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Design Solutions for High Temperature Heated Pipelines

Ilan Karupiah– Wood Subsea & Export Systems

Available Heating Technologies

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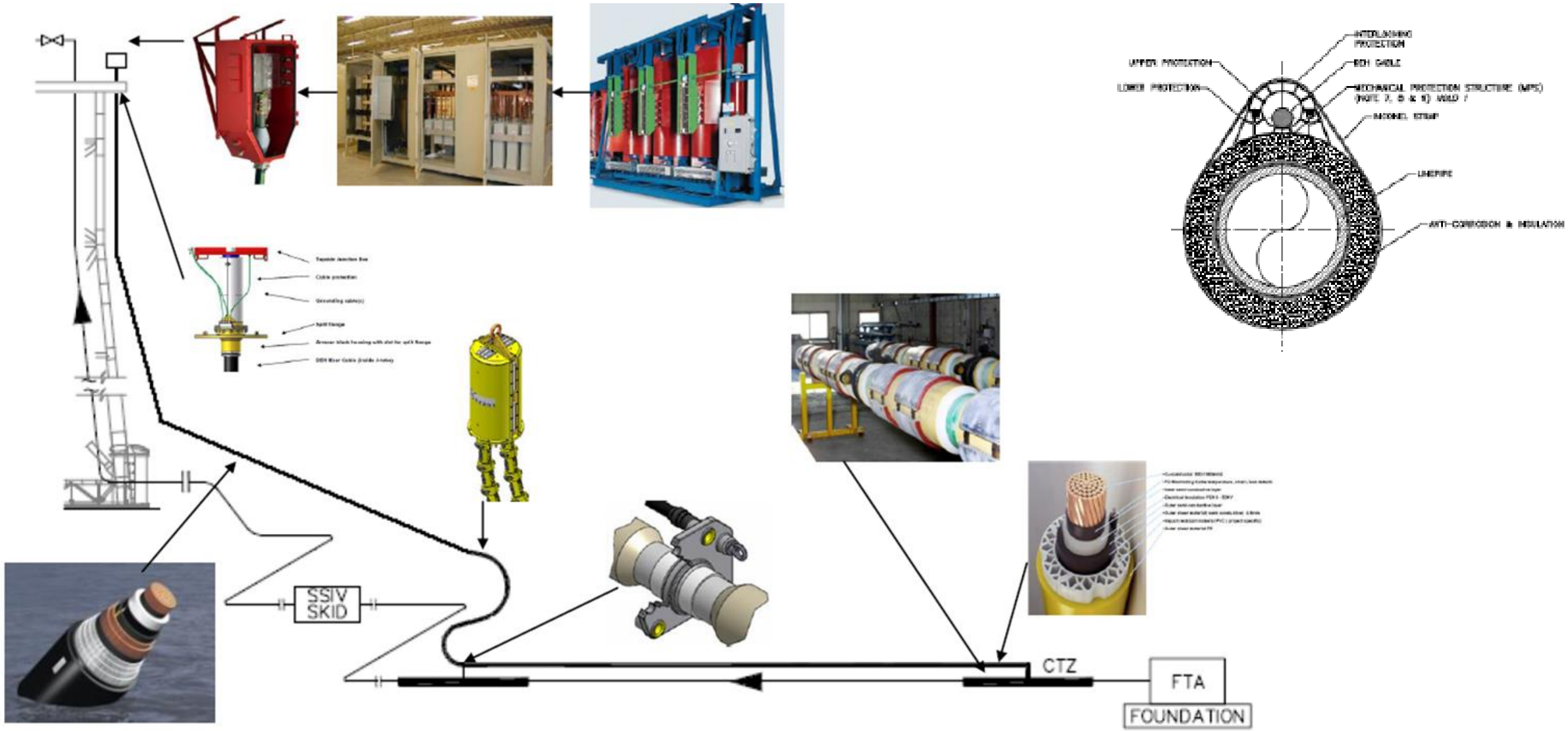
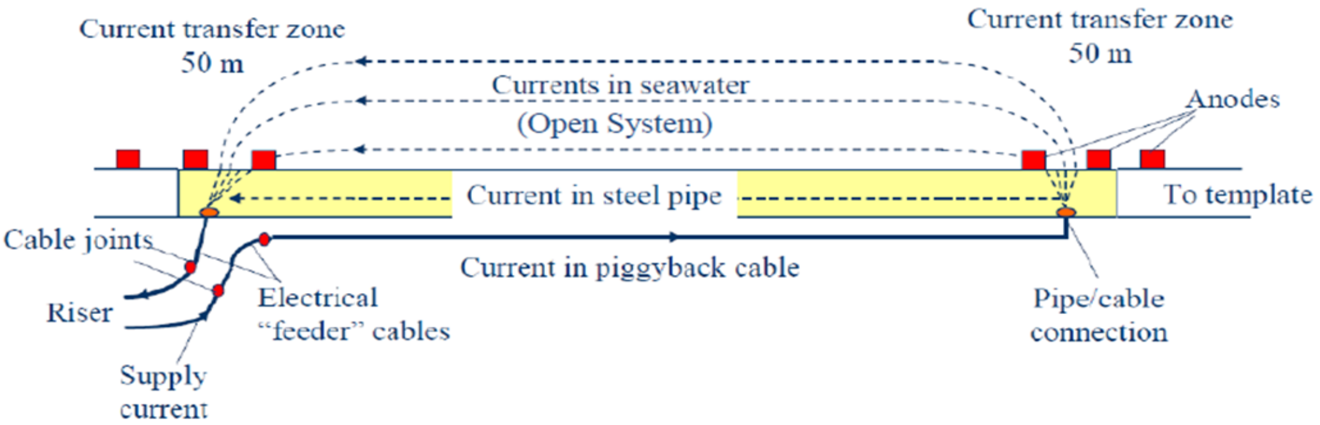
Direct Electrical Heating (DEH) system



