Sicherheit in Technik und Chemie

Best Paths
TRANSMISSION FOR SUSTAINABILITY

BAM
Bundesanstalt für Materialforschung und -prüfung

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ACCELERATED ELECTRICAL AND MECHANICAL AGEING TESTS OF HIGH TEMPERATURE LOW SAG (HTLS) CONDUCTORS

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The idea

Expansion of transmission system

Uprating of transmission lines

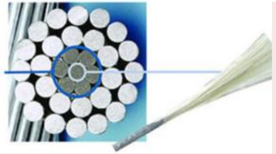
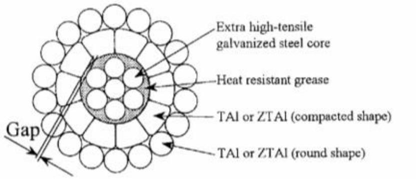
HTLS conductors

Higher capacity due to higher rated temperature
- Lower sag (thermal expansion)
- Temperature resistant materials

Limited long-term experience!

Material degradation? (RTS, electrical resistance, creep…)

Selected conductors

conductor	Core material	Outer layers	Structure
ACSR	Steel	Hard drawn aluminum	
ACCC, ACPR	Polymer matrix composite	Annealed or thermal aluminum	
ACCR	Metal matrix composite	Thermal aluminum	
GZTACSR „Gap“	Steel	Thermal aluminum	
Also tested: ACSS, ZTACIR, TACSR			

Conductor ageing

Reality (50 years)	Laboratory (6 months)
Everyday stress, wind loads	Tensile force
Thermal and electrical loads	Maximum rated and emergency temperature
Corrosion (temperature, environment)	not studied

Tensile force

Applied tensile force = Static load + Cyclic load

Static load (Everyday stress)

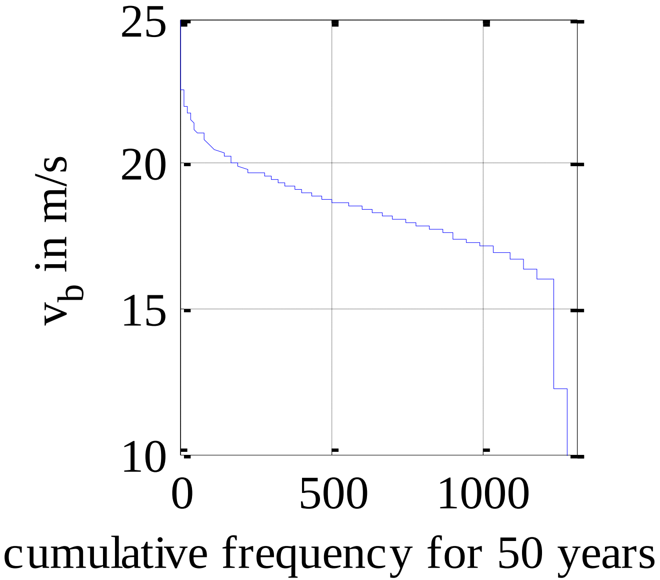
- Calculated for an ideal single span of 413 m and 15.5 m sag

→ ca. 15 % RTS (depending on the conductor‘s specific weight)

From wind velocity to tensile force

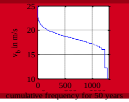
Wind velocities in 50 years

According to EN 1991-1-4 (10 m height, wind zone 2, rural terrain)

