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The challenges of the offshore environment

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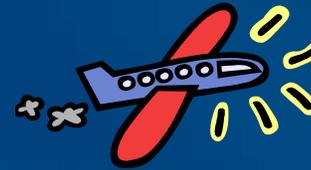
Programme

- The offshore environment
- From environment to requirements
- Classification of corrosivity
- Case study – design of accelerated salt mist
- Design guidelines
- Conclusion

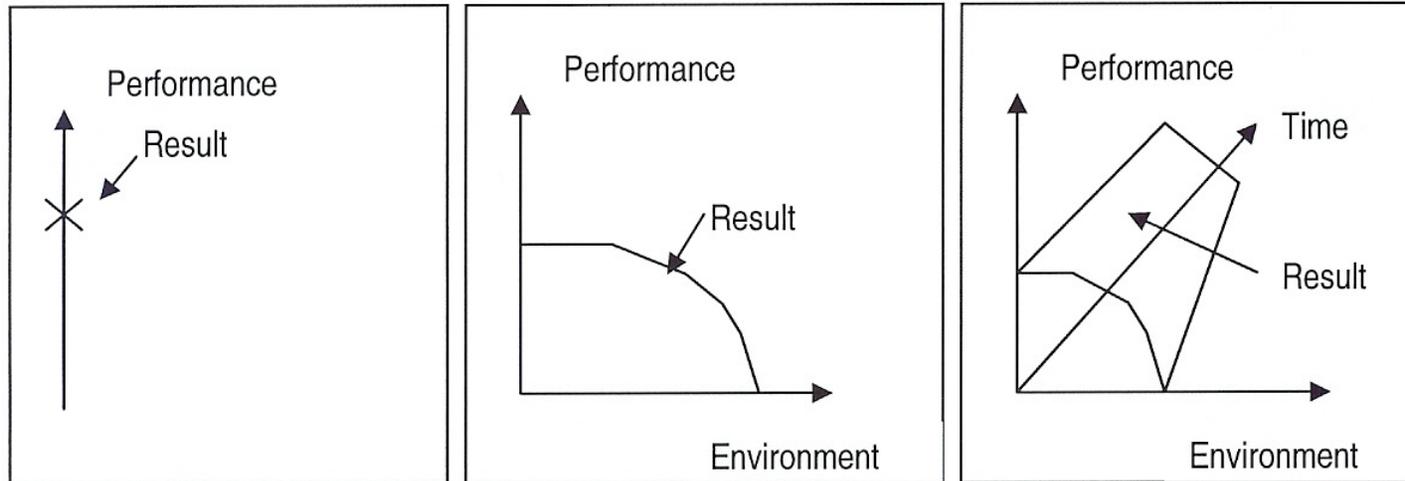


The offshore environment

- Solar radiation
- Temperature, humidity, icing,
- Corrosion, rain, hail
- Vibration
- Bump, shock
- Lightning
- Electromagnetic disturbances



