Dynamic Inter Array Cables

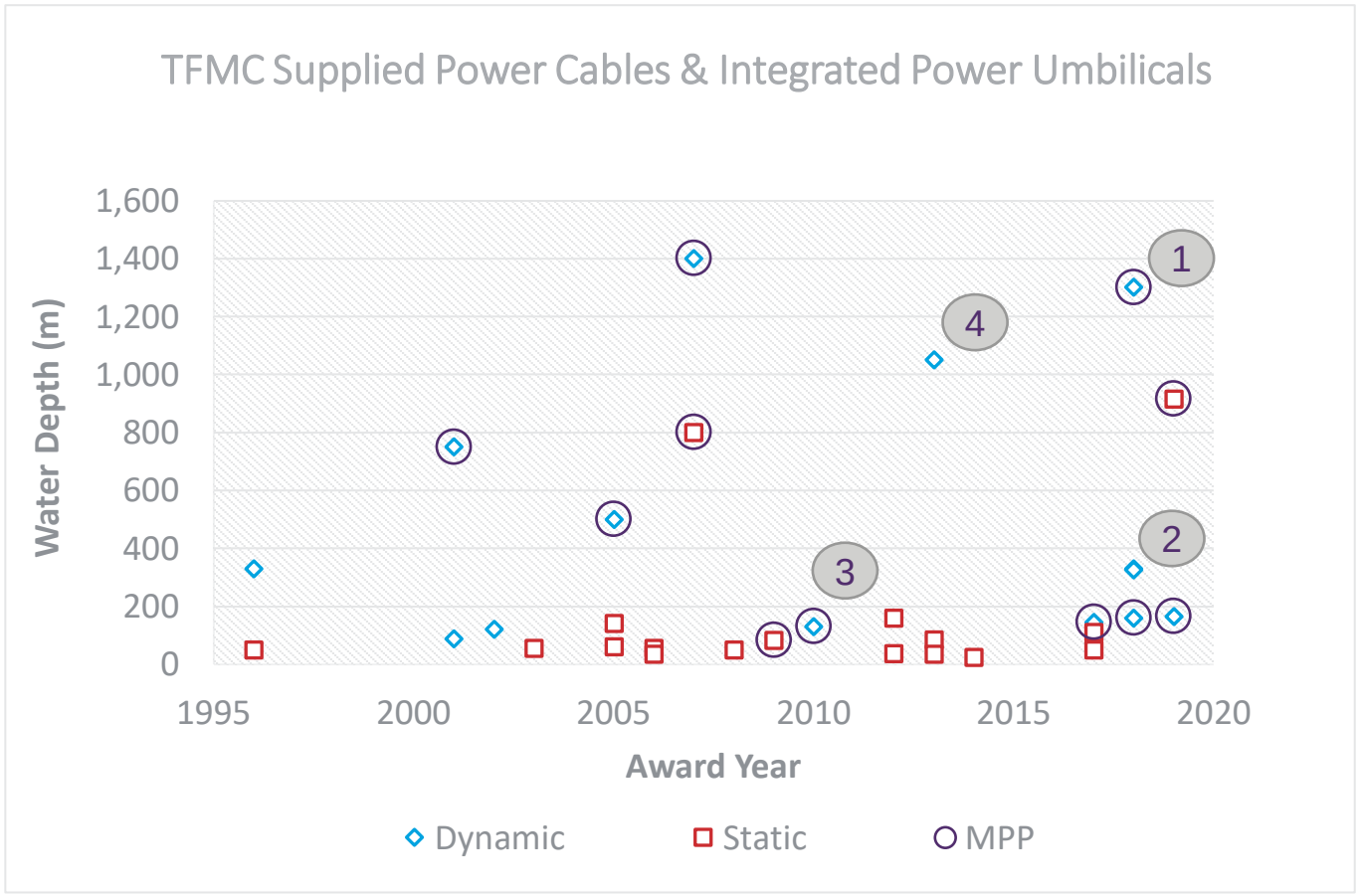
Risk & Risk Management

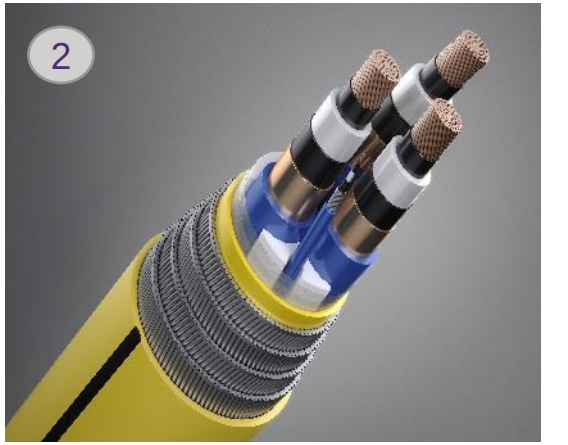
Dr Alan Dobson

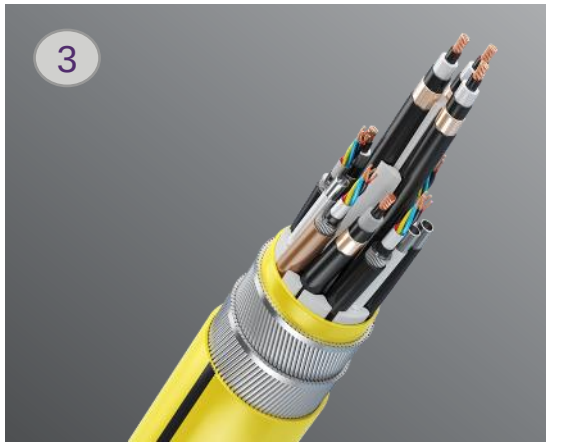
Umbilical Technology

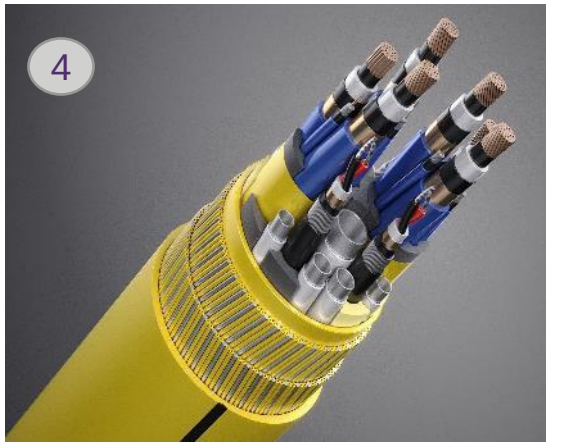
Medium Voltage Power Distribution Subsea

Typical Deep Water Multiphase Pumping Umbilical









Cable Technology
Dynamic Power Distribution Subsea: Umbilical Structure

Design Standards:

- ISO 13628-5
- API17E
- CIGRE TB623
- CIGRE TB722
- CIGRE TB862

#	Part	Function
1	Helical Bundle	Helically twisted bundle of components
2	Polymer Fillers	Improve handling and protect components
3	Tape	Improve handling during manufacture
4	Inner Polymer Sheath	Protect Components from armour loads
5	Armour Layers	Provide strength and ballast
6	Outer Polymer Sheath	Protect armour layers

Potential Failure Modes:

- Helical bundle over tension / bending
- Helical bundle wear
- Helical bundle torsional
- Helical bundle constriction
- Helical bundle compressive overload
- Inner / Outer sheath embrittlement
- Inner / Outer sheath hydrolysis
- Armour wire knuckles
- Armour wire bird-caging
- Armour wire tensile overload
- Armour Fatigue
- Armour wire corrosion
- Armour wire trellis wear
- Outer sheath tearing / piercing

Cable Technology
Dynamic Power Distribution Subsea: Power Core

#	Part	Function
1	Conductor	Power Transfer
2	Semi Conductor	Minimise electrical stress on insulation
3	Insulation	Insulate electrical conductor
4	Semi Conductor	Minimise electrical stress on screen
5	Conducting screen	Provides grounding for secondary currents
6	Outer Sheath	Protects screen