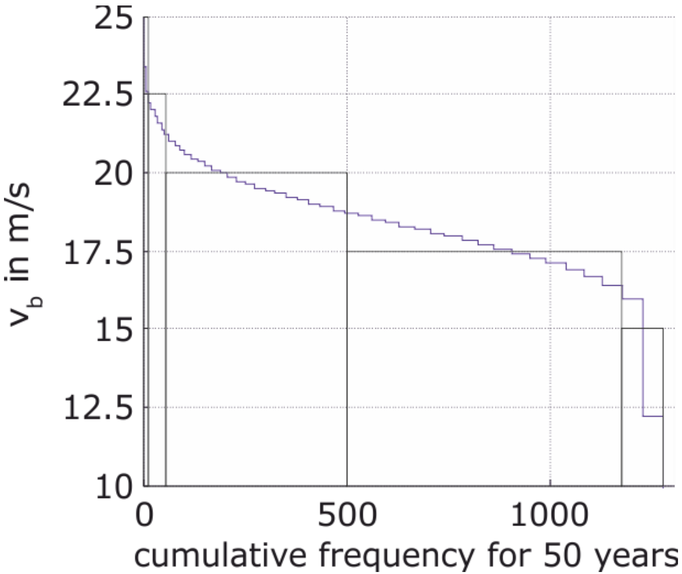


From wind velocity to tensile force

Wind velocities in 50 years

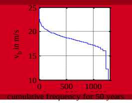


5 classes of wind speeds

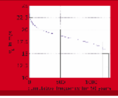


From wind velocity to tensile force

Wind velocities in 50 years

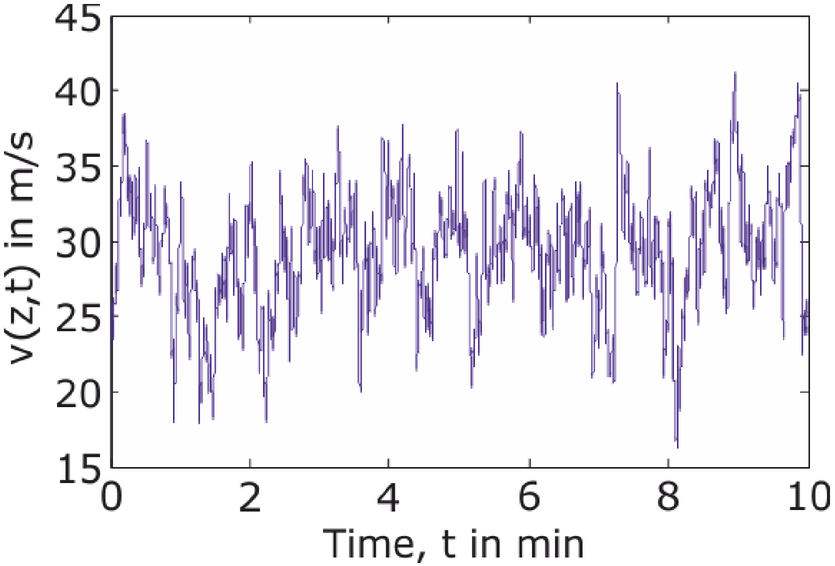


5 classes of wind speeds



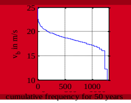
Turbulent wind field based on provisions

