NAVAL ENERGIES

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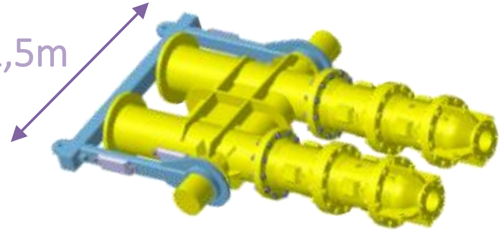
# DRYM: a DRY Mate connector dedicated to floating wind: Focus on long term behaviour of sealing system

**Dr. Mathieu PRISER, Deepwind Conference, Trondheim, January 2021**

# DRYM HISTORY

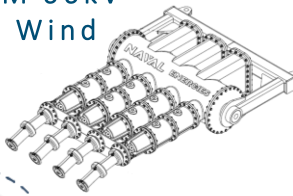


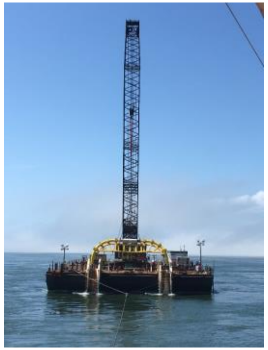

[https://natick.research.microsoft.com/](https://natick.research.microsoft.com/)

**DRYM concept based on Tidal Experience**
For in line connectors, a quadrant is requested to ensure no overbending of cables during installation

**DRYM II : Partnership with Nexans Euromold**
Design of connector delivered on Microsoft project (Natick) ➔ TRL 7

**DRYM IV: DRYM 66kV for Offshore Wind**





2014/2015 — 2016 — 2017 — 2018 — 2019/2020

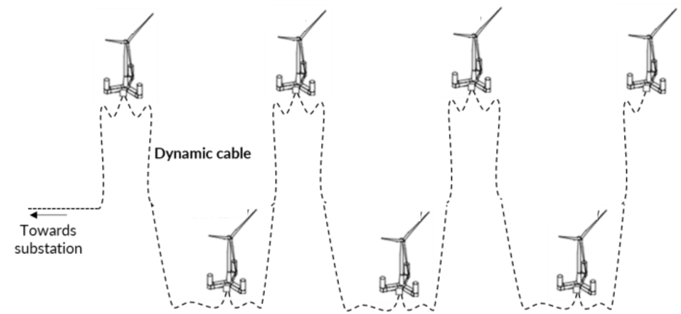

**DRYM I**
**Proof of Concept** : Development of an innovative sealing system and U-shape connector

**DRYM III : Natick deployment**
Connector OK after 24 months ➔ TRL 8
Optimization of the design
Evaluation of long term durability of the sealing system

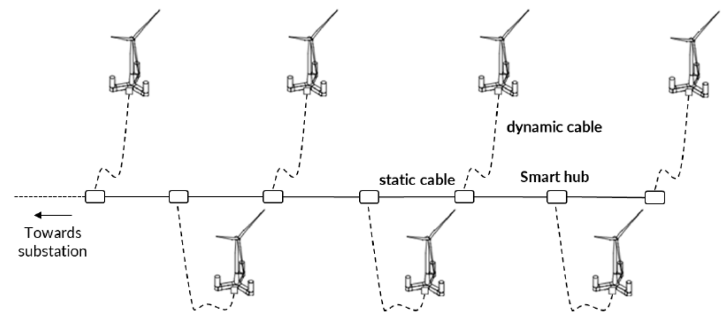
# DRYM : Floating wind application

- **Context of study :**
  - New needs for electrical grids requested for floating offshore wind
- **Issues :**
  - Standard electrical architecture derived from Bottom fixed mindset / not adapted to floating wind
- **Objectives :**
  - Mitigate the risks hold by dynamic cables by implementing new electrical architecture more compliant with floating wind constraints (so called fishbone architecture)
  - Introduce subsea technologies in the subsea IAC grid and ensure long term durability of these technologies to allow take off of these optimized electrical architectures