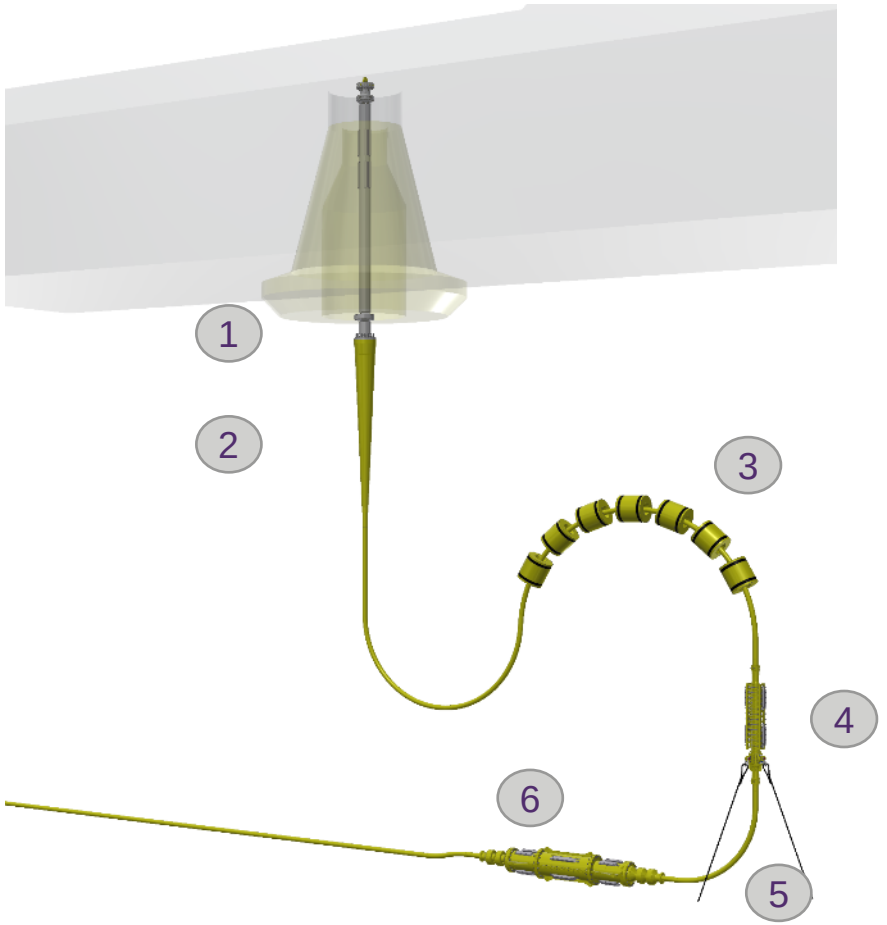
Design Standards:

- ISO 13628-5
- API 17E
- IEC 60502-2
- IEC 60840
- IEC 63026
- Cenelec HD605

Potential Failure Modes:

- Conductor mechanically over stressed
- Conductor strand trellis wear
- Insulation electrically overstressed
- Conductor Fatigue
- Insulation thinning
- Insulation ageing
- Insulation over heating
- Semi conductor delamination / thinning
- Conducting screen over stressed
- Outer sheath torn / pierced
- Corrosions of metallic layers
- Water penetration

