and Development activity in the UK

Thanks to our sponsors:

BP
Shell
Total
Subsea 7
Subsea UK
Scottish Enterprise
Wood Group Kenny

www.nsri.co.uk