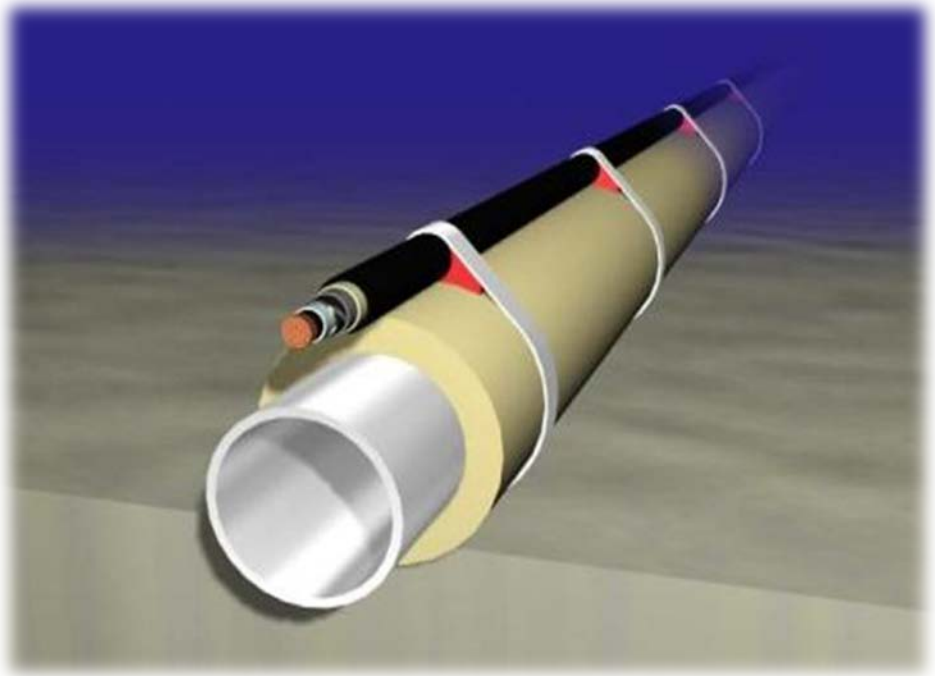
DEH development for deep water projects



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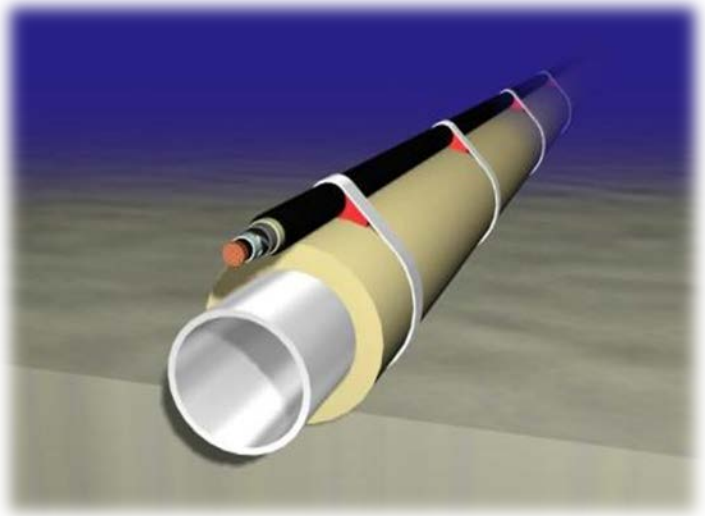
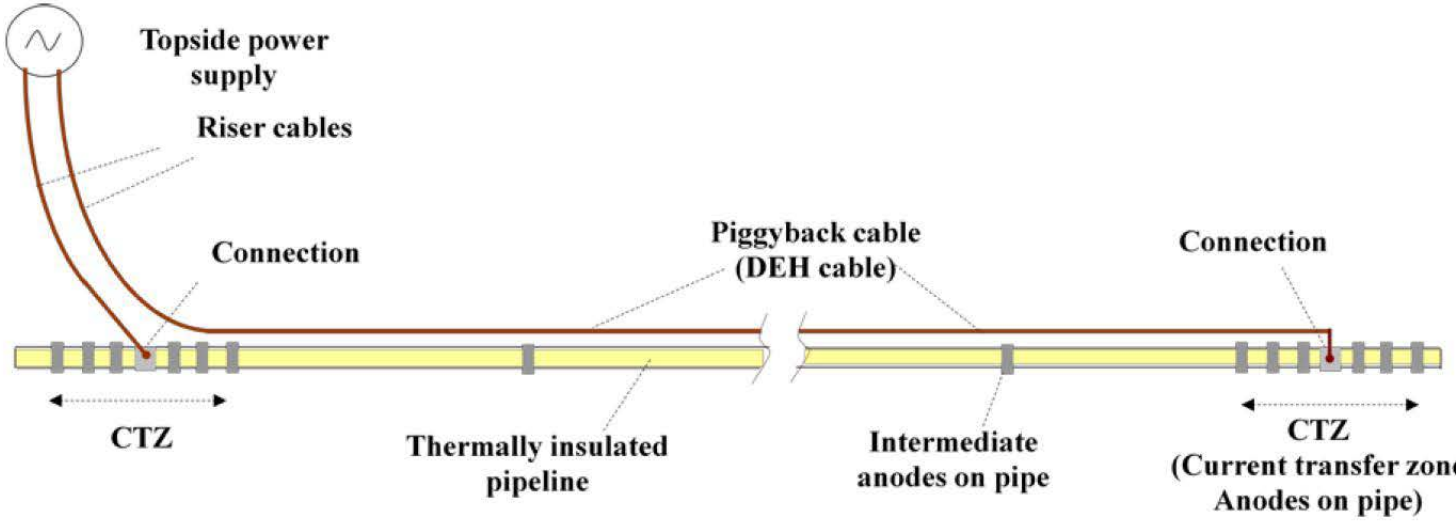
OUTLINE

