



COMPONENT & SUBSTRUCTURE TESTING CENTRE

Strategic partners



LCST – Lindø Component & Structure Testing

FORCE Technology - Lindø

Hans Henrik Matthiesen



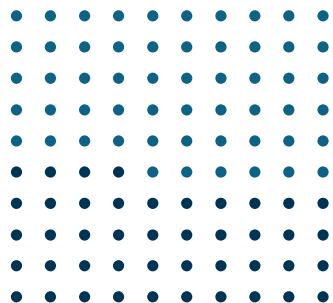
Nøgletal

2023



1.190 mio.

Omsætning i DKK



Andel af omsætning udland

Næsten halvdelen af FORCE Technologys omsætning stammer fra internationale kunder igennem eksport eller udenlandske aktiviteter.



1.037

Medarbejdere



7.000+

Kunder

Nøgletal

Forskning og udvikling



250+

Unikke faciliteter



5.000+

Kursister og eventdeltagere



150+

Samarbejdsprojekter



129

FoU projekter i 2023



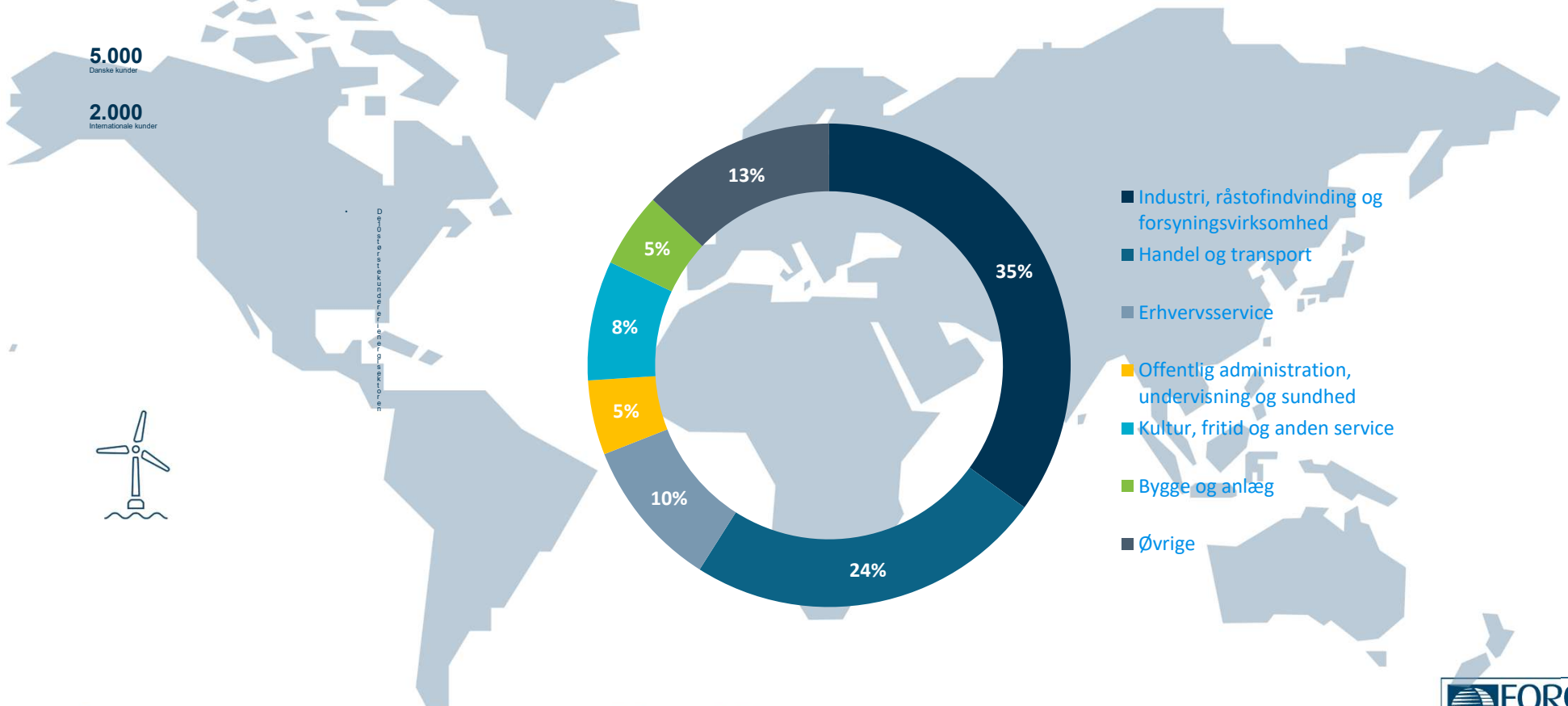
50+

Discipliner

En international virksomhed

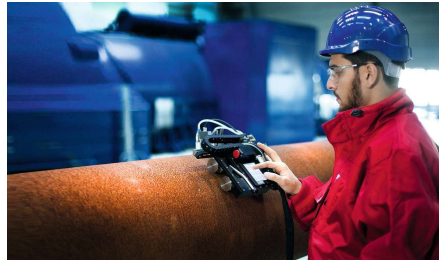