Cable Technology
Dynamic Power Distribution Subsea: Configuration



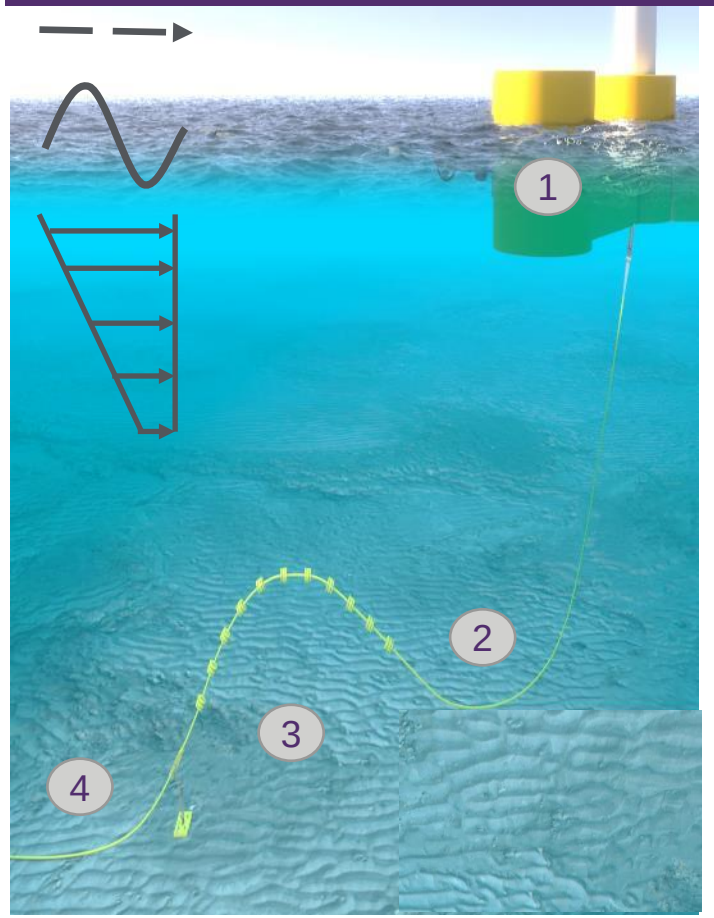
#	Part	Function
1	Latching Mechanism	Quick connection of cable to host
2	Bend Stiffener	Prevent overbending of cable
3	Buoyancy Modules	Support catenary overlength of cable
4	Tether Clamp	Connect cable to seabed
5	TDP Protection	Prevent wear to cable at seabed
6	Transition Joint	Connect cable to export or static cables

Potential Failure Modes:

- Fatigue of latching mechanism
- Wear of latching mechanism
- Bend stiffener cracking
- Marine growth fouling
- Buoyancy slipping
- Buoyancy flooding
- Clamp crushing cable
- Clamp slipping
- TDP protection wear
- Corrosion of metallic parts
- Embrittlement of metallic parts
- Cable splice electrical breakdown

