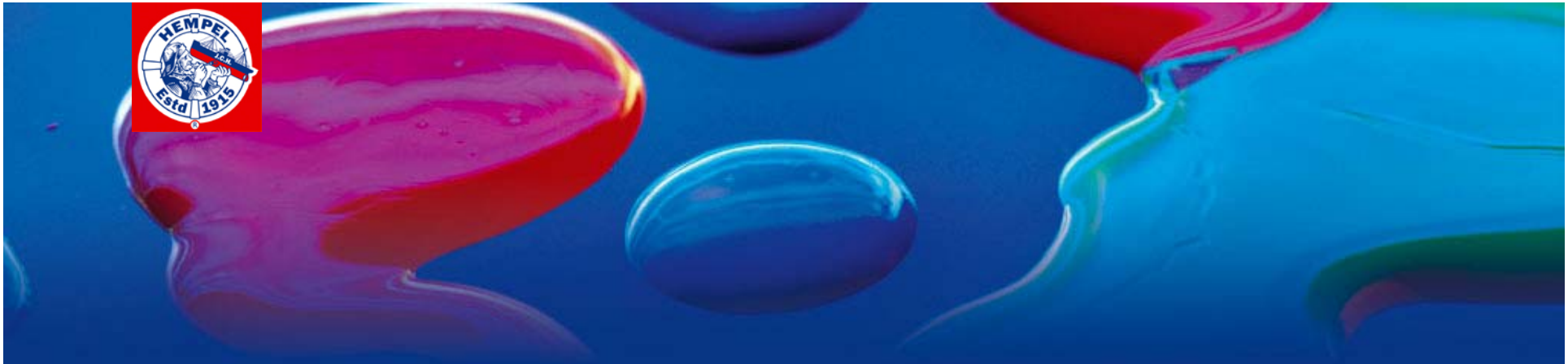

CORROSION PROTECTION OF OFFSHORE WIND TURBINES

By

Søren Nyborg Rasmussen

HEMPEL A/S

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THE OFFSHORE CHALLENGE

- **ABOVE WATER:**
  UV-light, Water, Chlorides, Oxygen.
  Corrosion rate of steel: 80 – 200 µm/year

- **SPLASH ZONE:**
  UV-light, Water, Chlorides, Oxygen, Water erosion, Debris and Ice?
  Corrosion rate of steel: 200 – 500 µm/year

- **BELOW THE WATERLINE:**
  Water, Chlorides, Oxygen, Fouling.
  Corrosion rate of steel: 100 – 200 µm/year

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COATINGS OFFER CORROSION PROTECTION

And can protect steel for many years

But it is not easy and simple – many factors must be considered and proper workmanship is crucial !

