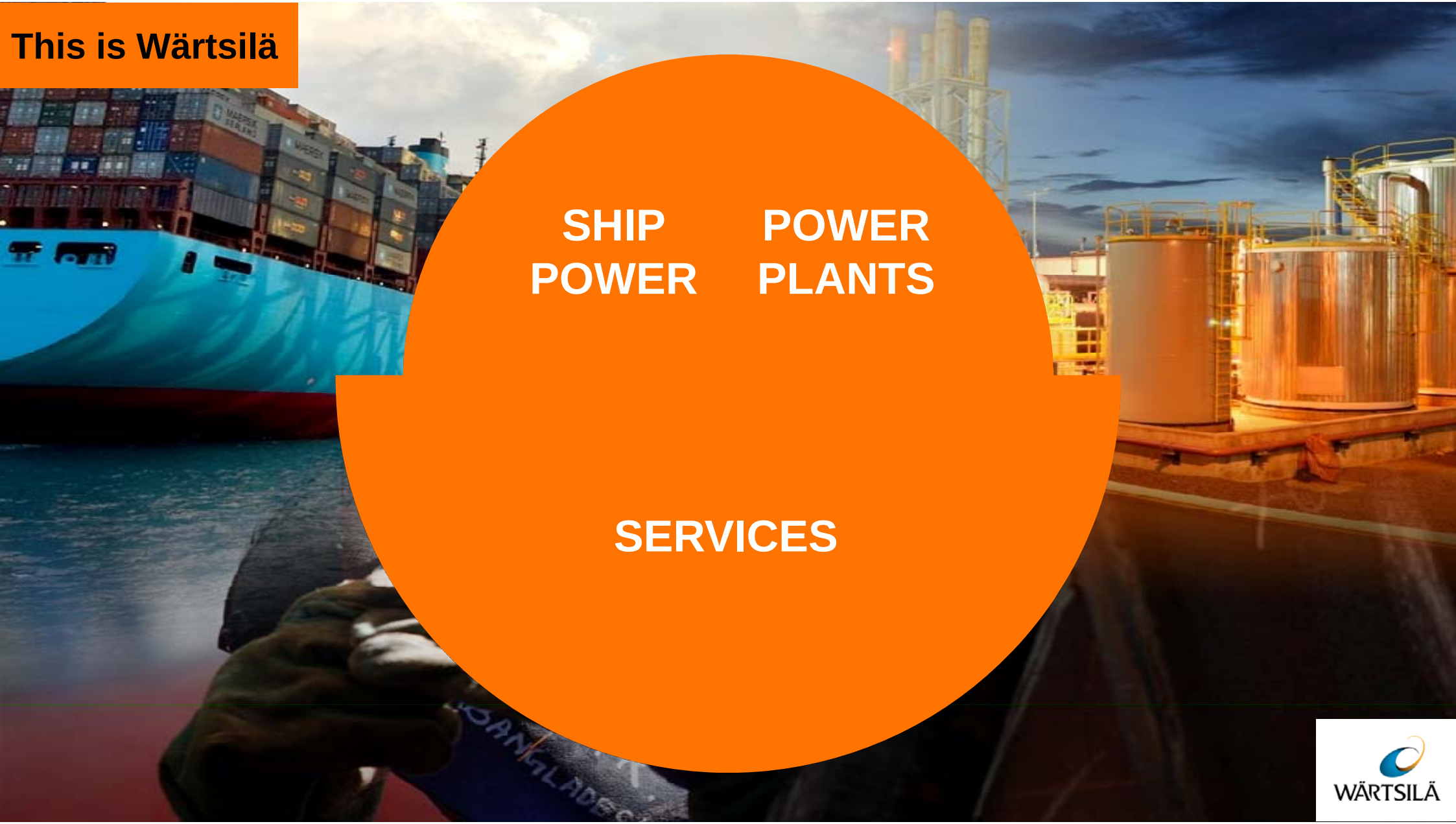
WÄRTSILÄ Electrical & Automation Services

DEH Topsides

S.U.T. August 17th 2011

- Wärtsilä
- Topside Basics
- DEH Usage
- Impedance Protection
- Line Break Detection
- Thermal Monitoring
- High Frequency AC
- FPSO Turrets

This is Wärtsilä



R&D in Stord, Norway

- Grunnavågen Product and Delivery Centres
  - Engineering Design, Manufacturing and Delivery of electrical and automation products and solutions for marine vessels, offshore FPSOs and drilling units.
  - Specialise in Medium and High Voltage Electrical and Automation Products
- Former *Aker Kvaerner Power And Automation Systems*
  - Acquired by Wartsila in 2006
- In late 1990's, partnered with Statoil and SINTEF on flow assurance
  - Statoil had problems with hydrate formation in subsea flow lines
    - Leading to reduced production volumes and pipe blockages
  - Their existing solution was "Anti Freeze"
    - Considered costly and environmentally poor practice
  - R&D teams came up with the Direct Electric Heating solution