DEH Wet Insulated Pipe - Working Principles

- Principle: Joule heating generated by AC current in the flowline
- Current supplied to far end, with zero voltage difference
- Piggyback cable separation from flowline is key parameter to system efficiency
- System is grounded to surrounding seawater, hence no potential difference. Large banks of anodes installed at either end to ensure good current transfer to seawater.
- Low efficiency : Heating efficiency of 50-70 % and Electrical efficiency 30-60%.



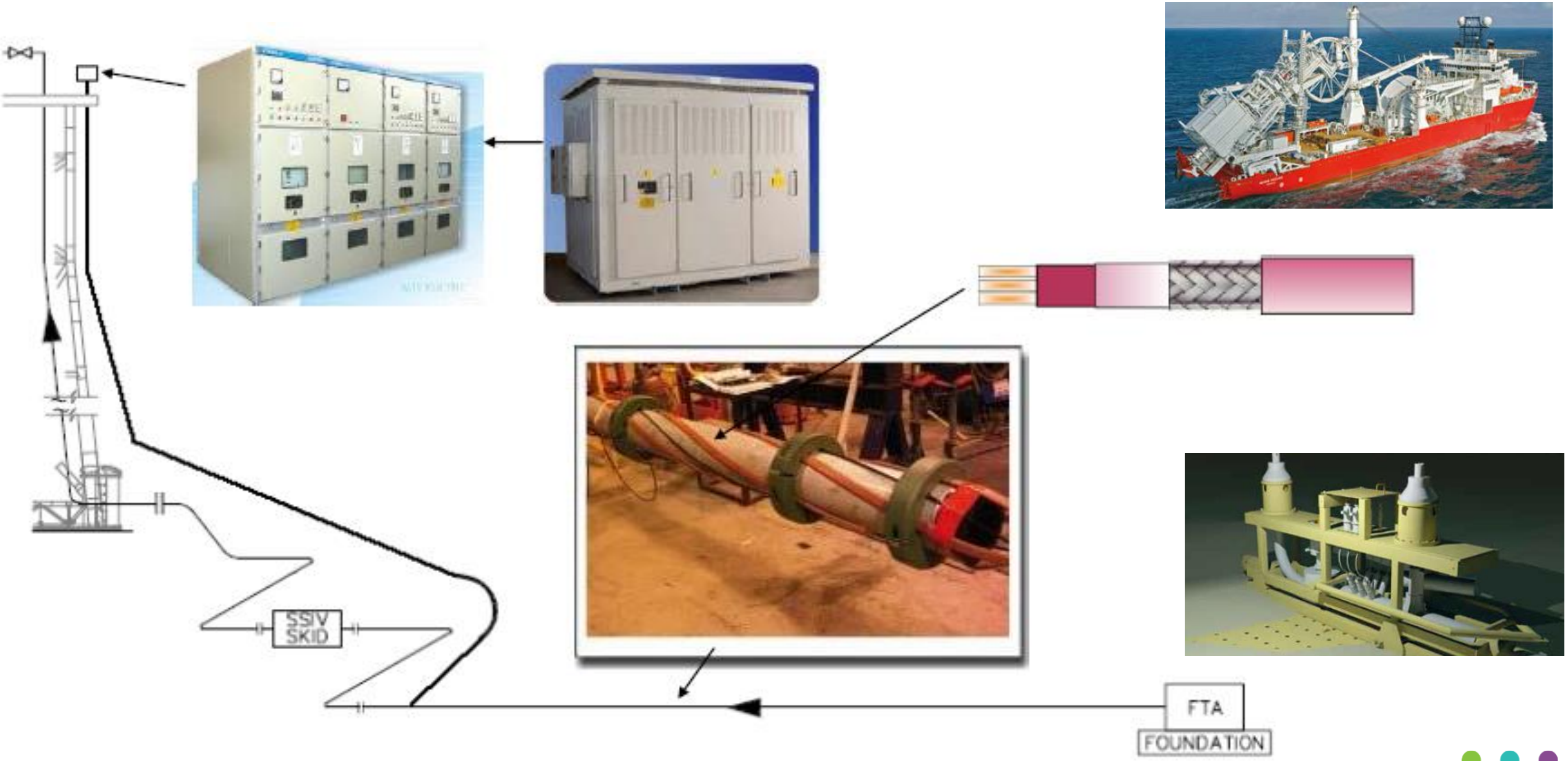
DEH System Limitations

- Low thermal performance due to wet insulation.
- Length limit by qualified cable electrical insulation – 50km.
- Cable are currently qualified for use in up to 1500m water depth, however alternative designs with high strength conductor strands have been developed, but are not full qualified.
- No possibility for redundancy.
- Available power requirement is a key factor for adding DEH pipeline to brownfield applications.
- Should be used in conjunction with a high integrity coating system, where parent and field joint sections fuse.
- Cable life limitation.