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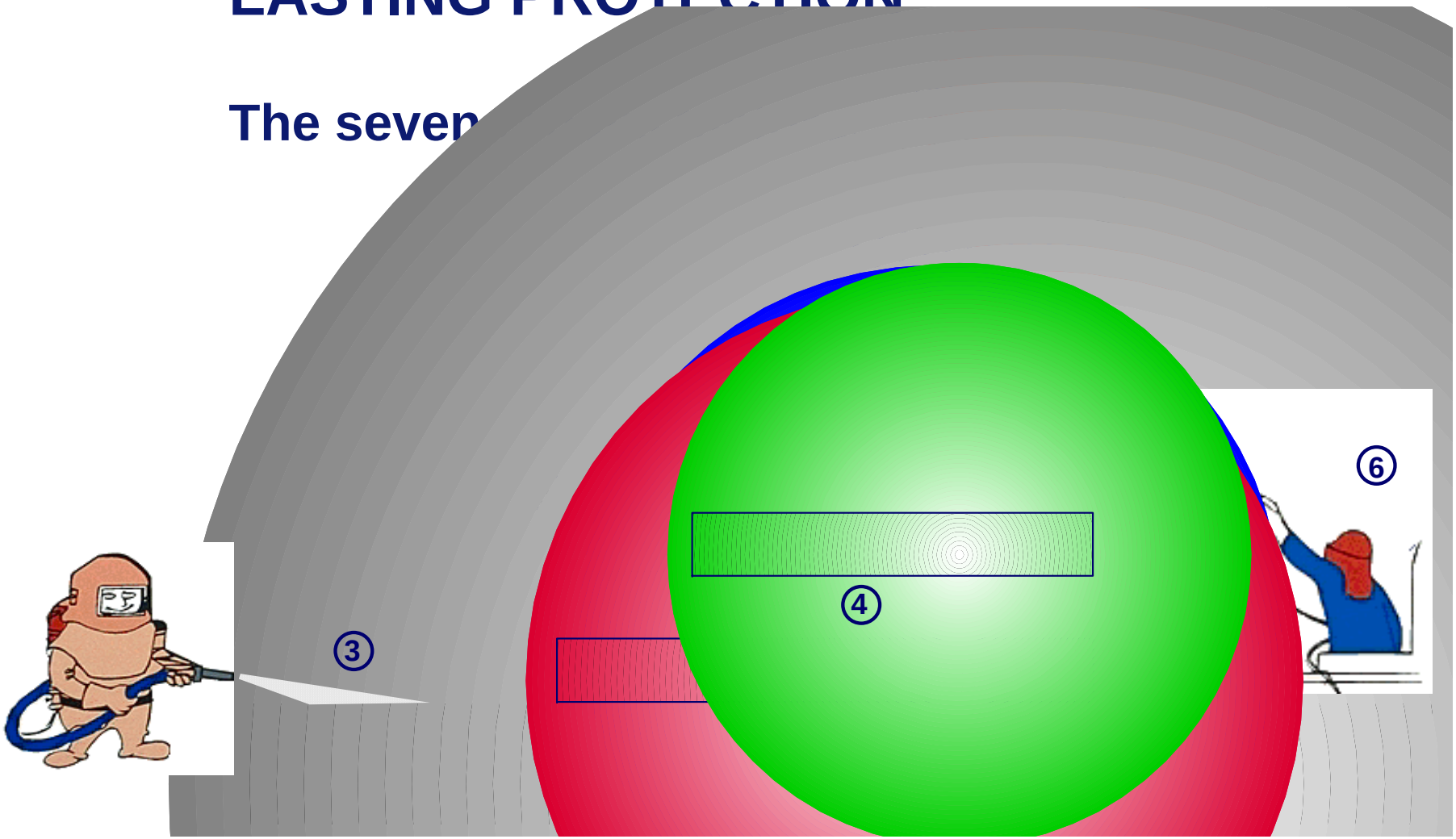
REQUIREMENTS FOR LONG LASTING PROTECTION

The seven



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SURFACE PREPARATION

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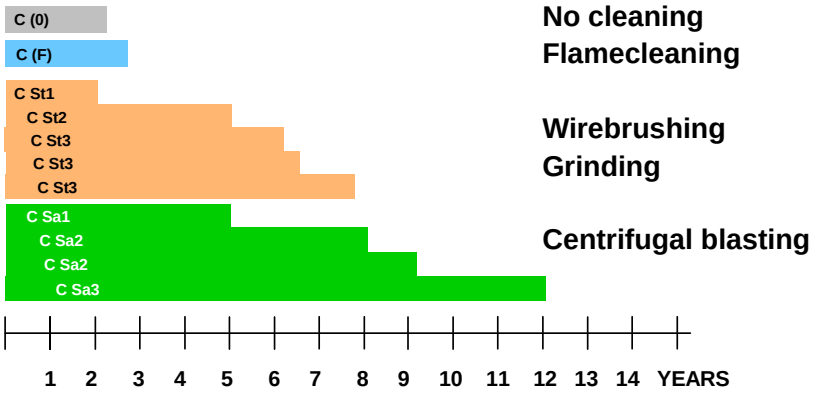
SURFACE PREPARATION

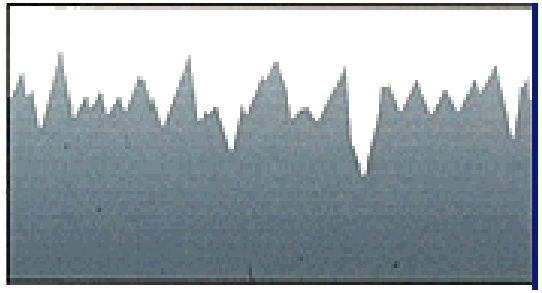
The better the surface preparation the longer the lifetime