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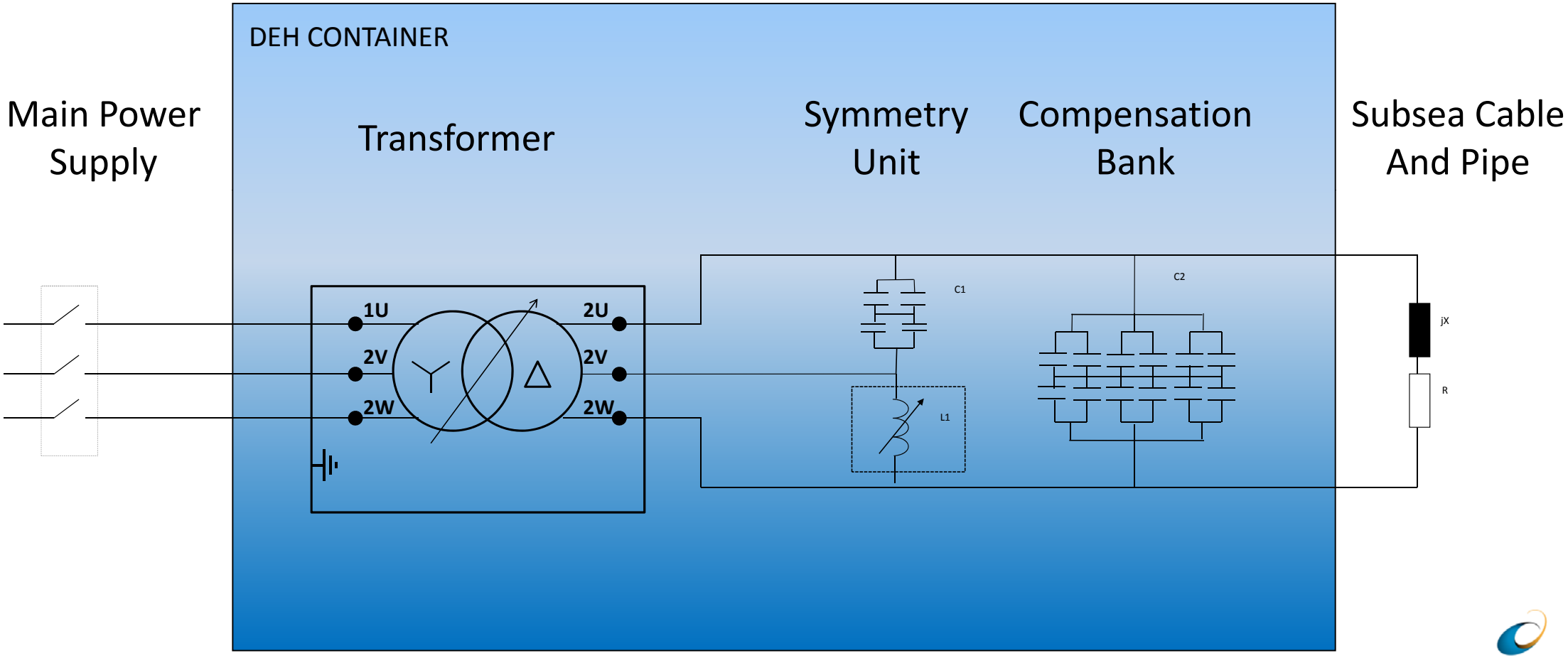
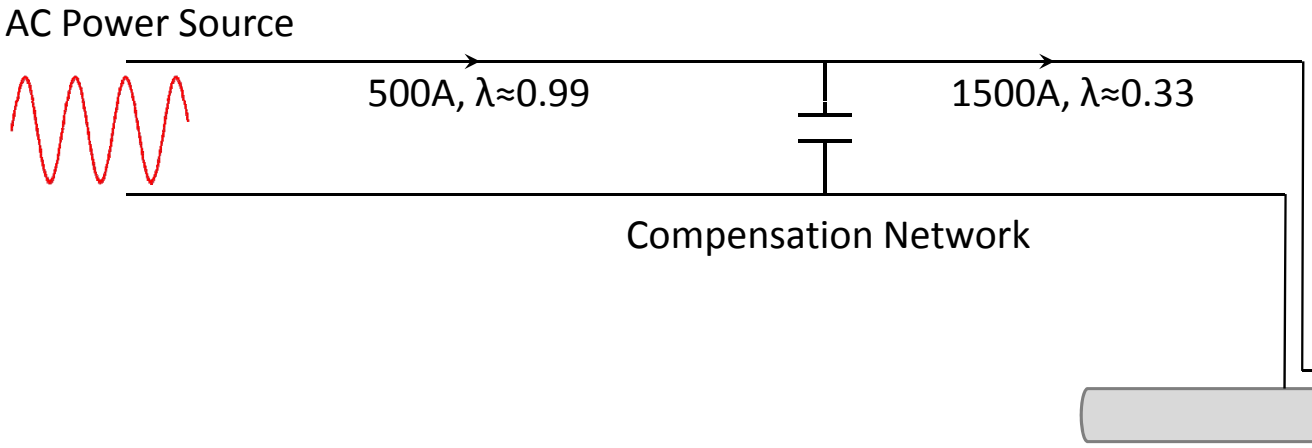
Standard Topside Components



Power Factor Compensation

- The Steel pipeline has a very low power factor
  - Very high current required to deliver actual power
  - Limits the power that can easily be delivered from the generator to the pipeline
- A capacitor bank in the system compensates for the low power factor
- The reduced Amps required simplifies the power generation & distribution system