Daisy chain electrical architecture




Fishbone electrical architecture



# Agenda

- DRYM History / Floating Wind Application
- Sealing solution for DRY Mate connector
  - Presentation of rubber packing
  - Design of a test set-up
- Evaluation of sealing long term behaviour
  - Description of test bench and instrumentation
  - Mechanical behaviour of seals and modelling
  - Comparison between experiment and numerical results for sealing performance
  - Accelerated ageing tests
- Conclusions

# Sealing system and test setup

- Sealing system :mechanical cable gland system
- Presentation of rubber packing
  - Stacking of machined EPDM V-seals up side down
  - Tunable compression stroke to adjust mechanical gap between cable and seal
  - Submitted to Heat Cycles during electrical production of the wind farms
- Design of a test set-up
  - Test setup combining thermal cycles and pressure
  - Multiphysic monitoring : Axial stresses, temperatures, leak rates, …

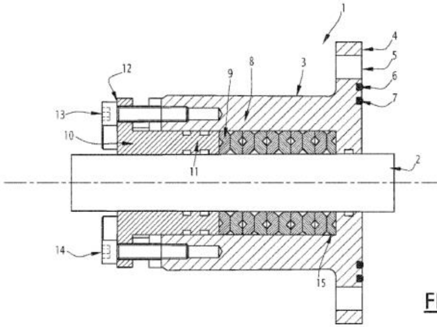
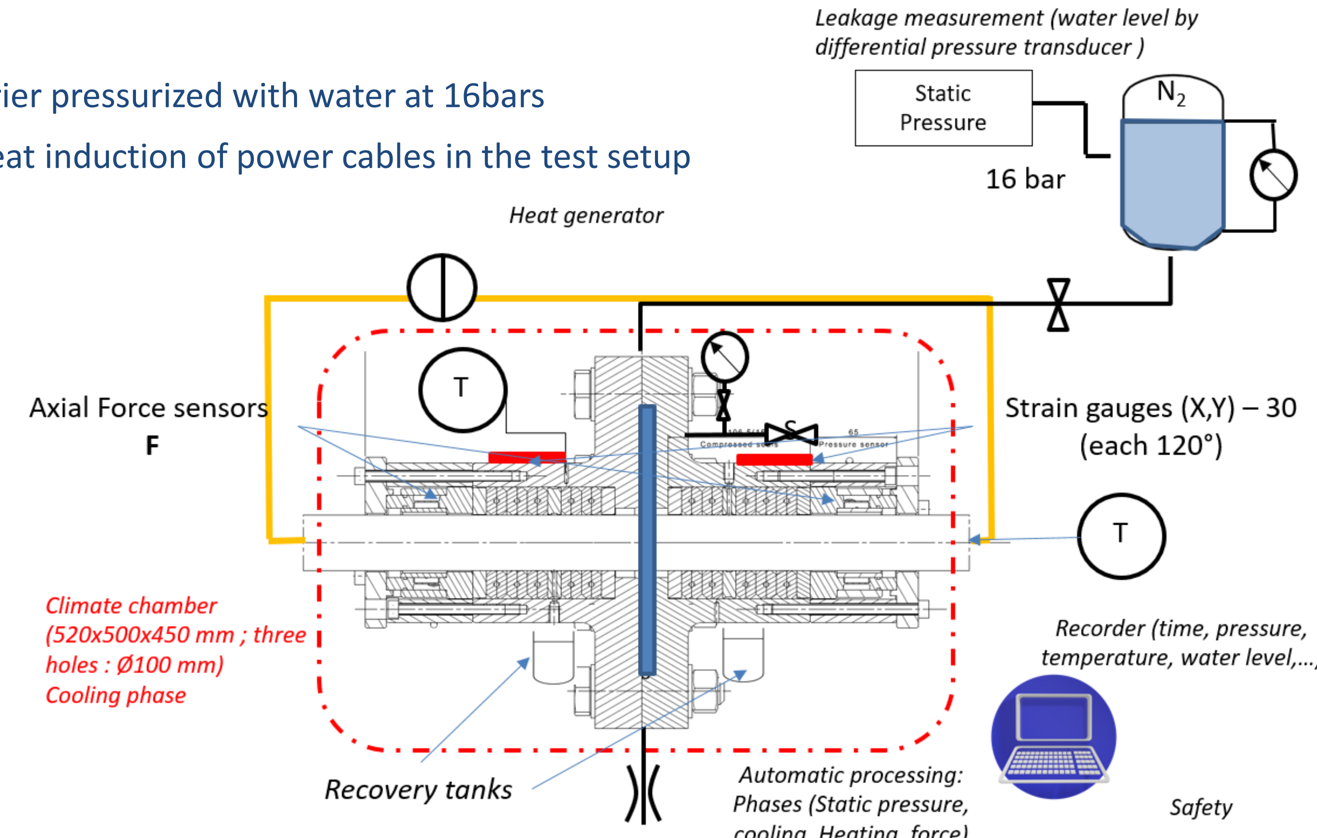