From environment to requirements



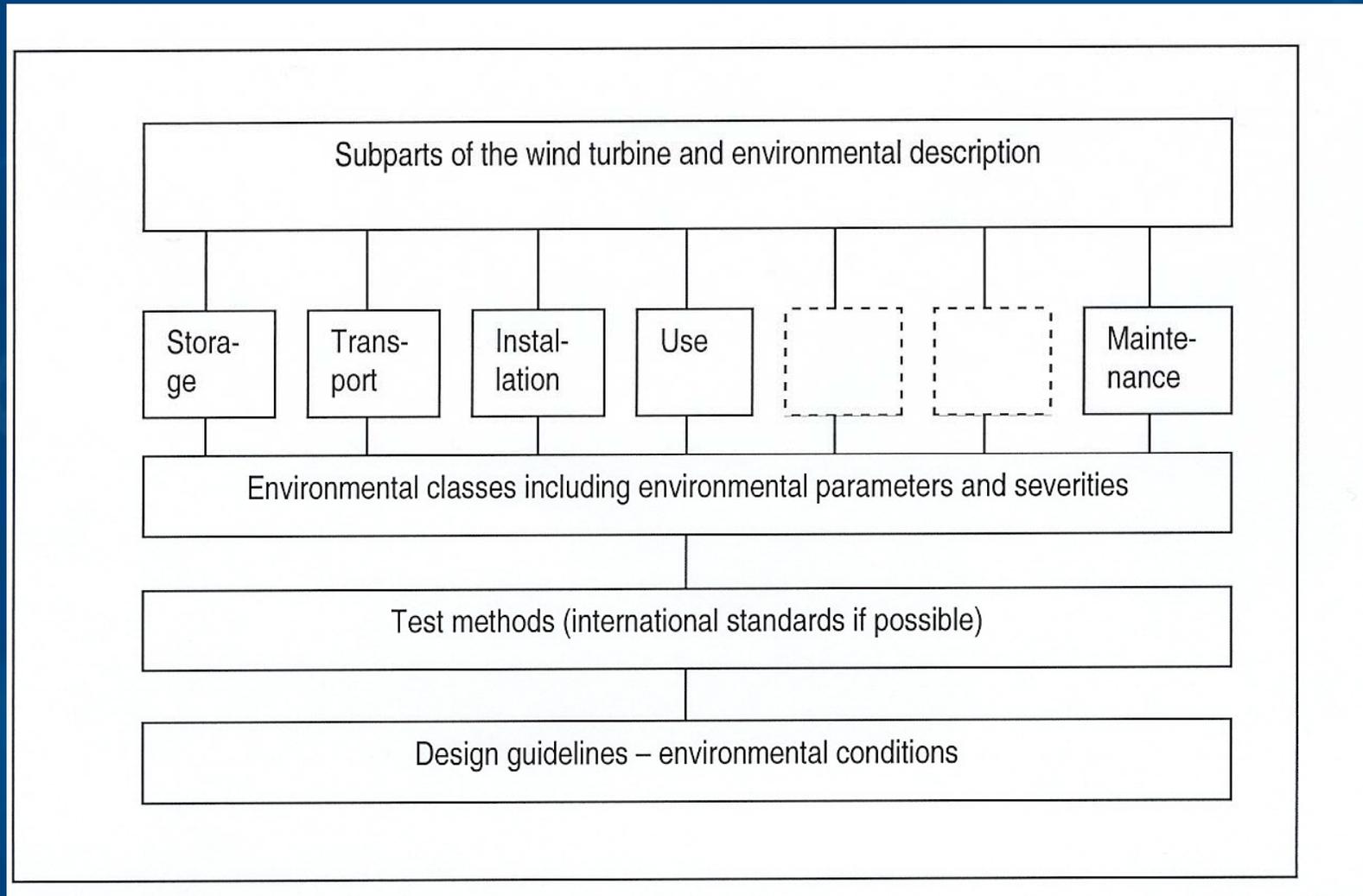
Function verification tests

Environmental tests

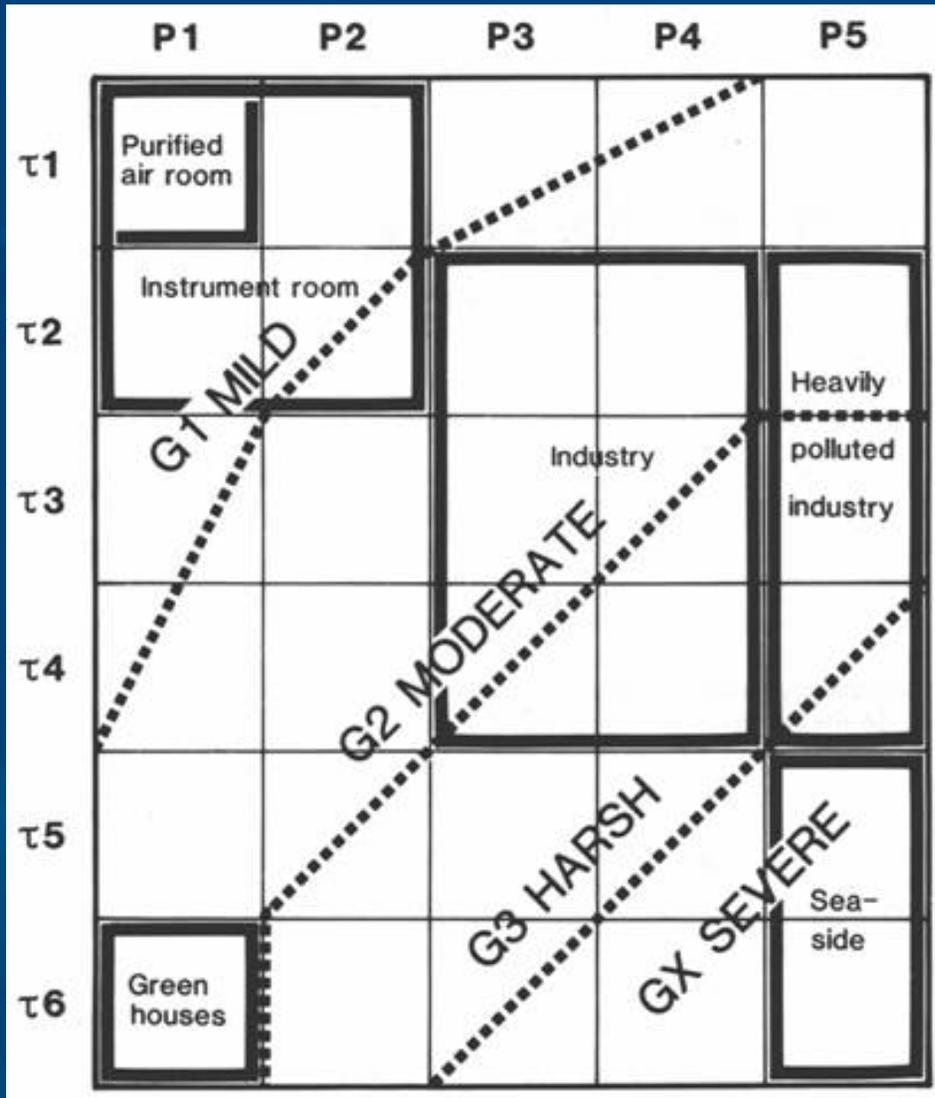
Reliability tests

Definition of purpose and constraints

Paradigm for design of environmental requirements



Classification of corrosion environments



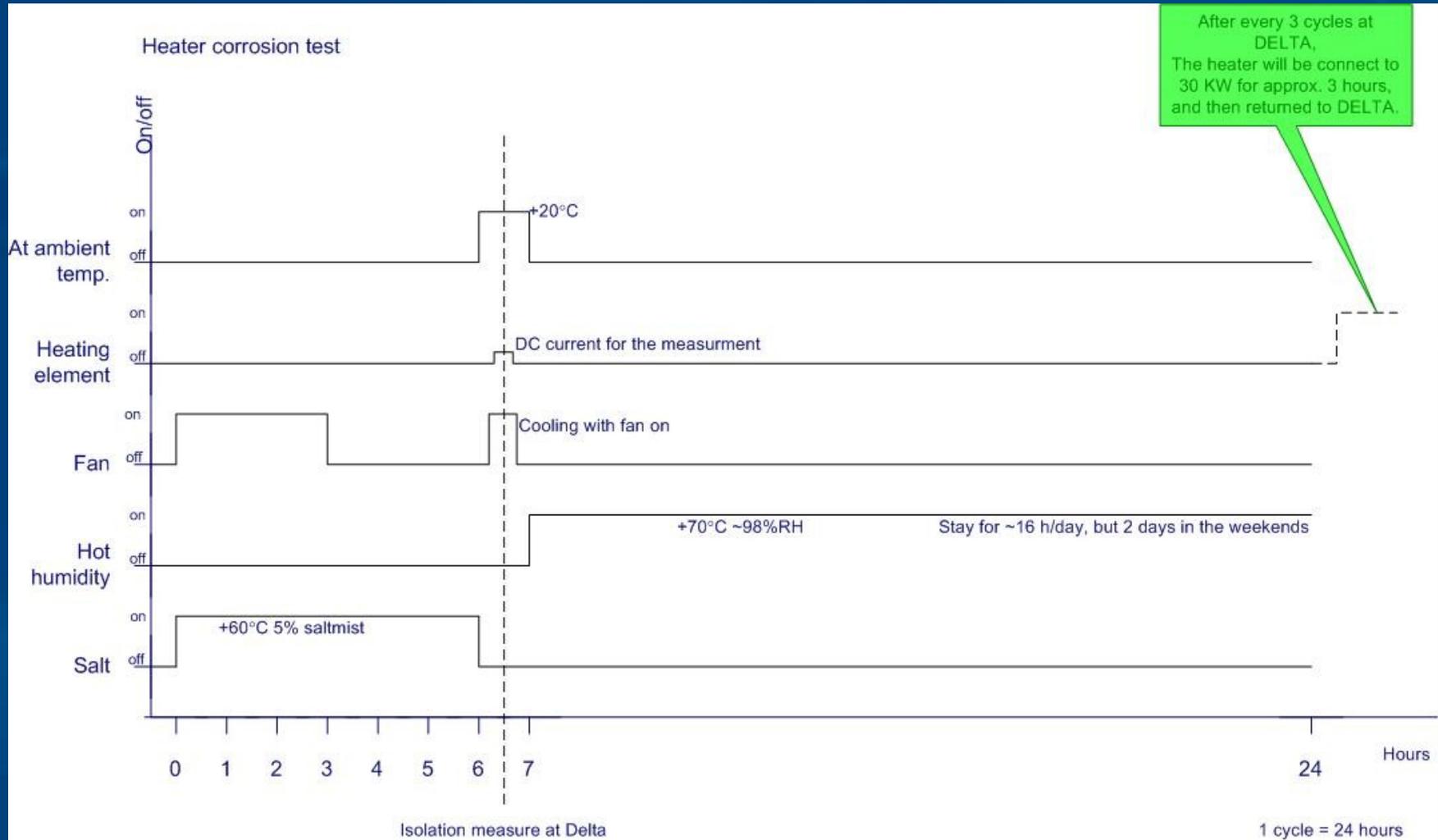
| Category | Time of wetness | | Example of occurrence. |
|----------|-----------------|-----------|----------------------------------------------------------------------------------------------------|
| | hours/year | % of year | |
| τ1 | < 10 | < 0.1 | Indoor air with climatic control. |
| τ2 | 10–250 | 0.1–3 | Indoor air in normal rooms for living or working condition. |
| τ3 | 250–1000 | 3–10 | Indoor air storage rooms . |
| τ4 | 1000–2500 | 10–30 | Indoor air in some production rooms. Outdoor air in cold zone, dry zone, parts of temperated zone. |
| τ5 | 2500–5500 | 30–60 | Outdoor air in parts of temperated zone, parts of warm zone. Indoor air in animal houses. |
| τ6 | >5500 | >60 | Outdoor air in tropical zone. Indoor air in greenhouse. |