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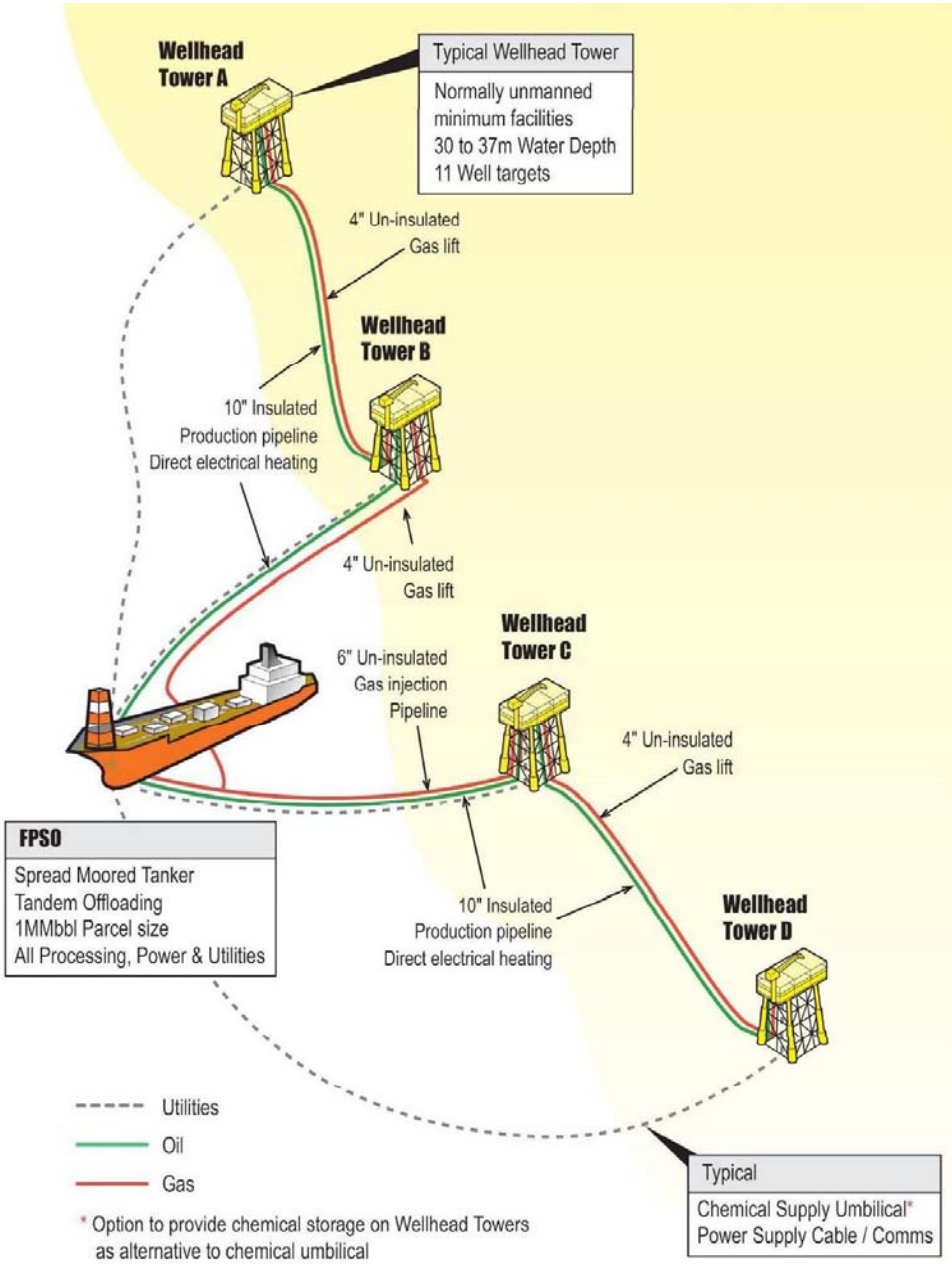
Typical Direct Electric Heating Operation

- DEH systems are used to restart cold fields
  - Pipelines have cooled to ambient temperatures
  - Hydrates form under pressure
  - DEH is only needed for a short period
  - Well temperatures then prevent Hydrates
- Statoil alone reports over 200 restarts
- DEH systems are usually kept offline
  - Power is only needed during system restart
  - DEH systems typically have little impact on vessel power requirements



