On Umbilicals’ and Power Umbilicals’ Sensitivity to the Ambient Temperature

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• Commonly performed umbilical analyses.
• Why umbilicals’ temperature sensitivity is highly important.
• Nexans Norway’s R&D study on umbilicals’ temperature sensitivity.
• Which umbilical properties are sensitive to temperature.
• Which umbilical elements dominate the umbilicals’ temperature sensitivity.
• Conclusions.
Cross section analysis establishes the umbilical’s mechanical properties:

- Axial stiffness.
- Torsion stiffness.
- Bending stiffness.
- Capacity (allowed combinations of axial tension and bending curvature).
- Tailor-made inputs to subsequent analyses.
Dynamic analysis considers the interactions between the umbilical and its surroundings to ensure that the umbilical is sufficiently robust:

- Fatigue analysis.
- Vortex-induced vibration (VIV) analysis.
- Extreme analysis.
- On-bottom-stability analysis.
- Installation analysis.

These analyses heavily depend on the results of the cross section analysis.
Umbilicals’ Temperature Sensitivity

• Umbilicals consist of multiple materials. Several are temperature-sensitive.

• Umbilicals’ mechanical properties are therefore temperature-sensitive.

• Temperature sensitivity should be considered during umbilical design, engineering, and analysis.
However...

- Umbilicals’ temperature sensitivity seems to get little attention in the industry.

- The scientific literature on cables’ and umbilicals’ temperature sensitivity is sparse.
Nexans Norway’s R&D Study

Nexans Norway launched an R&D study on umbilicals’ temperature sensitivity in 2013.

Motivations:

• Nexans Norway is observing different umbilical properties during winters (-20°C to 0°C) than during summers (+20°C to +30°C).

• Client requests.
The goals for Nexans Norway’s R&D study:

- To increase theoretical and practical knowledge.
- To include temperature sensitivity in umbilical analyses.
Nexans Norway’s R&D Study

Small-scale testing

First principle model

Analysis model

Analysis in client projects

Validation: FEM analyses

Validation: Large-scale testing
Nexans Temperature-Sensitive Properties

Temperature-sensitive properties

- Bending stiffness.
- Fatigue properties.
- Maximum allowable bending curvature.

Near temperature-insensitive properties

- Axial stiffness.
- Torsion stiffness.
- Maximum allowable axial tension.
Bitumen’s Temperature Sensitivity

The diagram illustrates the relationship between shear modulus and temperature. As the temperature increases, the shear modulus decreases, indicating a decrease in stiffness. This is typical for materials like bitumen, which exhibit temperature-dependent properties.
Novel Rig for Model Validation
Novel Rig for Model Validation

1. Applied curvature
2. Tube in rig
3. Measuring force
4. Calculating moment
5. Measured moment
6. Simulated moment
7. Mathematical model
8. Known bending stiffness
Novel Rig for Model Validation
Conclusions

• Umbilicals’ temperature sensitivity may not have got its deserved attention in the scientific literature, in analysis tools, and in the industry.

• Nexans Norway launched an R&D study on umbilicals’ temperature sensitivity to increase knowledge and improve analyses.

• Bending stiffness, fatigue properties, and maximum allowed bending curvature are particularly temperature-sensitive.