DEH System Main Risks

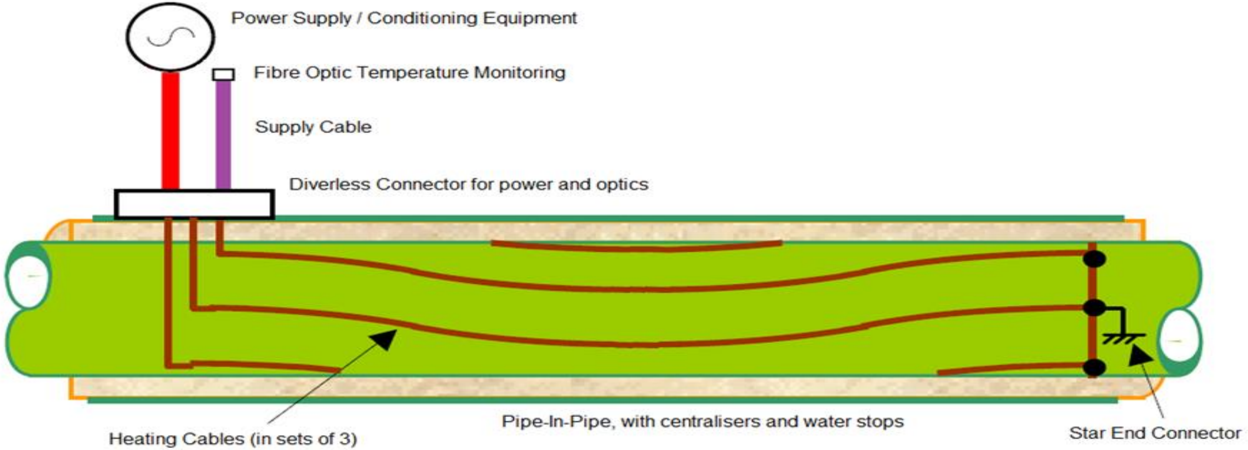
- AC corrosion can cause depletion of anodes and external corrosion of the pipeline (or existing neighbourhood structures) leading to Pipeline integrity risk.
- Wet insulation system & field joint integrity.
- The significant electromagnetic field which is developed during DEH system operation, introduces risks to divers and/or ROVs nearby. Exclusion zone should therefore be put in place around operational system.
- No redundancy in the system exists but system is reparable - a number of systems have been successfully repaired in situ e.g. BP Skarv.
- Damage to electrical cable during installation.

Electrical Traced Heating (ETH PiP) System



ETH PiP - Working Principles

- Principle: Joule heating generated by AC current in heat tracing cables wrapped around the inner pipe.
- Pipe-in-Pipe system, with highly efficient annulus insulation.
- Subsea system electrical efficiency: 90 to 95%.
- High redundancy: up to 300%.
- Even heating: homogenous longitudinal and circumferential heating of fluid.
- System length limited to 50km with single power supply at one end of pipeline.