Continuous Operation of DEH

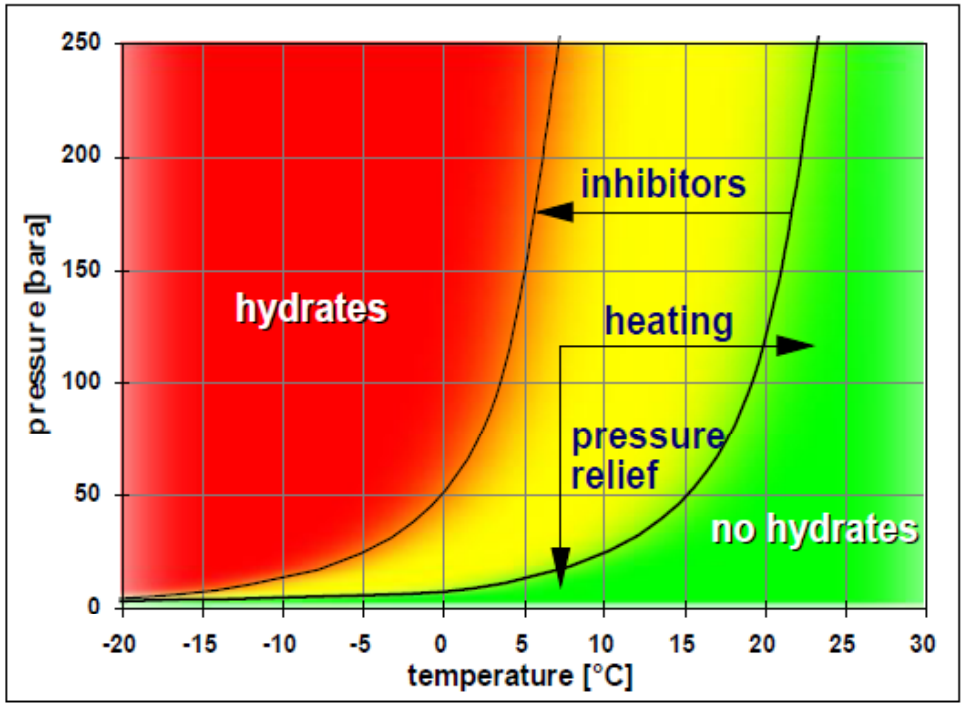


Image supplied by Statoil

- DEH systems can operate at all times
  - High water content in gas flow lines
  - Waxy components in oil flow lines
- Example : Olowi Field off Gabon
  - Continuous heating to 43°C
- DEH Topsides remain the same
- Easier for monitoring equipment
- Power requirements must be considered

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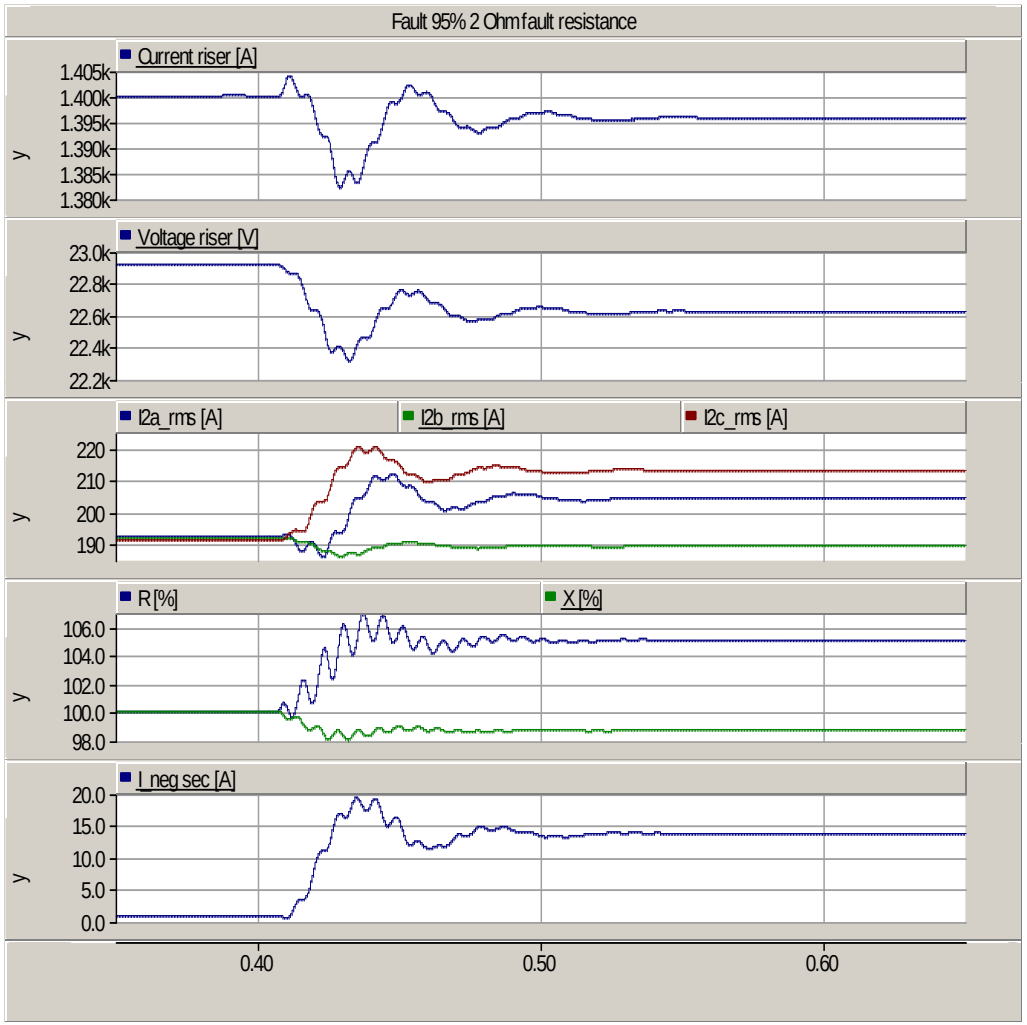
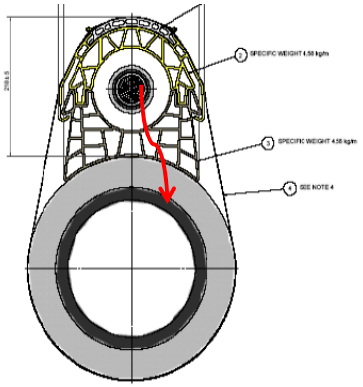
Impedance Measurement