Cable Technology
Dynamic Power Distribution Subsea: Dynamic Service Risks

Impact of Dynamic Environment

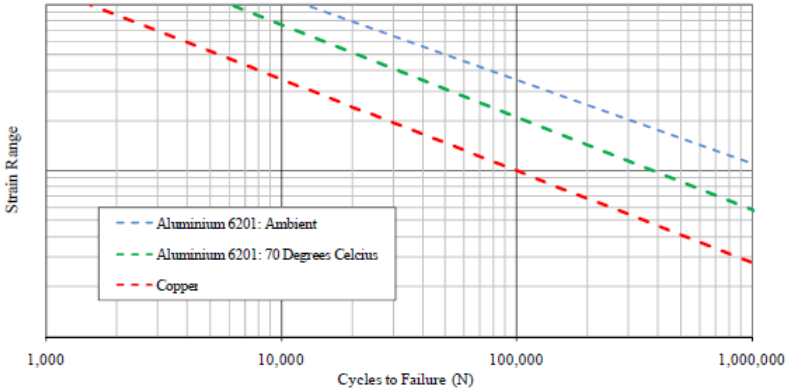


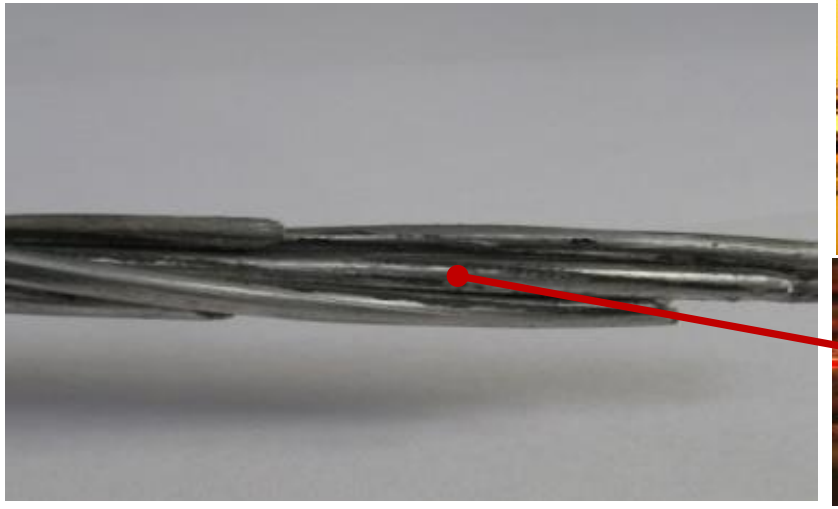
Hang-Off
Impact
VIV Fatigue
Environmental Fatigue