1. What is Direct Electrical Heating (DEH)?
2. History of DEH.
3. DEH for deep water application.
4. Active Heating - Technology comparison.
5. Summary.

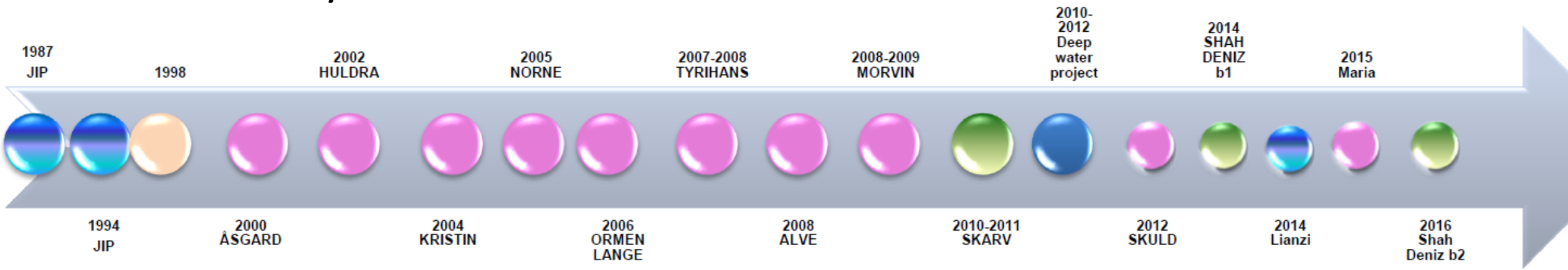
1. What is DEH?

- DEH is flow assurance by actively controlling the temperature on the pipe.
- Utilizes conventional wet insulation.
  - Efficiency of DEH pending on U-value.
- Intermediate use, heat-up or continuous use of Nexans DEH.
  - Based on aging tests carried out.





2. History of DEH



- Nexans has delivered complete DEH system for 30 flowlines.
- Pipe length: Installed from ~ 3 km up to 43 km.
- Flowline dimensions: 8 – 18 inch (30 inch for retrofit).
- U-value: 1.9 - 8 W/m^2K.
- Steel material: Cr13%, Carbon, Carbon w/ clad.
- Installed DEH up to 1070 meter water depth (at far end).

2. History of DEH

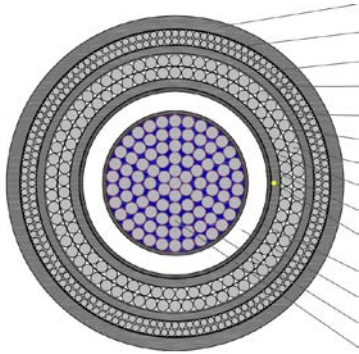
- Lianzi: Worlds deepest - installed up to 1050m water depth
  - Installed 2015 and in operation since November 2015.
  - 43 km.
- Maria DEH Riser project
  - Installation 2016.
- Shah Deniz DEH project
  - Worlds largest and most complex DEH system.
  - Installation commences May 2016.
  - 120 km of flowlines to be heated.
  - 530 m water depth at far end.