- Continuously calculated from
  - Pipeline Volts
  - Pipeline Amps
  - Reactance
- Impedance changes can be due to changes in pipeline temperature or indicative of faults in the system



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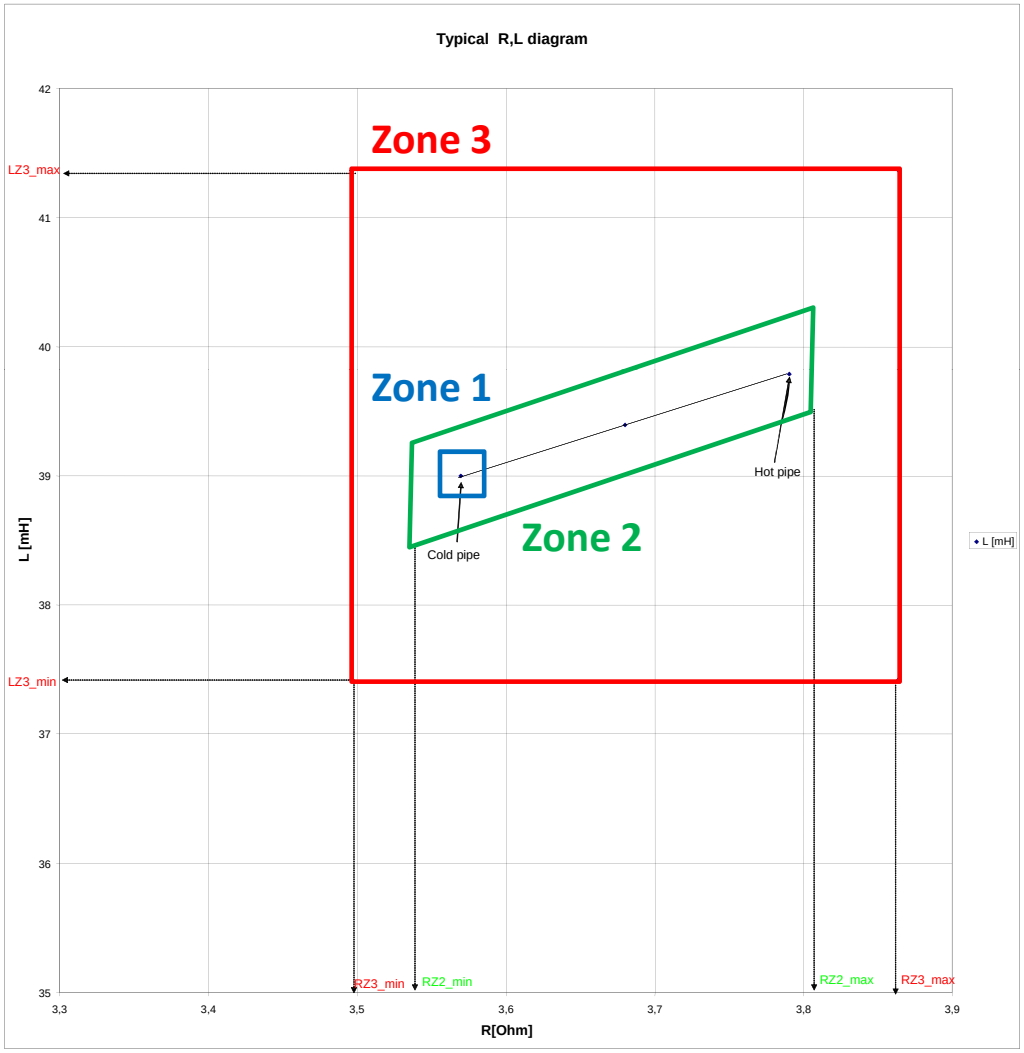
Active Impedance Protection



Pipeline impedance is not fixed but will have natural variation in the area between the values given for “cold pipe” and “hot pipe. A PLC calculates the live resistance and inductance and where necessary, generates alarms and trips protection relays.

Zone 1

This zone is a dynamic zone that follows the pipeline impedance from cold pipeline to hot pipeline. The region is constantly updated based on recent, historical data. The objective of this zone is to have a sensitive zone that detects small variations in the impedance within the normal operation area. Excursions for several seconds outside Zone 1 will cause a system trip.

Zone 2

This zone is an optional, fixed zone, covering the range of normal operation resistance and inductance from cold to hot pipeline and is calculated during commissioning. The protection relays trip if the measured R and L go outside the area defined as Zone 2 for a few seconds.