Hvem er vores kunder?





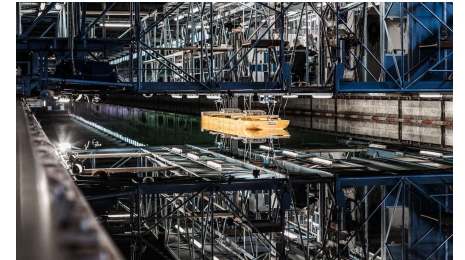
Compliance & Product Testing



Digital Asset-Integrity Solutions



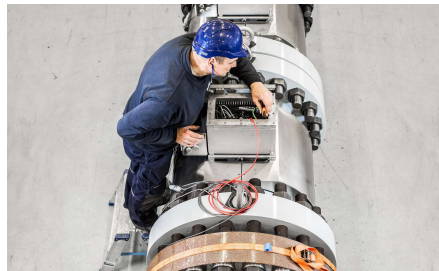
Integrity Management & Monitoring



Maritime, Air & Sound



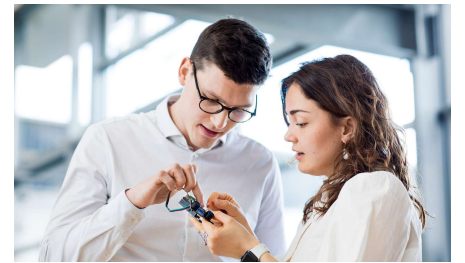
Materials & Structures



Metrology & Calibration



NDT, Pressure & Welding



New Technologies & Business



Materials &
Structures



Test, analyse og rådgivning
indenfor materialer,
strukturer, kemi og beton



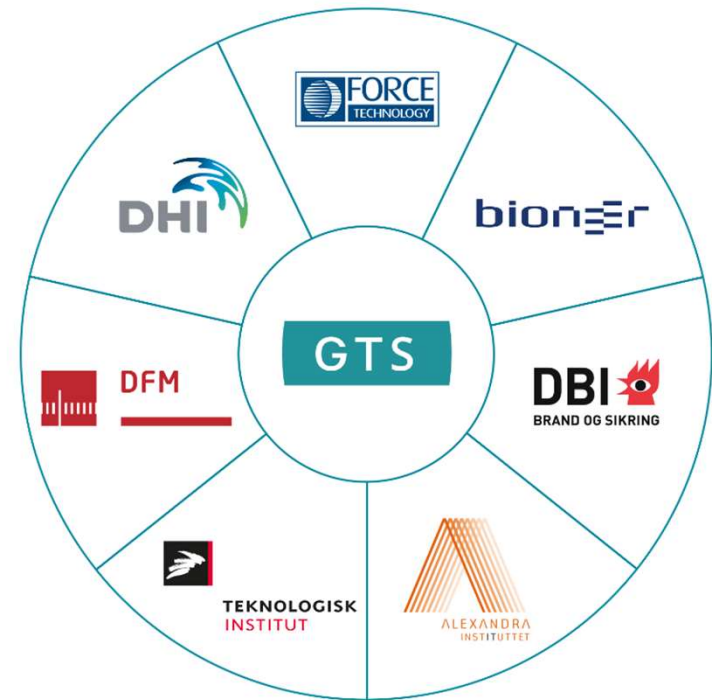
Godkendt Teknologisk Service (GTS)

Som GTS-virksomhed er vi dedikerede til at udvikle og bruge teknologier og ny viden til gavn for erhvervsliv og samfund som helhed.