No cleaning
Flamecleaning

Wirebrushing
Grinding

Centrifugal blasting



Cleanliness

Roughness

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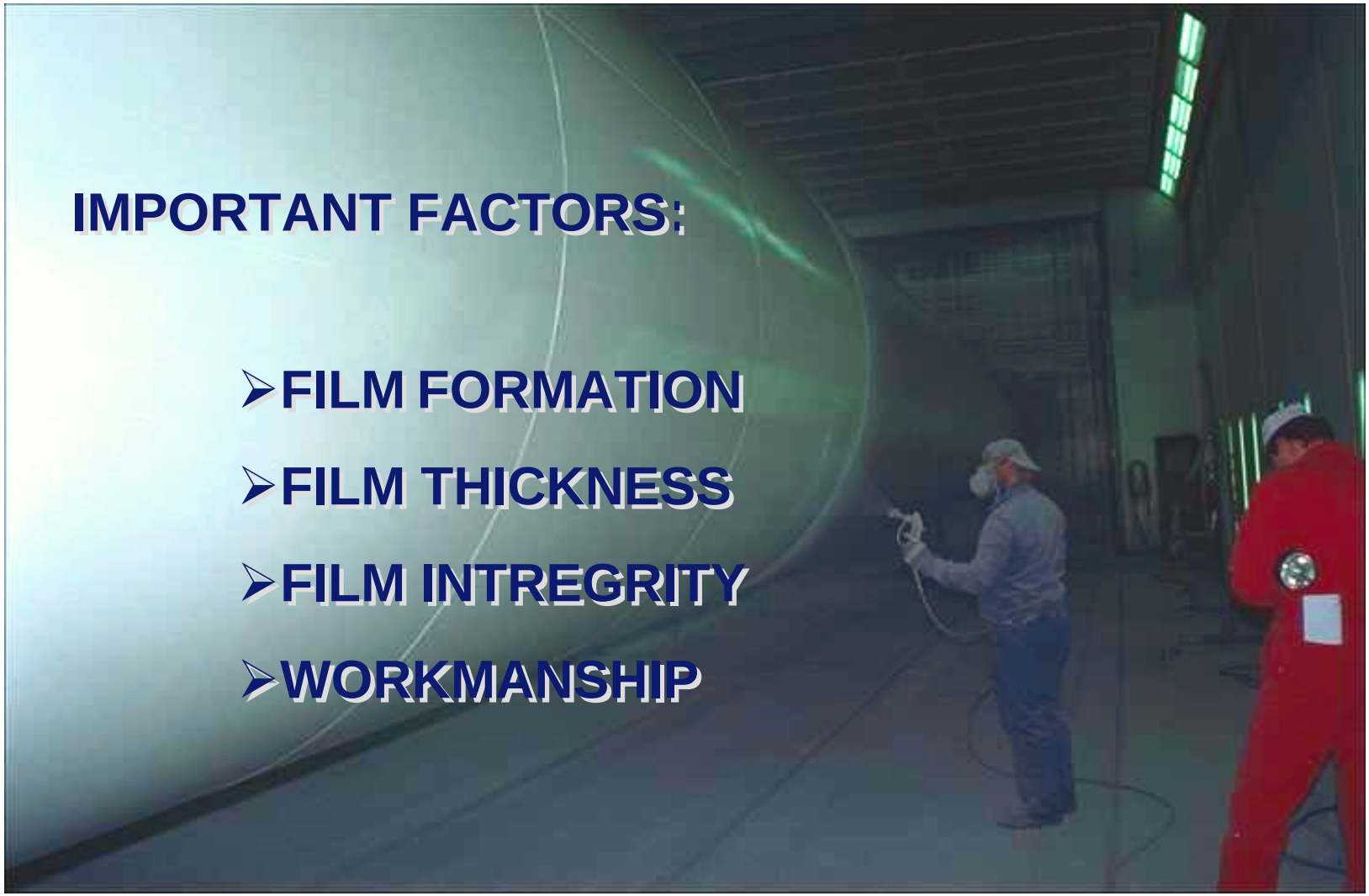
PAINT APPLICATION



IMPORTANT FACTORS:

- FILM FORMATION
- FILM THICKNESS
- FILM INTREGRITY
- WORKMANSHIP

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CHOICE OF COATING SYSTEM

IMPORTANT FACTORS

- GENERIC TYPES OF COATINGS
- NUMBER OF COATS
- TOTAL FILMTHICKNESS
- MECHANICAL DESIGN
- QUALITY OF THE COATINGS

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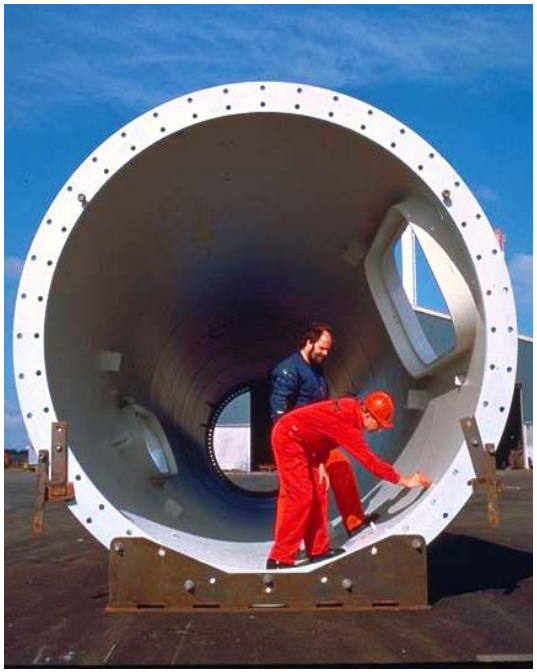
QUALITY CONTROL

IS A MUST IN ALL STAGES OF THE JOB!

	1983 – 1990 (without ISO 9000)	1990 – 2000 (with ISO 9000)
Faulty coating material	2 %	2 %
Wrong specification	19 %	41 %
Changed environmental conditions	11 %	11 %
Faulty processing/wrong application	68 %	46 %



Damage analysis, 120 cases, Australia

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OFFSHORE STANDARDS

- NORSOK M501 (first edition in 1994)
- ISO 12944 (first edition in 1998)
- ISO 20340 (first edition in 2003)
- NACE TM 0204, 0304 and 0404 (first editions in 2004)

NORSOK

ISO International Organization for Standardization

NACE INTERNATIONAL THE CORROSION SOCIETY

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THE OFFSHORE CHALLENGE

- **ABOVE WATER**:

  Zinc-Rich primer, Epoxy intermediate and polyurethane topcoat. Minimum 3 coats and minimum 320 µm DFT total.

- **SPLASH ZONE:**

  Epoxy or Polyester (Immersion grade). Minimum 2 coats and minimum 600 µm DFT total.

- **BELOW THE WATERLINE:**

  Epoxy (Immersion grade) Minimum 2 coats and minimum 450 µm DFT total.

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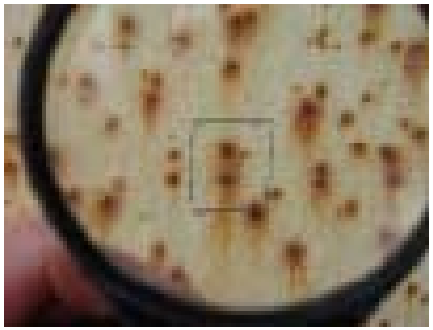
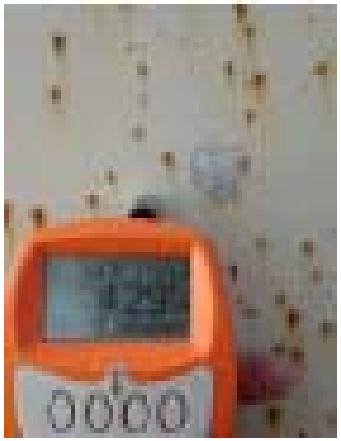
NO SHORTCUTS!





2 year old offshore wind turbine !

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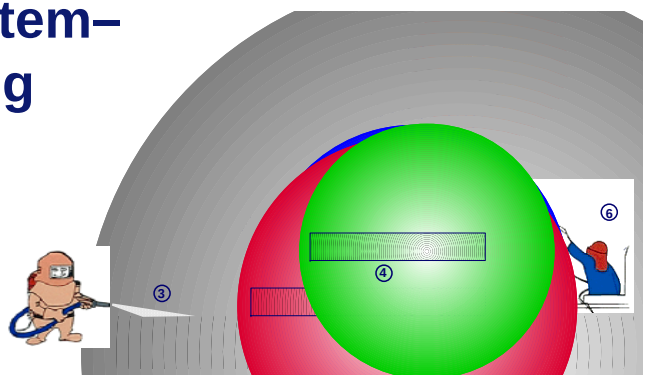
CONCLUSION

- ✓ Sound substrate
- ✓ Good surface preparation
- ✓ Proper application
- ✓ Right choice of coating system for the environment
- ✓ Quality coating system– confirmed by testing
- ✓ Proper inspection

High durability of the coating system



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