Zone 3

This zone is a fixed zone with a wide range of resistance and inductance, for fast tripping of faults within the feeder, current transformer or voltage transformer. Excursions outside Zone 3 are tripped in 200-300ms.

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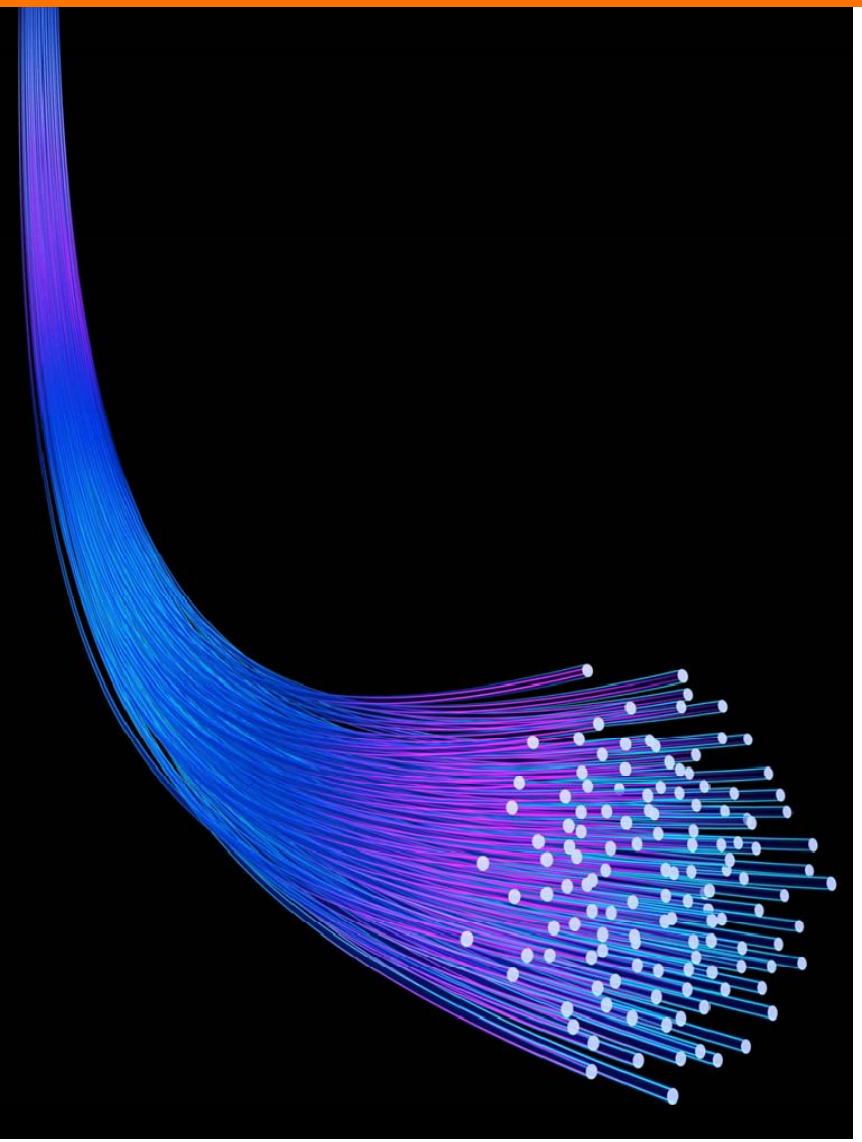
Fiber Optic Line Break Detection



- Impedance protection works for online systems
- DEH systems can lie unused for years
  - *How can you be sure its ready to use when you need it?*
- Fiber Optic cables can be used to detect damage
  - Test messages transmitted along the full cable length
  - Responses received and checked by PLC's
  - Any fault in the system can be alarmed immediately
- Used for Tyrihans and Skarv systems in 2009
  - Nexans cable with six fiber cores
  - Provides for three loops per cable and allows for voting
  - Minimizes the potential for false alarms