Generation of a 10 minutes wind field

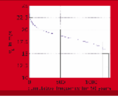


From wind velocity to tensile force

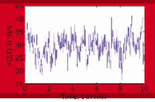
Wind velocities in 50 years



→ 5 classes of wind speeds

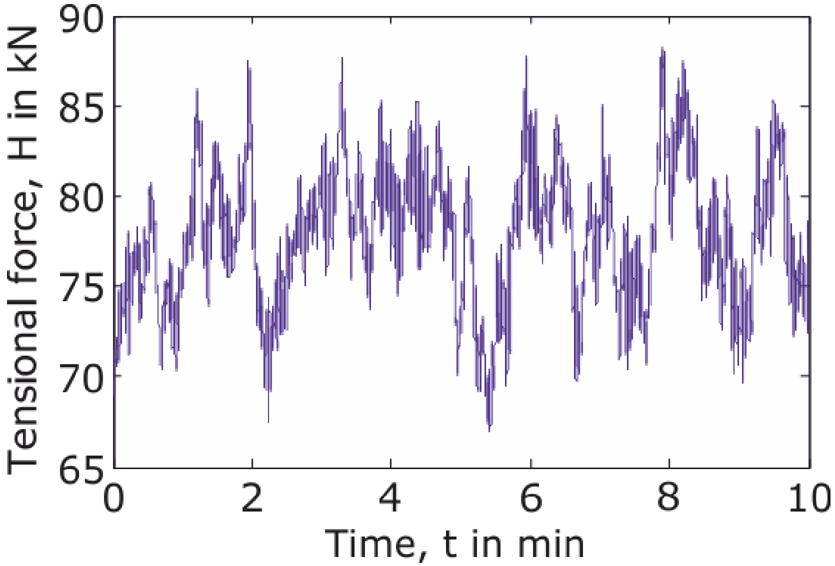


→ Turbulent wind field based on provisions

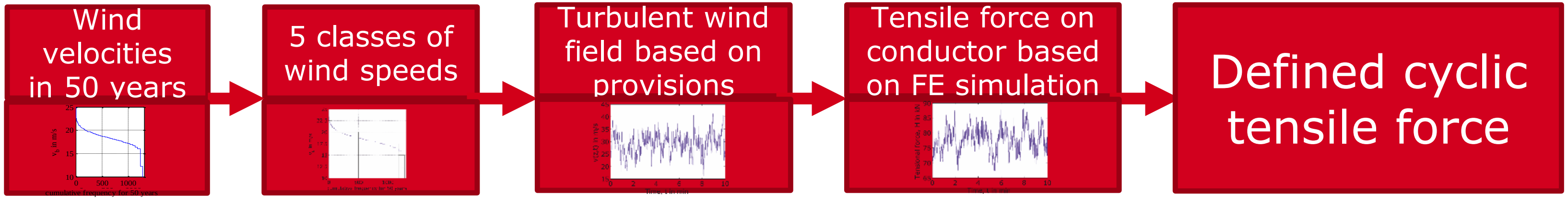


→ Tensile force on conductor based on FE simulation →

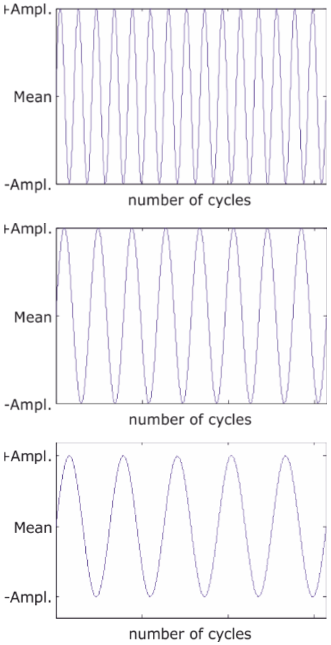
Validated FE-model for existing overhead line in Northern Germany



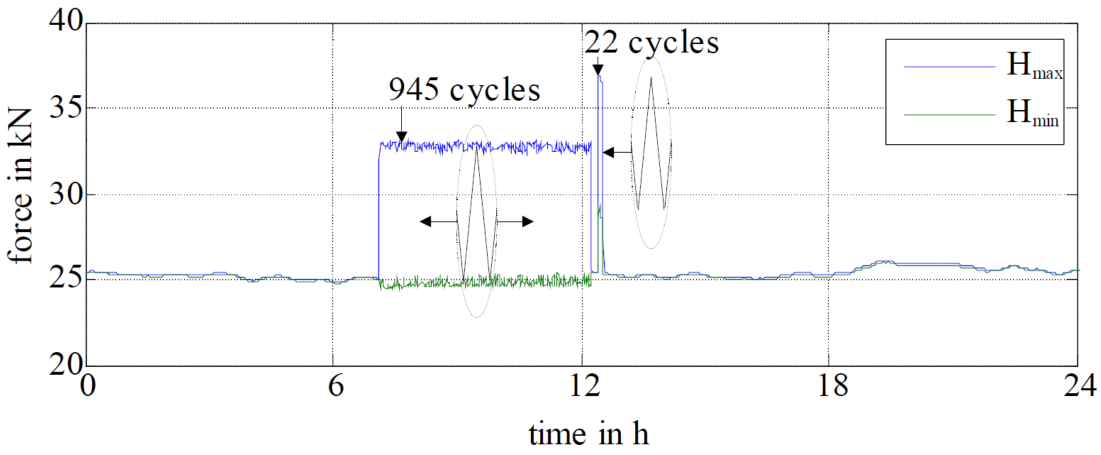
From wind velocity to tensile force



- Equivalent harmonic forces with defined mean, amplitude and number of cycles using rainflow count
- Reduction to 3 cyclic loads and amplitudes using Palmgren-Miner



Cyclic loading for ACSS (RTS = 156 kN)

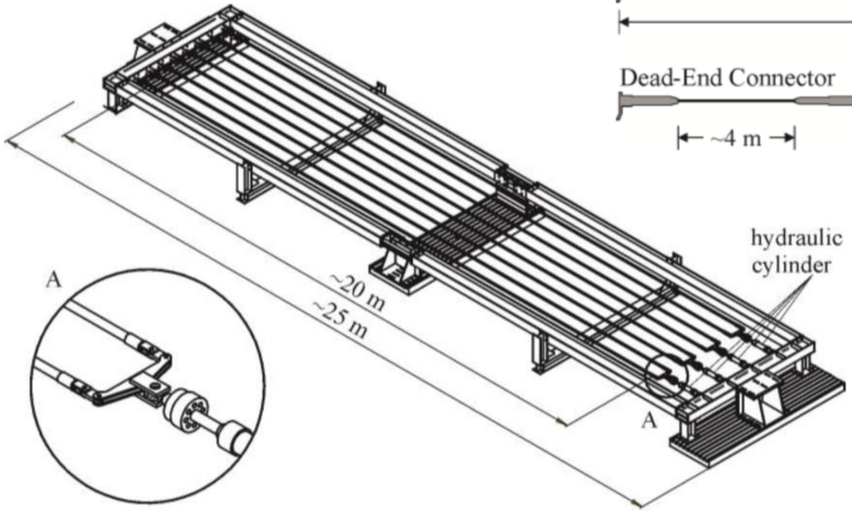


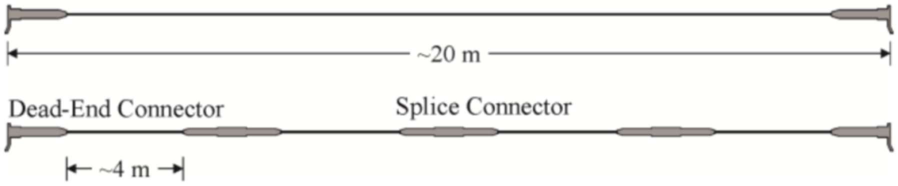
x 150 days at 200 °C

	Minimum load [kN]	Maximum load [kN]	Number of cycles
Static loading	24	24	Constant
Wind load 1	24	33	141,780
Wind load 2	29	37	3300
Wind load 3	33	41	30