3. DEH for deep water application

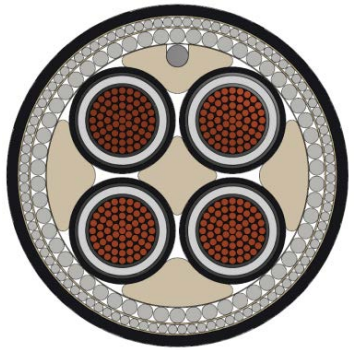
- Today DEH technology is targeting 3000 m water depth (WD).
- Dynamic Riser Cable for high loads (tension) qualified for 3000 m WD.
- Piggyback Cable
- HV cable wet mate connector/splice development.
- “Pipelay is not limiting DEH” and “DEH is not limiting pipelay” for deep water application.

3. DEH for deep water applications - Dynamic Riser Cable

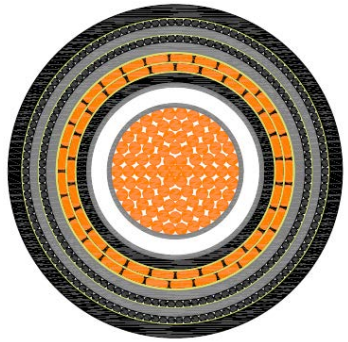
1. Deep water cable design with aluminium conductors.



2. Deep water cable design with copper conductors, steel armour and optimized lay angles.



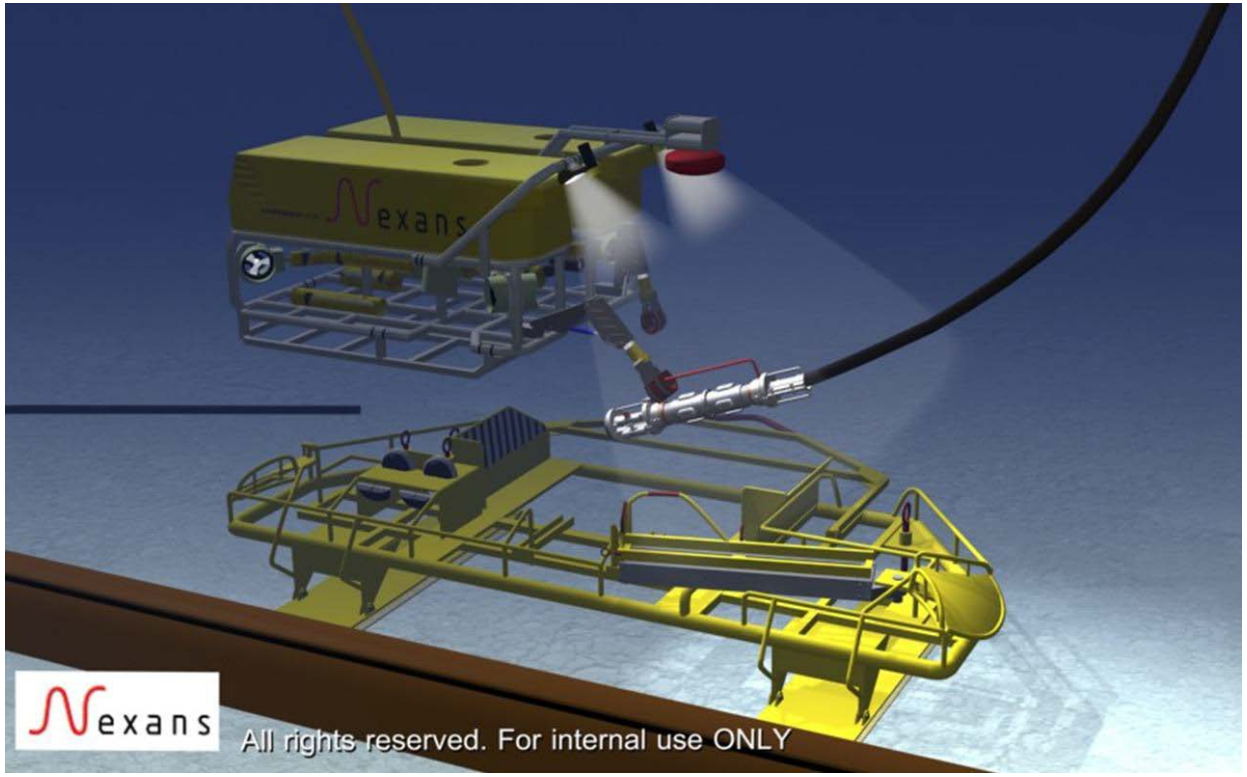
3. Deep water cable design with copper conductors and armour of carbon fibre rods.