FIG.1

*Naval Energies Patent WO 2018/172524 AI*

# Description of test bench and instrumentation

- Sealing barrier pressurized with water at 16bars
- Electrical heat induction of power cables in the test setup



# Thermal Cycles according to IEC EN 61442

- 5h heating, 3h cooling for each cycle
- 126 Heat cycles = 42 days

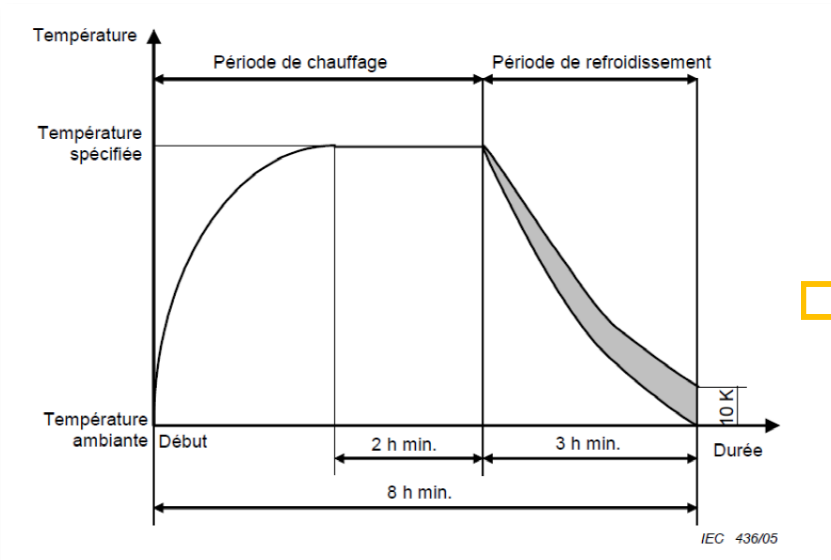
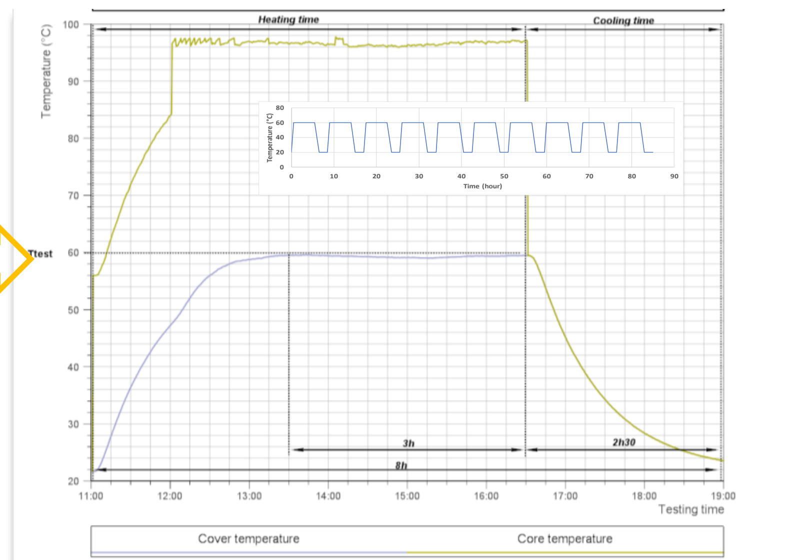
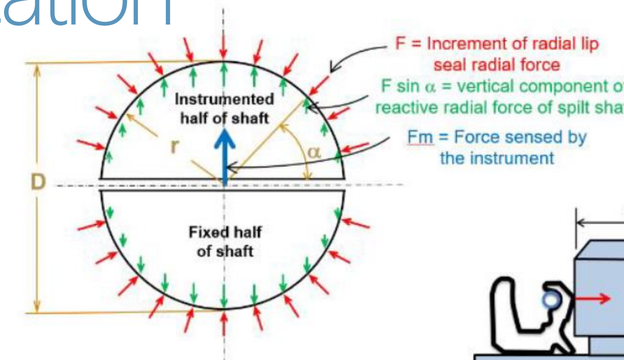