GTS-institutterne er sat i verden for at gøre det muligt for flere virksomheder at anvende ny forskning og teknologi.

I kraft af teknologiske kompetencer og state-of-the-art faciliteter løser GTS-institutterne konkrete problemer for virksomheder. Det skaber innovation, vækst og arbejdspladser.

Hvert år bistår GTS-institutterne op mod 30.000 virksomheder.



Testing facilities at Lindø



Testing facilities at Lindø

- Lindø Component and Structure Testing A/S (LCST)
 - 50/50 joint venture between **FORCE Technology** and **Lindø Offshore Renewables Center (LORC)**
- LORC is a non-profit and independent commercial foundation established in 2009 by major companies in the offshore renewables sector
- FORCE Technology is a technology consultancy and service company which strives to create positive technological change and make the world more sustainable and safer.



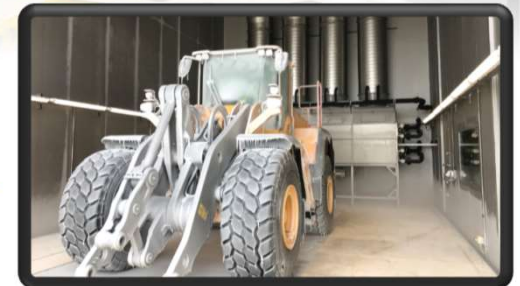
LORC

Nacelle Testing



LCST

Lindø Component &
Structure Testing
[Strong Floor + Climate Chamber]



Testing facilities at Lindø

LORC

(Lindø)



FORCE Technology

(HQ, Brøndby)



LCST (LORC & FORCE Technology)

(Lindø)





FACILITY

Mechanical tests of large structures

Testing full-size structures using static and dynamic multi-axial loads or fatigue testing

The possibility of testing full-scale systems will give you the documentation of the durability of the structure based on real-world effects.

The mechanical test bench can be used to test large components for simple strain robustness or for fatigue resistance.

The test bench has a large, strong floor and inter-related reaction walls along two sides of the plane. This structure makes it possible to test full-size structures with a three-dimensional stress set-up, relevant for structures exposed to e.g. waves, wind and alternating rotating loads simultaneously.

[Link to facility at forcetechnology.com](https://www.forcetechnology.com)

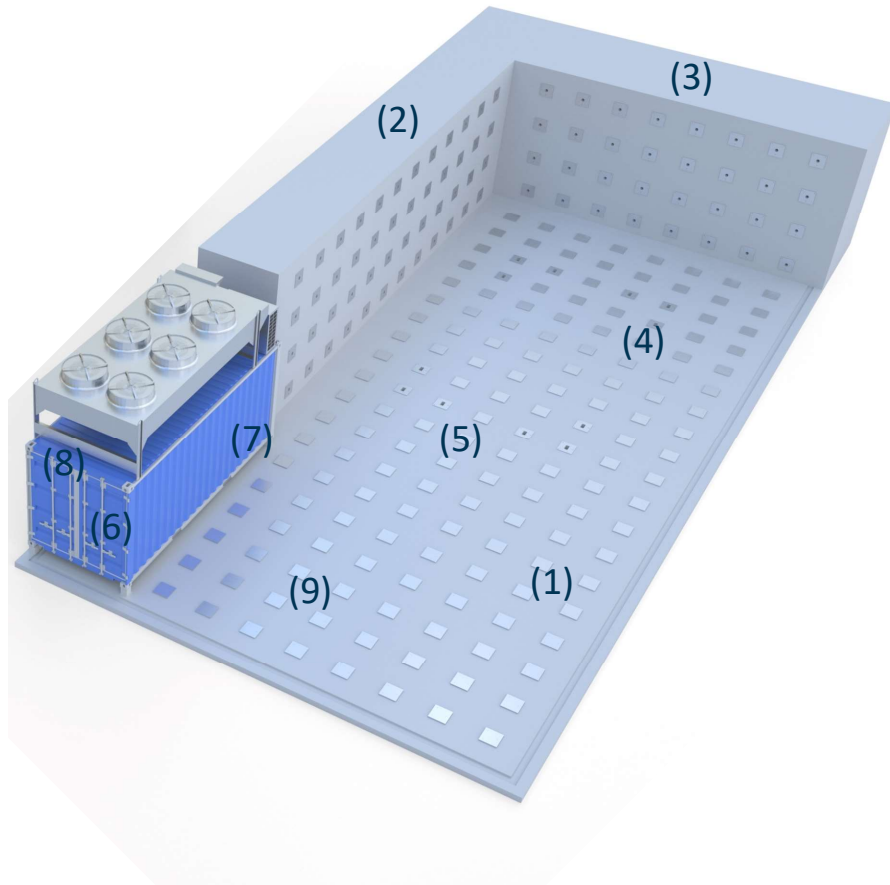
[Link to LORC: https://www.lorc.dk/](https://www.lorc.dk/)