ETH PiP System Limitations

- Length limited by qualified heating cable electrical insulation – currently 50km – with midline power connections a flowline heated length could be increased as per requirements.
- Mainly ETH PiP concept based on reeling and continuous PiP annulus. J-lay and S-lay options has successfully done, however this introduces a significant number of cable splices.
- Max 12in ID (of inner pipe) and 18in OD (of outer pipe) - limited by Reel-lay installation method.
- Water depth limited by vessel capability for laying of a PiP system. However the system has been installed at WD up to 1400m.
- Tracing cables or splices cannot be repaired once installed subsea. Components are protected w/in carrier & High level of redundancy.

ETH PiP System Main Risks

- System is not repairable once deployed without flowline retrieval as the cables are within the PiP annulus.
- A breach of the carrier pipe could lead to the entire annulus being flooded. This would render the entire system redundant unless the longitudinal water spread was mitigated.

Installation Issues

DEH Fabrication Methodology

- No specific fabrication required for S-lay / reel-lay installation
- For J-lay installation a fabrication yard for preparation of double or quad joints is required.
- For Reel-lay installation a spool base is needed for fabrication of single pipe stalks.
- Fabrication of Current Transfer Zone anode and termination plate joints required for all installation options.

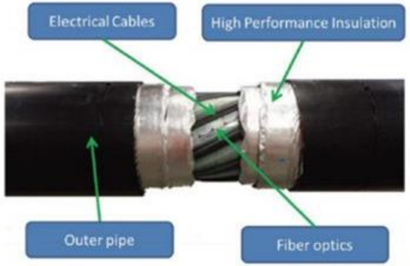


DEH Installation Methodology

- Has track record of both S-lay and Reel-lay installation.
- Installation standardly split into 2 scope – pipelay and tie-in scope.
- Pipelay scope – cable strapped in piggyback to flowline during normal pipelay operations. Cable connections to a flowline made at near and far end- with installation vessel potentially stationary for up to 48 hours for near end connections. Far end connection duration is circa 18 hours.
- Tie-in scope – riser cable installation, feeder cable repositioning and dry splicing installation of the subsea junction box between these 2 cables.

ETH PiP Fabrication Methodology

- For ETH methodology based on reeling it requires a spool base for PiP stalk fabrication which is not the case for J-lay method.
- In addition to PiP assembly, a cable winding machine is required to install continuous section of heating cables around the inner pipe.
- Pipe stalks would be manufactured in length of 500 – 1000m.
- Stalks will be joined during reeling to the vessel, with all electrical and fibre splices completed as part of this stalk tie-in scope.
- After each splice, the heating and fibre optic cables would be tested for continuity.



ETH PiP Installation Methodology

- Installed as a standard PiP system.
- Heating system splices performed at tie-in locations (between pipe stalks or inline structures)
- Riser power cable/umbilical installed as standard flexible product
- ROV tie-in of electrical and optical flying leads.

Operational Issues

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DEH System Operability

- System set-up with typically 2 heating mode – reheat and keep warm. Can also be used continuous to maintain or boost arrival temperature.
- Limited ability to tailor heat input to system, fixed by transformer tapping points.
- No direct method of reading achieved temperature during system operation. Temperature change can be drawn from system pressure change.
- Cables have 90°C temperature limit, and therefore control system may require alarm or interlocks to protect cable integrity.

DEH IMR / Reliability

- Regular inspection of CTZ anode to ensure exposure. Also recommended to inspect cable connections to flowline as part of normal IMR scope.
- No specific maintenance requirements
- System cable be repaired in-situ without flowline recovery.
- No DEH has failed during service, however there have been a number of failures during commissioning

ETH PiP System Operability

- Topside system can be configured for manual, semi-automated or fully automated with control system to response to pipe temperature data.
- Real time temperature measurement along the whole pipeline length can be provided to the operator.
- Heat applied to pipe can be adjusted depending upon the real time temperature data.

ETH PiP IMR / Reliability

- No inspection of the heating cables, annulus insulation is required or possible.
- System is not repairable, but spare heating cable can be used if primary set of the cables fail – 200% to 300% redundancy.
- System requires no particular maintenance.
- Regular inspection of flying leads and wet-mate connectors is recommended, as per standard IMR scope.

Conclusion

Conclusions

- A wide range of subsea pipeline heating systems are available
- The level of qualification varies by system and contractor
- Advanced engineering and testing are playing a major role in delivering reliable heating systems
- The risk profile of each system varies
- Perform plenty of system and component testing
- Seek independent advise and technical assurance

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