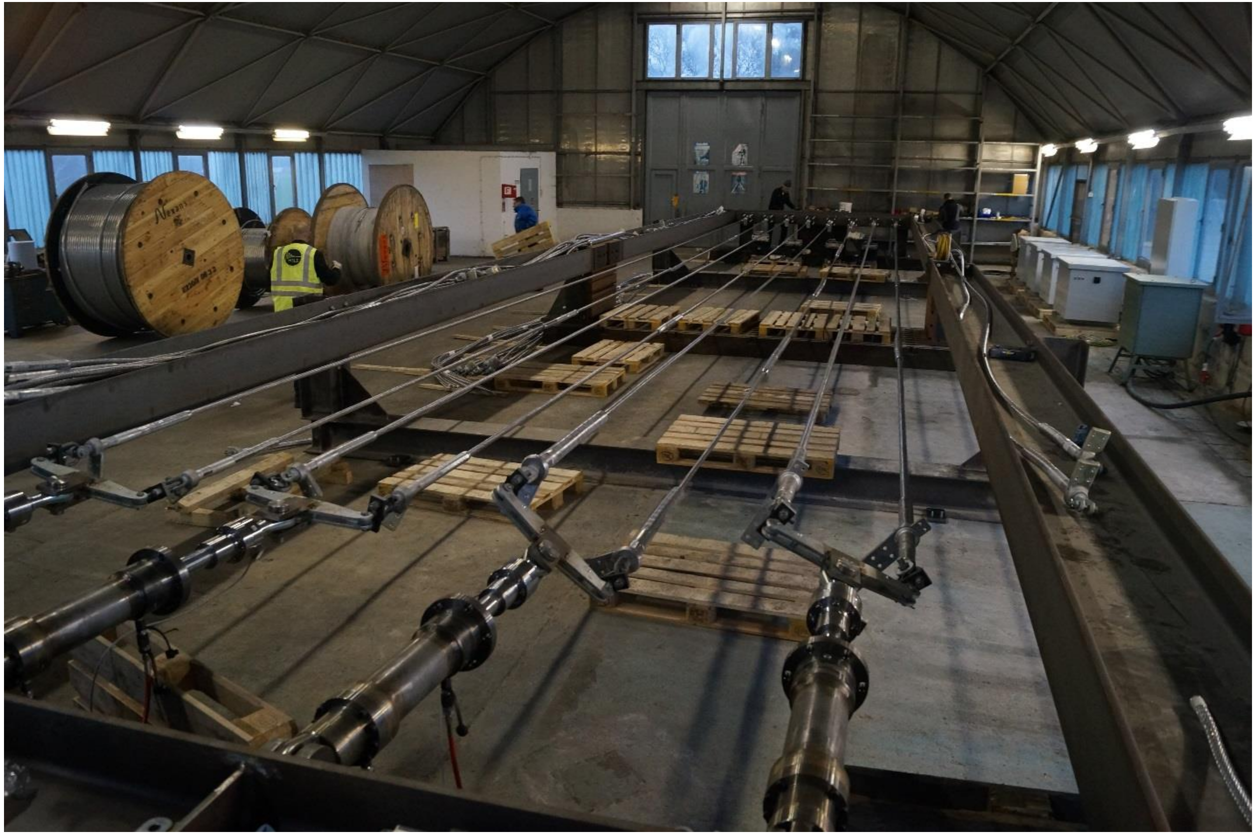
Testing rack for artificial ageing

- Test of 4 different conductor types simultaneously in two parallel lines
- Conductor length of approximately 20m





Testing rack in Ragow (Germany)



Conductor tests

Single wire stress strain

Conductor stress strain

Creep

Self-damping

Ductility test on wires

Grease test

Electrical resistance (TU Dresden)

Electrical and mechanical accessories tests

Test result: Tensile strength of aluminum

- Note: in the original presentation, a significant drop of tensile strength in aluminum alloy AT3 was described.
- This was due to a insufficient quality of the product, delivered by the manufacturer
- In validation experiments, no significant drop of tensile strength in AT3 was detected

Summary

- Scientific development of an artificial ageing regime
- Successful implementation in a test stand
- Ageing of 8 different conductor technologies
- Extensive mechanical and electrical test program prior and after ageing
- First test results show interesting ageing effects
- Overall results expected at the end of 2017

Test specimen

20 m continuous conductor with dead end clamps

20 m conductor with 3 splice connectors and dead end clamps
(cut out piece for single-wire tests)