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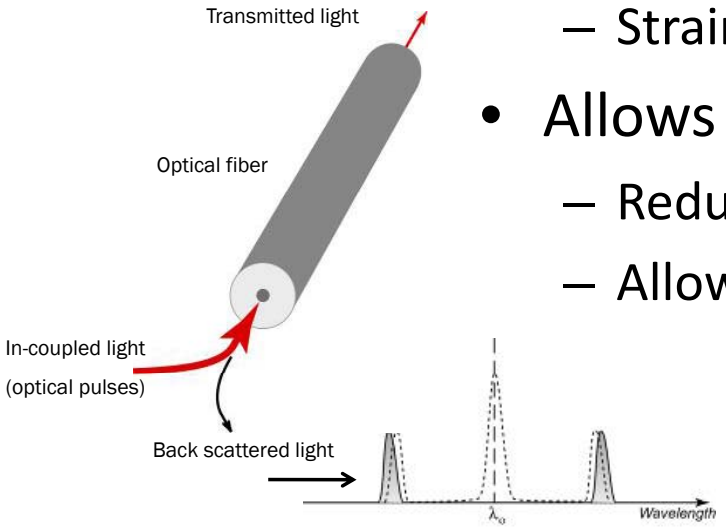
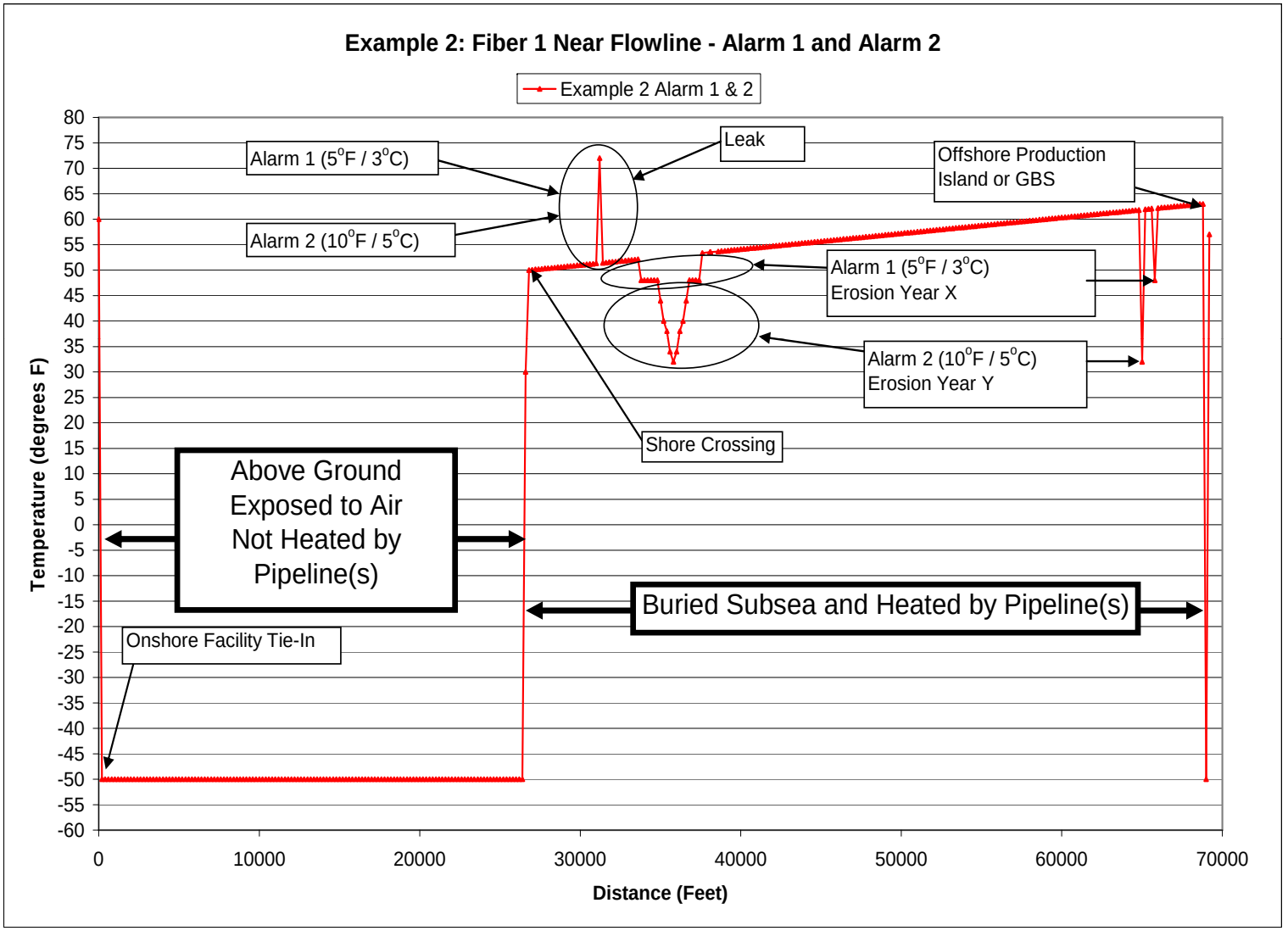
Thermal Monitoring



- Fiber optic cables can be used for thermal monitoring
- Pulses of light are sent down the fiber cable
- Spectral analysis performed on the back scatter
- Changes in the scatter are indicative of cable changes
  - Thermal
  - Strain
- Allows for continuous monitoring of cable conditions
  - Reduces risk of thermal damage to cables
  - Allows designers to push the limits of cables for larger projects

Example Temperature/Distance Plot



High Frequency AC

- Proposals exist to operate at up to 200Hz rather than 50Hz or 60Hz
- At higher Frequency, the pipeline impedance increases
- Power = $Amps^2$ x Resistance
  - Higher Impedance leads to greater heating at lower amperages
  - Lower amperages leads to thinner sub sea cables
  - Thinner cables leads to reduced costs
- Unfortunately, high frequency switching may effect the subsea cables
  - Risk implications as life expectancy of cables under high frequency is unknown
- At present, the perceived additional risk outweighs the benefits
- Wärtsilä believes that this will change at some point in the future
  - We have a solution prepared based on our own, in-house, hardware.