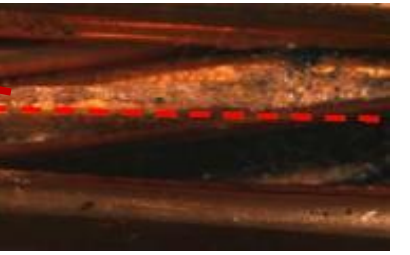
Sag & Hog
Fatigue

Touch Down Point
Fatigue
Abrasion

Cable Fatigue Damage

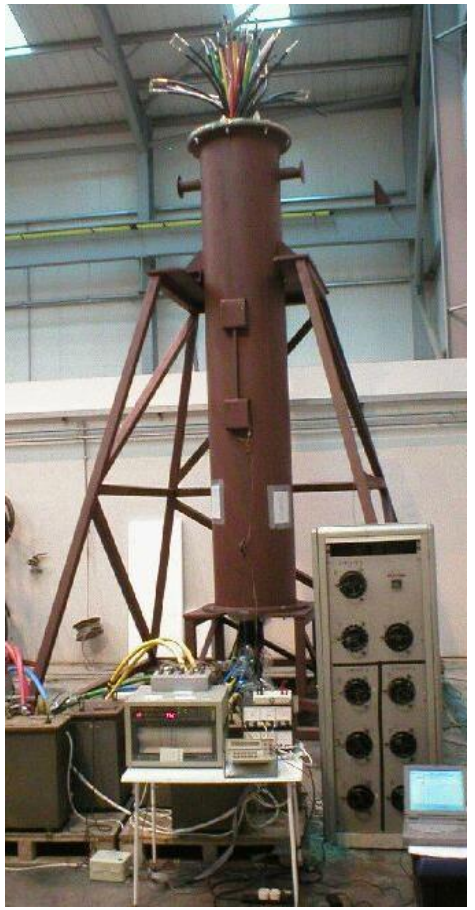


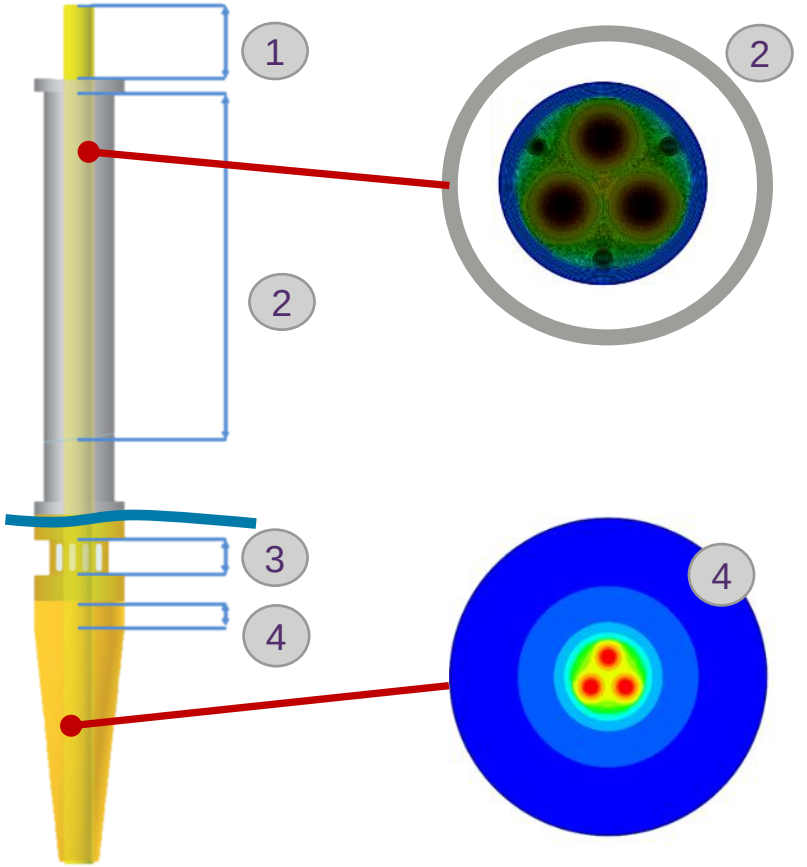


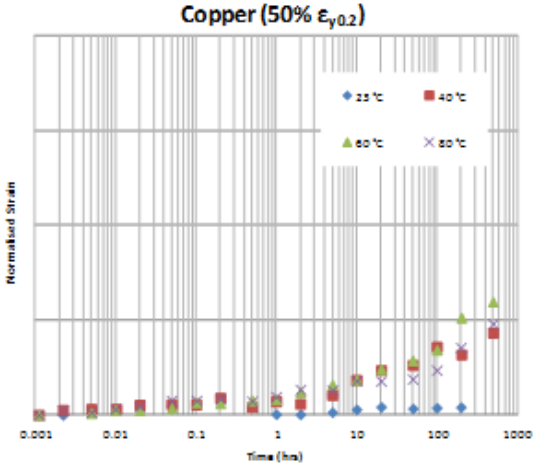


Cable Technology
Dynamic Power Distribution Subsea: Static Service Risks

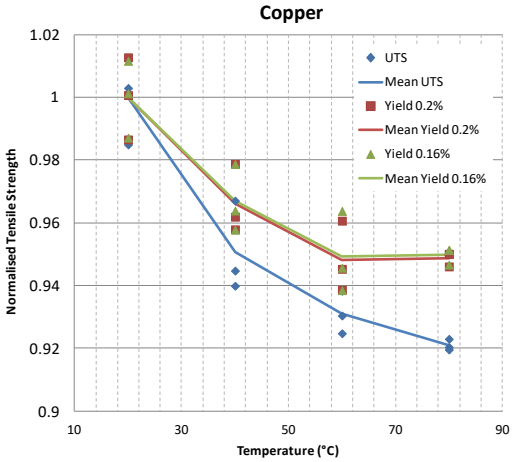
Environment & Current induced Temperature Rise







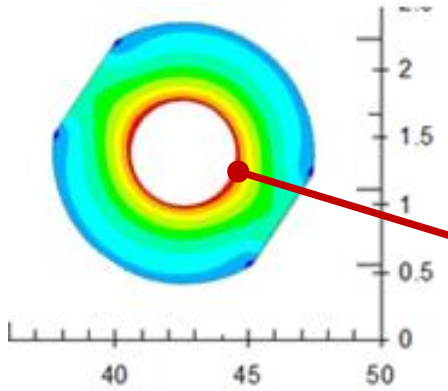
Impact of Operating Temperature:
Bundle load share
Material Creep
Thermal ratcheting