3. DEH for deep water application - Piggyback Cable

- Qualification for 3000 m WD
  - Installation by weight taken by pipe, possibility for repair subsea.
  - Internal strength element in order to retrieve.
- Strength needed in event of repair on vessel
  - No damage to XLPE insulated cable in service from Nexans due to insulation system since 1993 (new production tower and test regieme).
- Aging of insulation system
  - XLPE insulation of wet design subjected to high pressure, temperature, environment of ageing.

3. DEH for deep water application - HV wet mate connector/splice



- Nexans R&D.
- Wet joint for subsea repair in deep waters.
- Rated for 52kV, 1670A .
- Ongoing qualification following the SEPS standard for 3000m WD – to be completed 2017.
- Joint may also be used to simplify jointing during installation of a DEHS.

3. DEH for deep water application - Pipelay

- All installation methods feasible: Reel-lay, S-lay or J-lay.
- No limit in flowline length or DEH due to installation constrains.
- Based on installation vessels available top-tension capacity up to 2000 mT:
  - 30” OD flowline up to 2000m WD
  - 24” OD flowline up to 3000m WD
- Increased installation loads in Piggyback Cable may be taken by the piggyback system i.e. pipeline.
- No particular logistic constrains:
  - Cables could be delivered directly to an installation site on reels – including delivery to limited access areas like Caspian Sea; i.e. outside critical path for vessel.
  - No need for special fabrication sites or spool base.

4. Active Heating – Technology comparison

Direct Electrical Heating (DEH)

+ Wet insulation = reduction in CAPEX.
+ Field proven application in 30 projects.
+ DEH could be repair or retrofitted.
+ No limit in pipe OD by the installation methodology: S-lay, reel-lay or J-lay.
+ Today for 22” pipe no limit up to 3000m WD due to installation requirements (top tension).

- Lower heating efficiency = min U-value typically up to 2 W/m2*K.
- Lower electrical efficiency 60% = higher power requirements.

Electrical Trace Heating (ETH)

+ Low U-value (1 W/m^2*K) = high thermal performance = high heating efficiency.
+ System high electrical efficiency 90% = lower power requirements for operation (including continuous use) = reduction in OPEX .
+ Direct flowline temperature measurement with integrated FO.
+ Redundancy in the system up to 300%.

- Not fully qualified, nor field proven in service.
- Non repairable.
- Limited length (voltage rating on cables)
- Due to reel-lay method: limited to 12” OD flowline (reel limitations) and to 2000 m WD (top tension limitation of 800 mT).

4. Active Heating – Technology comparison

- Example on power rating

Flowline	**DEH**		**ETH**
Typical U-value	3 W/m^{2}K	2 W/m^{2}K	1 W/m^{2}K
Flowline OD	323 mm, (ID 280mm)		
Hydrate temp	25°C		
Min Sea temp	3°C		
Flowline length [km]	19.5 km		

Preservation at 25°C			
Current [A]	1030	845	63
Voltage U_0 [kV]	6.7	5.5	2.22
Topside Power [MW]	1.83	1.23	0.5
Power Requirement in pipe	57.1 W/m	38.9 W/m	21.5 W/m

5. Summary

- DEH is gaining popularity with operators
  - Potential large reduction in CAPEX.
  - Very good operational feedback from users.
- Technology qualification pushed by Nexans
  - Deepest water.
  - Longest lengths.
  - Continuous use.
  - The most challenging projects (numerous lines).
  - In-house design and manufacturing of DEH systems.
- Both DEH and EHT PIP have individual benefits and can co-exist in marked.

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total DEH knowledge, engineering, production and testing inhouse.

Thank you for your attention!

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