Figure 5. Thermal cycle (NF EN 61442).

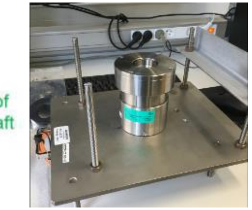


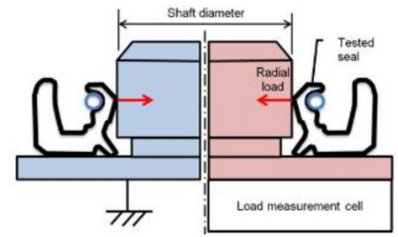
# Numerical Simulation : Material parameters identification

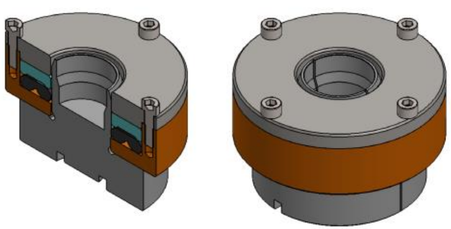
- Mechanical behaviour of seals and modelling

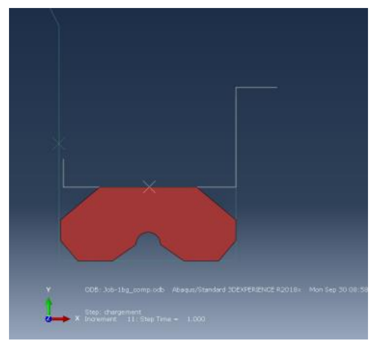



$$Fm = 2\int_0^{\frac{\pi}{2}} F.r.sin\alpha.d\alpha = D.F$$

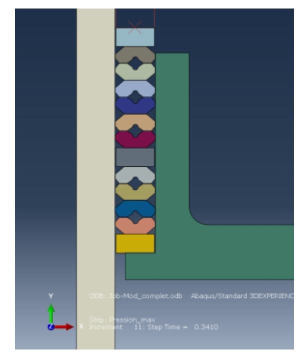






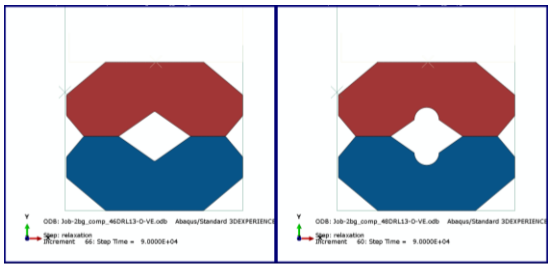
Abaqus®



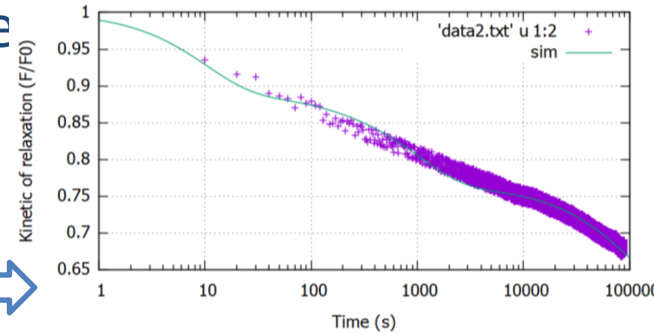
# Numerical Simulation : Material parameters identification