Mechanical test bench

- Size (floor): 20 x 9 m
- Size walls: 13 x 4 m and 9 x 4 m (WxH)
- Cylinder capacity: 125 kN up to 3 MN
- No. of cylinders: Up to 6 simultaneously
- Max. bending moment: 60 MNm.

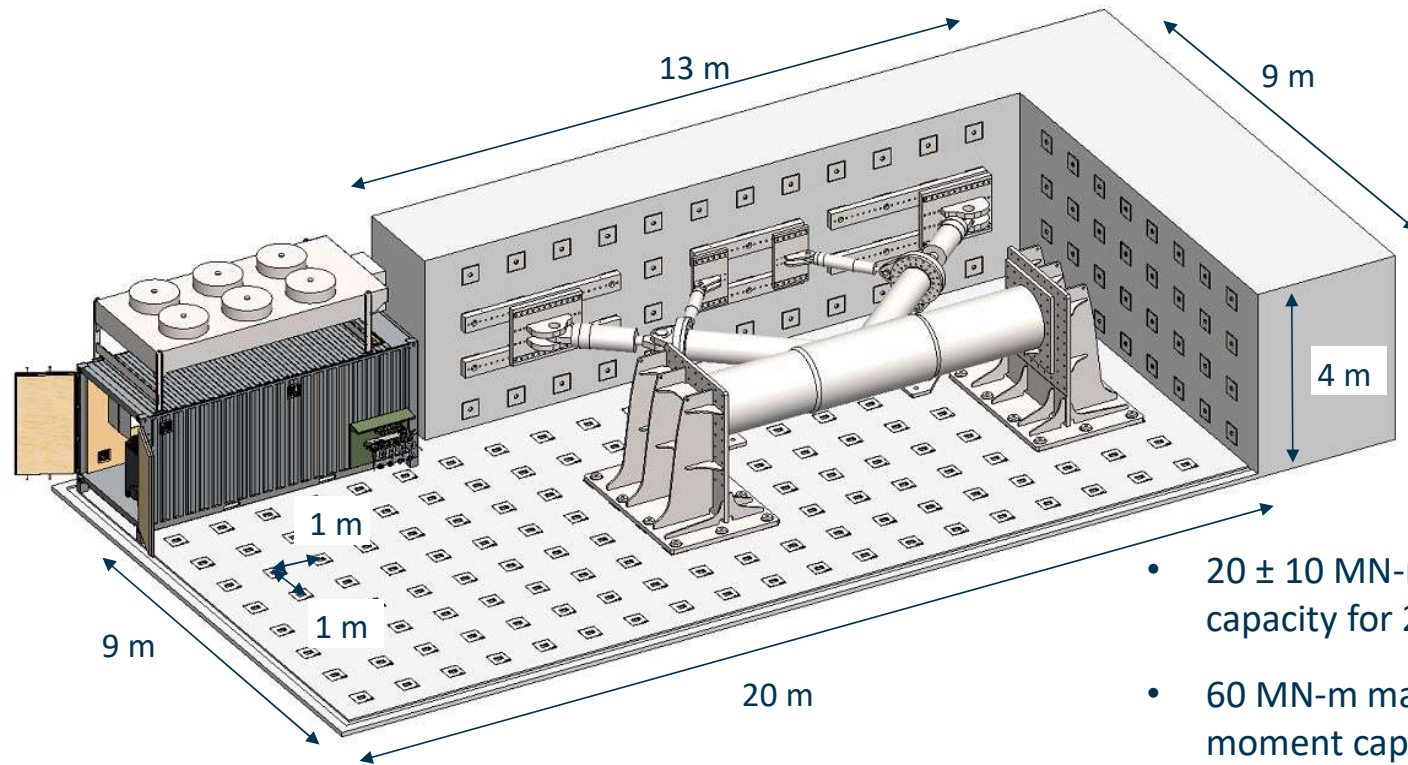


Mechanical Test Bench



- (1) Strong floor: 9 m wide and 20 m long
- (2) Strong wall: 4 m tall and 13 m long
- (3) Strong wall: 4 m tall and 9 m long
- (4) Strong points: 1000 kN push/pull
250 kN shear
- (5) Hydraulic actuators: Ranging from 125 kN up to 3000 kN
- (6) Hydraulic power station and controls
- (7) Hydraulic actuator connections for up to six simultaneously
- (8) Data acquisition with up to 128 channels
- (9) Adapters available for a variety of test specimens

Mechanical Test Bench



- 20 ± 10 MN-m dynamic moment capacity for 2×10^7 cycles
- 60 MN-m maximum static moment capacity

Mechanical Test Bench