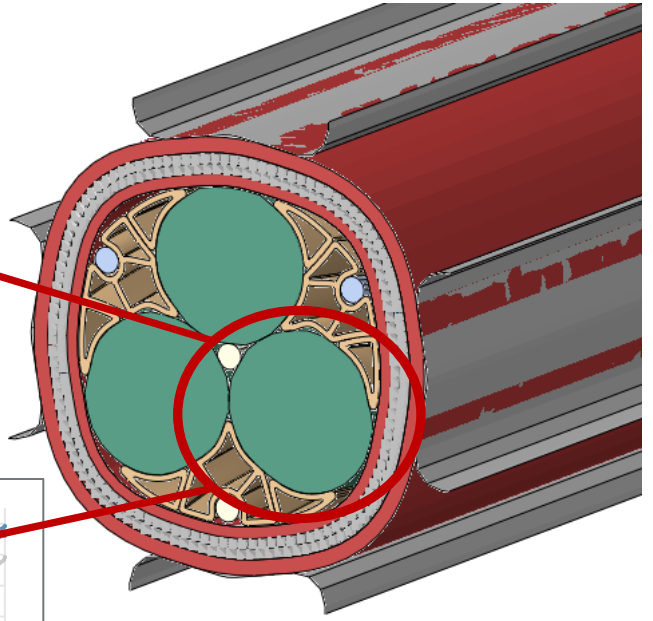


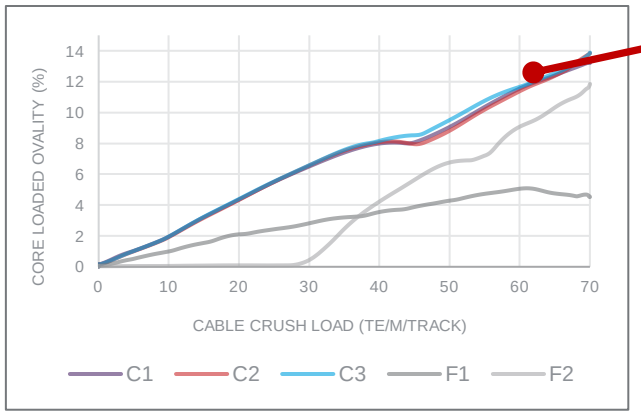
Impact of Operating Temperature:
Corrosion of Metallics
Electrolysis of Polymers
Fatigue strength reduction
Tensile Strength reduction

Cable Technology
Dynamic Power Distribution Subsea: Clamping Risks

Impact of Radial Loading

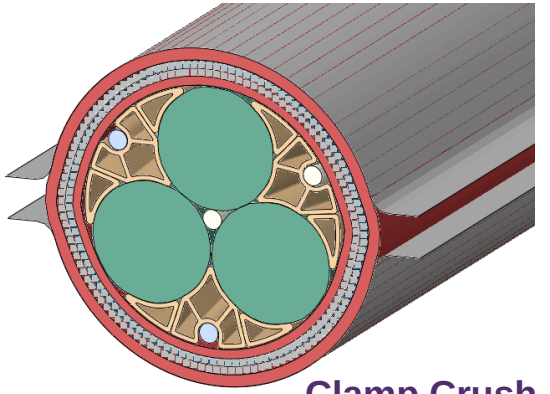




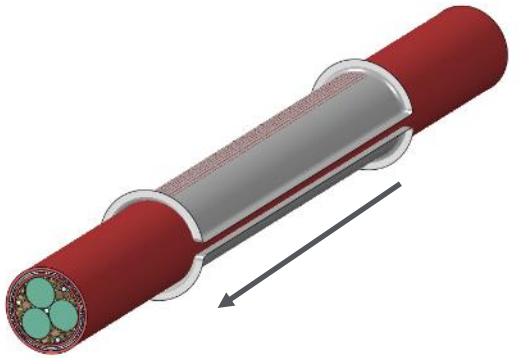


Cable Deformation
High Electrical Stress
Overheating
Premature Ageing
Fatigue Life Reduction

Clamping Consideration



Clamp Crush



Clamp CoF

Cable Technology
Dynamic Power Distribution Subsea: Summary

Guaranteed System Integrity Requires:

- A comprehensive understanding of the coupled mechanics of the system: Thermal, Mechanical and Electrical
- A comprehensive understanding of the material ageing mechanisms which are influenced by the system mechanics
- Qualified and proven materials and system design guidelines to minimize the influence of ageing