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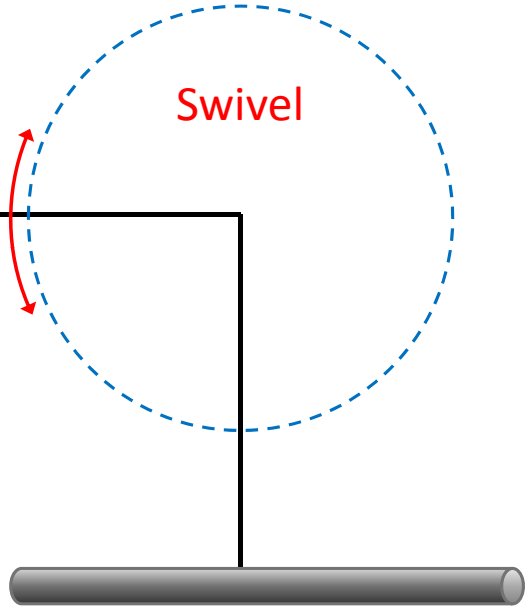
FPSO Turrets

Power Generation

11kV
255A

Direct Electric Heating Topsides

6.3kV
1350A



- FPSO Turrets provide an interesting challenge
  - How do you provide high voltage, high current connections across the swivel?

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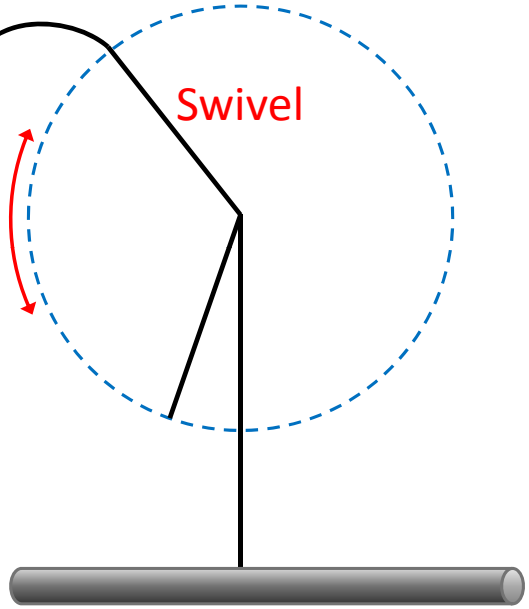
Simple Solution: Multiple Connections

Power Generation

11kV
255A

Direct Electric Heating Topsides

6.3kV
1350A



- Handle a wide range of rotation – up to 160° has been field proven
  - Allowance for 2 x 160° if a link can be opened, moved and closed
- Works well in principle, but difficult and dangerous in high seas
  - The process can take an hour to prepare and move the cable

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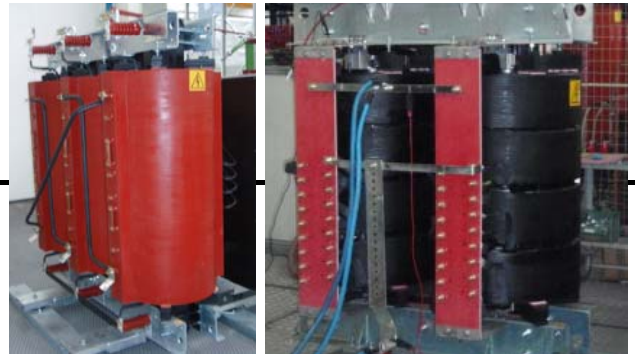
Smart Solution: Separated Compensation Unit

Compensation Unit

Power Generation

3Phase
11kV
255A

Transformer and Symmetry Units



Single Phase
6.3kV
450A
pf=0.99

Swivel

6.3kV
1350A
pf=0.33

- Power Factor Correction massively reduces the required current
  - Pipeline typically has a power factor of 0.25 to 0.33
  - The Compensation Units correct the power factor back to 0.99
- The Compensation Unit can be separated and placed onto the swivel
  - Requires only a low current connection between the deck and the swivel
- Based on the same concept, Subsea installation is also an option

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Complete System Design & Analysis

- DEH systems utilise existing technology
  - Based on standard transformers and capacitors
- Engineering involvement for system behaviour
  - Will the system effect other electronics?
  - What happens during a failure?
- Wärtsilä takes on the Full Design Responsibility
  - Verify interaction with other power systems
  - Harmonic calculations
  - Dynamic resonance calculations
  - Short circuit and fault simulation
  - Perform system tuning during commissioning
- Wärtsilä has a long track record of success

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The DEH Track Record is Wärtsilä's Track Record

Location	Flow Lines	Length	Power	Voltage	Water depth	Completed
Åsgard B	6 lines	7-9km	2.5 – 3.5 MW	2 – 4 kV	350m	2000
Huldra Veslefrikk	1 line	10 km	4 – 5 MW	8 – 9 kV	175m	1999
Kristin	6 lines	6-8 km	2 – 3.2 MW	2.4 – 5.6 kV	310-380m	2003
Norne Satellites (URD)	1 line	9 km	2.8 MW	3.8 – 6.3 kV	380m	2005
Norne Satellites (ALVE)	1 line	15.5 km	3.4 MW	2.6-8.9 kV	380m	2009
Tyrihans	1 line	42 km	> 10MW	10-26kV	300-400m	2009
Olowi	3 lines	4 – 5 km	1MW	1.6 – 3.4 kV	30-40m	2009
Skarv	1 line	13 km	(Supplied optical protection for existing DEH system)			
Goliat	2 lines					2011

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