- High-load static testing up to Meganewtons
- Fatigue testing programs
- Loading for up to 6 hydraulic actuators simultaneously



- 128 Channels of data acquisition
- 24/7 run-time with online monitoring



FACILITY
Mechanical tests of large structures



Fatigue Testing History

- Three full scale K-Nodes: Comparison of two robot welded K-Nodes and one manually welded
- Twelve T-Nodes: Comparison between three post weld treatments
- Four T-Nodes: Multiaxial fatigue testing

Development programs

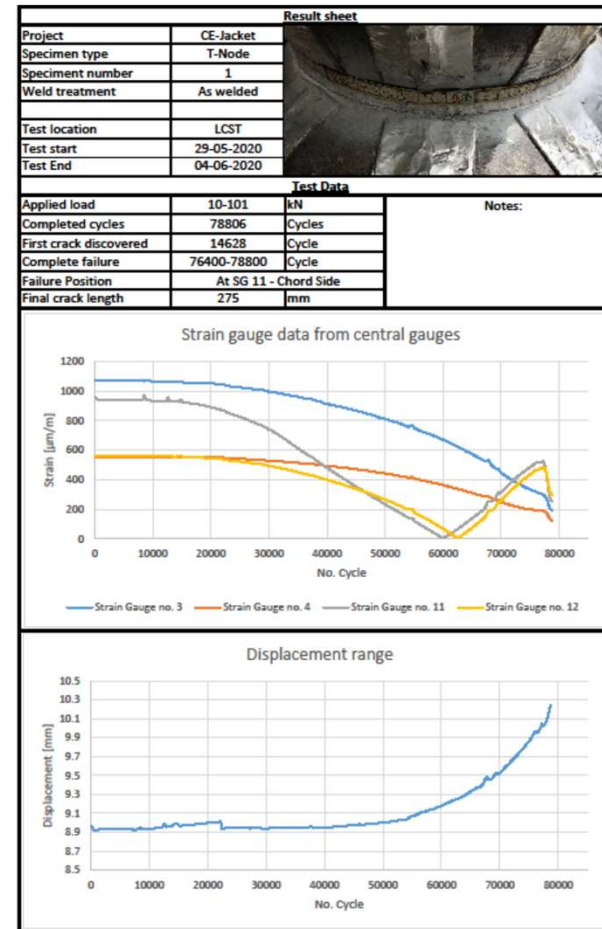
- Offshore wind foundation node on an industrial scale
- CE-Jacket
- High5Jack

Mechanical Testing Examples

- Fatigue Testing – T-Nodes



17





FACILITY

Mechanical tests of large structures

Design verification testing

- Blade bearings
- Pins and connections for floating offshore foundations
- Various components for construction and lifting