| Category | Pollutants $\mu\text{g}/\text{m}^3$ | | | | | | | Remarks |
|----------------|-------------------------------------|-----------------|-----------------------------------------------|-----------------|-----------------------------------------------|-------|--------|----------------|
| | SO ₂ | NO ₂ | H ₂ S | Cl ₂ | NH ₃ +NH ₄ ⁺ | CF | Soot | |
| P1 (very low) | <10 | <25 | <3 | <1 | <10 | <1 | <2 | Rooms purified |
| P2 (low) | 10–30 | 25–150 | 3–10 ¹⁾ 3–20 ²⁾ | 1–2 | 10–250 | 1–5 | 2–20 | |
| P3 (medium) | 30–100 | 150–500 | 10–50 ¹⁾ 20–100 ²⁾ | 2–5 | 250–1000 | 5–10 | 20–75 | |
| P4 (high) | 100–300 | 500–1000 | 50–100 ¹⁾ 100–200 ²⁾ | 5–10 | 1000–10000 | 10–50 | 75–150 | |
| P5 (very high) | >300 | >1000 | >100 ¹⁾ >200 ²⁾ | >10 | >10000 | >50 | >150 | |

¹⁾ Limits if silver is used. ²⁾ Limits for other materials than silver.

SO₂ 1 $\mu\text{g}/\text{m}^3$ = 0.38 mm³/m³ NO₂ 1 $\mu\text{g}/\text{m}^3$ = 0.53 mm³/m³
 H₂S 1 $\mu\text{g}/\text{m}^3$ = 0.71 mm³/m³ Cl₂ 1 $\mu\text{g}/\text{m}^3$ = 0.34 mm³/m³
 NH₃ 1 $\mu\text{g}/\text{m}^3$ = 1.43 mm³/m³

Case study – design of accelerated salt mist test



Design guidelines

- Temperature limits – thermal management
- Humidity requirements – sealing/ventilation/heating
- Corrosion – selection of materials
- Vibration requirements – mounting, fastening, dimensions
- Electromagnetic disturbances – grounding, filtering

Conclusion

- The offshore environment is significantly more severe than that of land based wind turbines
- Environmental requirements are basis of the design and development process
- A paradigm for the design of environmental requirements is suggested
- Further measurements of environmental data are required
- Transformation of field data/test experience into an accelerated salt mist test is demonstrated