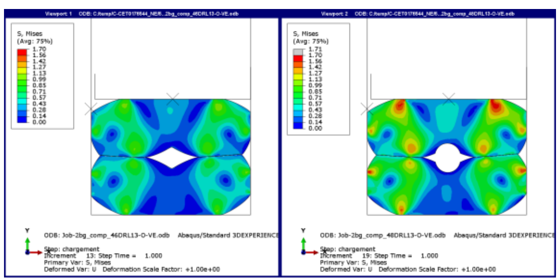
- Mechanical behaviour of seals and modelling

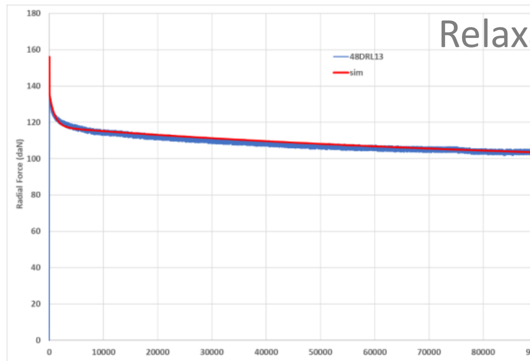
## – Identification of material paramete



Inverse engineering



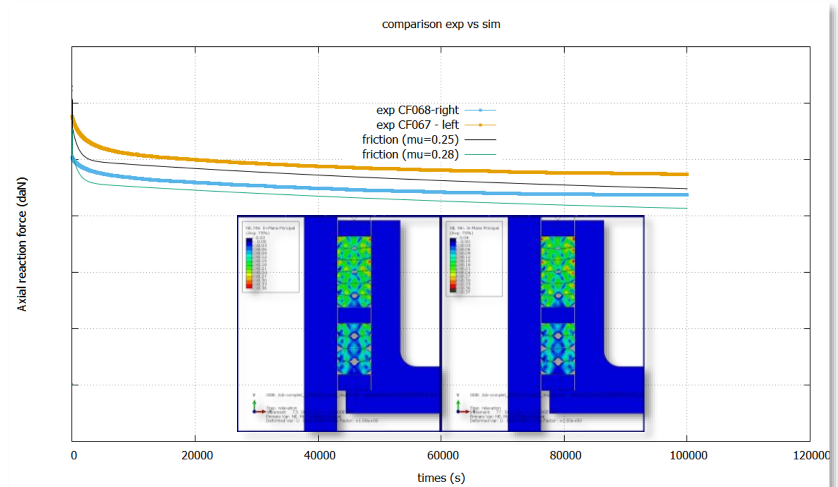


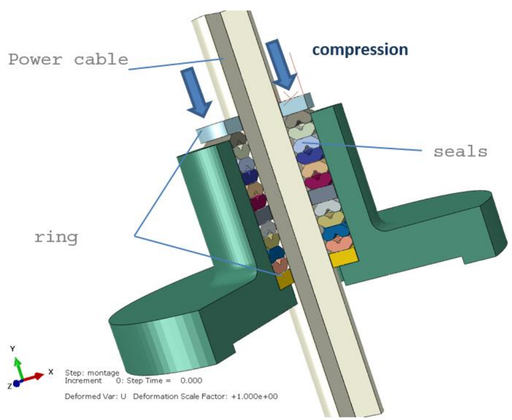

Relaxation phase

Prony series in hyper-viscoelastic material models

# Numerical Simulation : Sensitivity analysis

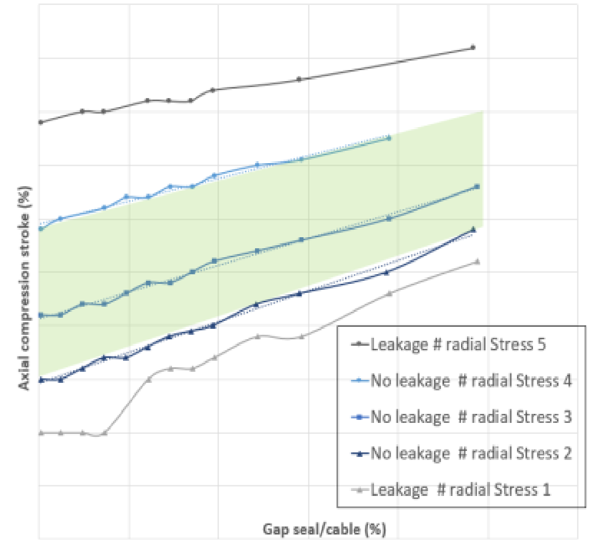
– Comparison between experiment and numerical results for sealing performance ; impact of:
  - Friction coefficient (lubricated or not)
  - compression level
  - Diameter of cable,
  - Design and hardness of seal
  - Temperature (inside and outside)

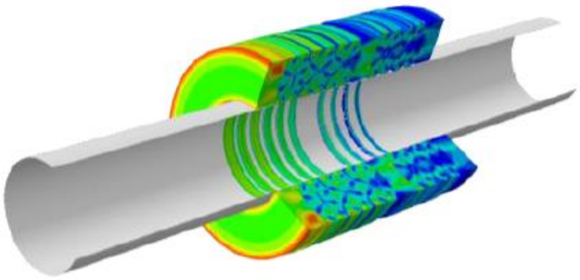


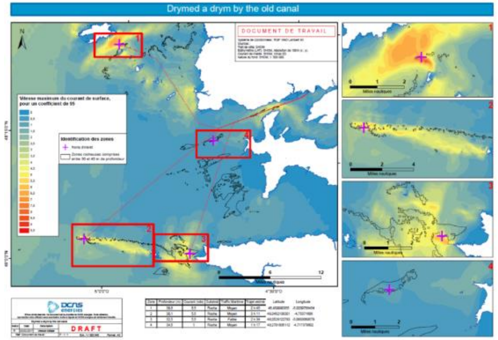
# Numerical Simulation : Design space

- Improvement the knowledge of the sealing system for lifetime prediction
  - Safe design area identified between over stressed and under stressed area
- Development and validation of abacus to determine clamping conditions

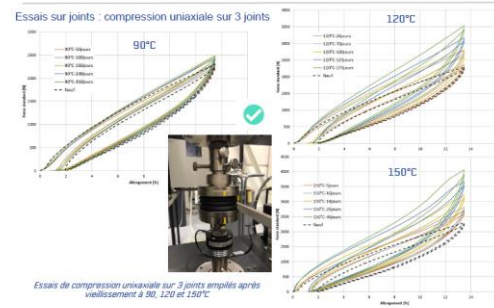


# Ageing tests




- **Ageing of EPDM seals in sea water**
  - Re-use of DRYM I Proof of Concept for natural ageing and immersed in Fromveur Channel (3 years immersion in area 1)
  - Accelerated ageing lab tests
- **WLF Time/ Temperature equivalence for rubber material**
- **No expected damage after 25years of natural ageing**




Eprouvettes

| Ageing | Samples | | | | | |
|---|---|---|---|---|---|---|
| | Temperatures | | | | | |
| | Neuf | 90°C | 105°C | 120°C | 135°C | 150°C |
| Durations | 0 days | 50 days | 30 days | 24 days | 15 days | 5 days |
| | | 100 days | 50 days | 70 days | 30 days | 10 days |
| | | 150 days | 100 days | 100 days | 50 days | 14 days |
| | | 250 days | 200 days | 125 days | 75 days | 25 days |
| | | 350 days | 300 days | 175 days | 126 days | 49 days |

T0

T0 + 3 years

# Conclusions

- Technical and scientific benefits
  - Mechanical behaviour assessment of rubber packing with heat cycles under pressure
    - Mechanical cable gland system compliant with thermal cycles requirements
  - Accelerated and natural ageing tests on rubber seals

  ➔ Validation of long-term durability of the system on a XLPE power cable
  - Experimental procedures for qualification of sealing system ready
  - Definition of interface requirements with power cables
  - Design Abacus ready for upscale to 66kV applications

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