Mechanical Testing Examples

- Multi axial load testing
 - Up to 5 loading direction



Mechanical Testing Examples

- Offshore foundation systems – monopiles, jacket nodes, floater concepts
- Nacelle frames
- Main bearings
- Blade (pitch) bearings
- Full-scale corrosion fatigue tests
- Towers and masts
- Pipelines
- Building frames
- Bridge decks and components



CASE – Vestas Wind Systems

Project Management of a Verification Test for the next generation of Wind Turbine Pitch Bearings

"We are a link between Vestas Test facilities in UK, R&D Prototype in Denmark and the Project Management in India. Relationship is our buzz-word. We must share information both internally and externally as well as supporting each other to fulfill this task"

Per Baunegaard With Jensen,
Test Engineer at Lindø Component and Structure Testing

Challenge

Design Verification Test of Blade Bearings.
Vestas has the knowledge and their own test set-up based in UK, whoever they do not have facilities big enough for the new generations of turbines (15MW+)
Lindø Structure and Component Testing has the facility for such test set-up.
Negotiate an agreement in High Risk-classification with new Terms & Conditions (legal)

[Link to full case story at forcetechnology.com](https://www.forcetechnology.com)

Solution

Close collaboration with Vestas' pitch bearing specialist in UK and the Project Management in DK and India. Setup a Core Team and series of meetings.
FORCE Technology made the design of the test set-up (counter structure) together with FORCE Norway.
For maintenance, the NDT and Material Consultancy (161) has been involved.
Closer collaboration and supporting in the Steering Committee and support from finance (contingency)

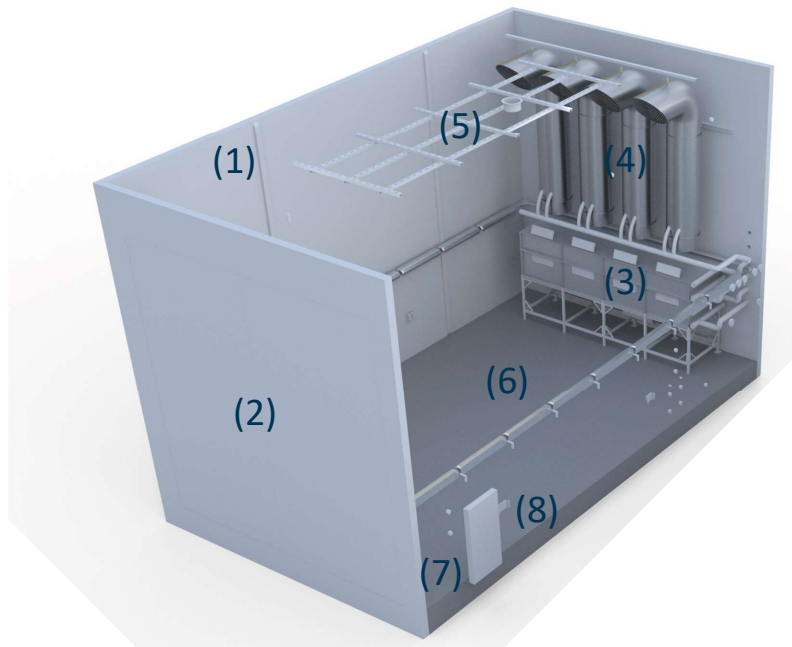
Result

Testing with many stakeholders meant that we had to structure our meetings. Weekly Core Team meetings with Project Status and Technical issues in focus. Monthly meetings with SteerCo. with new improved reporting structure with Risk's and Forecast (economy) in focus. → In Time – In Quality – In Budget

Vestas asked FORCE Technology to quote an additional 1 or maybe 2 Pitch Bearing tests - success

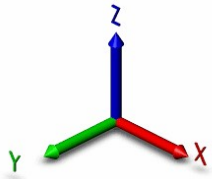


Climate Chamber



- (1) Climate chamber: 8m wide, 8m tall by 14m (12,4) long
- (2) Chamber door: 7m wide by 7m tall
- (3) Temperature: -60°C to +60 °C
- (4) Humidity: 10% to 95% above 10 °C
- (5) Salt spray available
- (6) Heavy load floor with over 1000 tons capacity
- (7) Built-in exhaust extraction for up to two vehicles
- (8) Data acquisition with up to 104 channels
- (-) Sun simulation rack (IR-lamps)

Large Scale Climatic Testing Chamber



Dimensions:

Size: 14x8x8 m (LxHxW) (add. 4.5 extension available)

Usable space: 12,2x8x8 m

Floor load capacity: 10 t/m²

Temperature Control

Temperature range: -60 °C to +60 °C

Cooling rate:

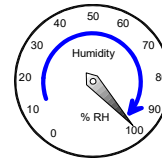
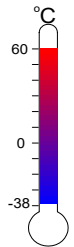
- 0,15 K/min with 50 t.
 - +40 °C to -30 °C in 8 hours
 - Test ran in 2.5 hours
- 0,06 K/min with 150 t.

Heating rate:

- 0,25 K/min with 50 t.

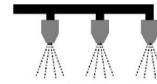
Maximum cooling capacity:

- 210 kW at -10 °C
- 60 kW at -35 °C



Humidity control:

- From 10 to 95+ % RH at 10 - 60 °C



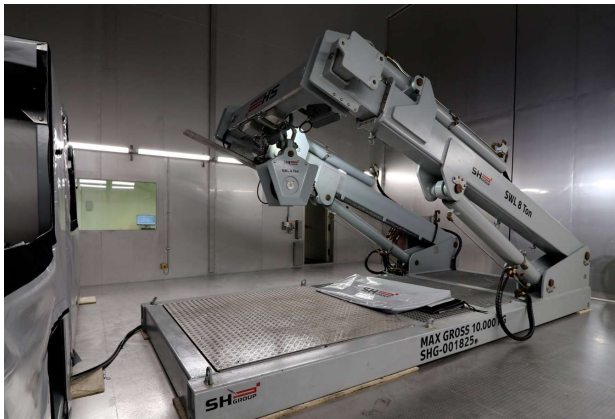
Salt water spray

- Up to 4 % mix
- From top and side(s)
- 11 hours of contentious spray

Climatic Chamber Testing Examples

Examples of tests:

- Start-up and function tests
- Cyclic temperature tests
- Split-system tests – between inside and outside of chamber
- Low temperature with over-icing
- Salt-spray / atmospheric corrosion tests



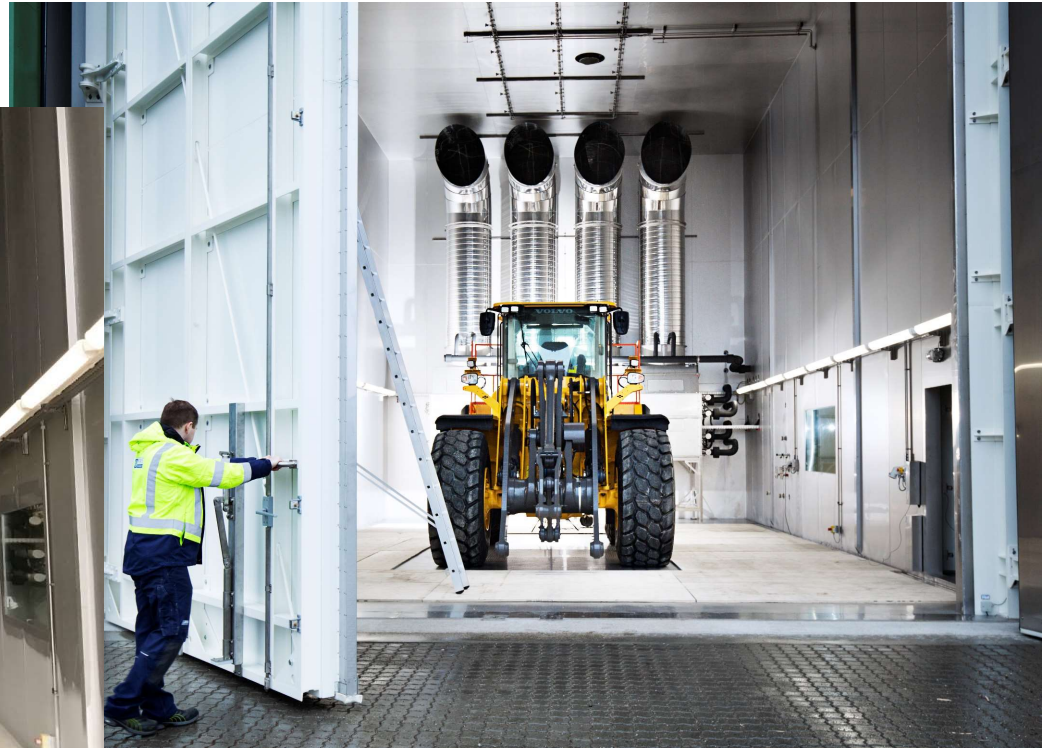
Climatic Chamber Testing Examples

Commissioning test

- Wind turbine cooling unit
- Chamber at -35 °C
- 450 cycles over 7 days
- Cold start with over icing



Large Scale Climatic Testing Chamber



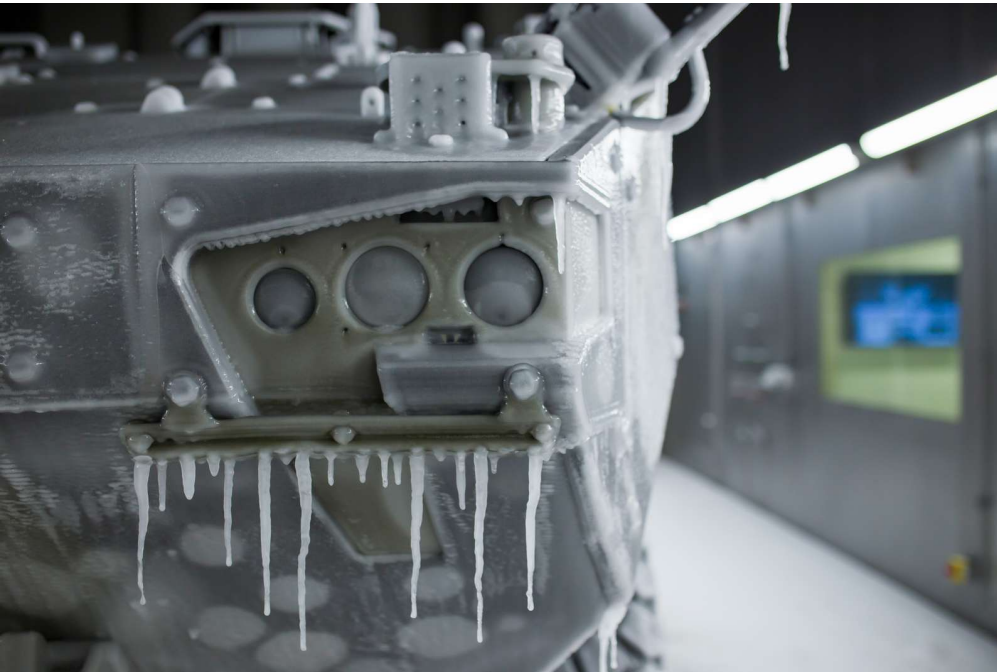
Large Scale Climatic Testing Chamber



Large Scale Climatic Testing Chamber



Large Scale Climatic Testing Chamber



Large Scale Climatic Testing Chamber



Local Time	Meteorological Conditions		
hours	Ambient Air Temperature °C	Relative Humidity %	Solar Radiation W/m ²
0100	35	6	0
0200	34	7	0
0300	34	7	0
0400	33	8	0
0500	33	8	0
0600	32	8	55
0700	33	8	270
0800	35	6	505
0900	38	6	730
1000	41	5	915
1100	43	4	1040
1200	44	4	1120
1300	47	3	1120
1400	48	3	1040
1500	48	3	915
1600	49	3	730
1700	48	3	505
1800	48	3	270
1900	46	3	55
2000	42	4	0
2100	41	5	0
2200	39	6	0
2300	38	6	0
2400	37	6	0

Large Scale Climatic Testing Chamber

4.5 meter extension available



Thank you for your attention !



Further information at forcetechnology.com

