ENERGY

DNV GL standard harmonization – Recommended practice on corrosion protection of offshore wind farms“

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October 14th 2015

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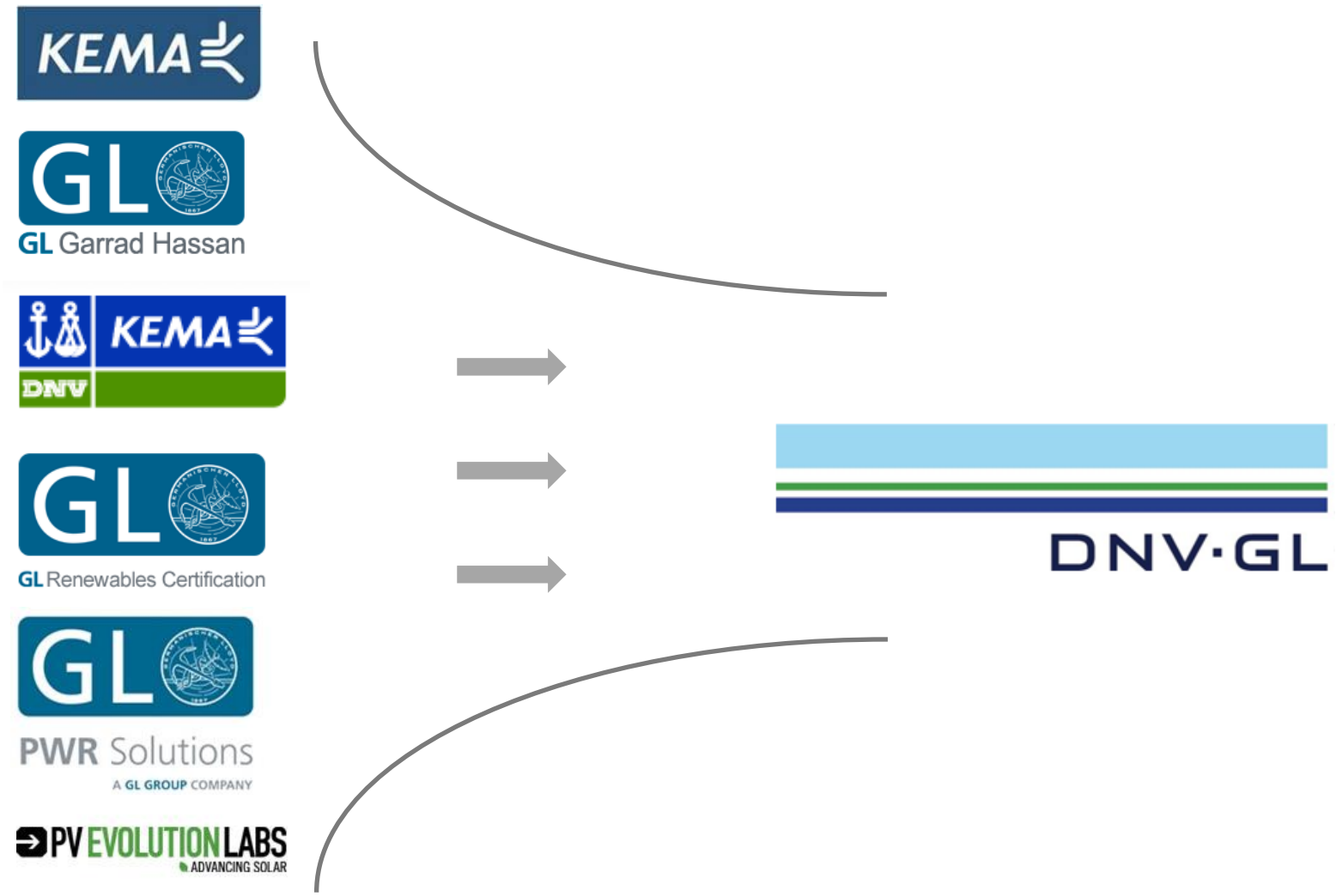
1. **Who we are**
2. Motivation
3. New Recommended Practice
4. Outlook

Who we are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- Government / NGOs

Industries:

- Onshore Wind
- Offshore Wind
- Wave + Tidal
- Solar




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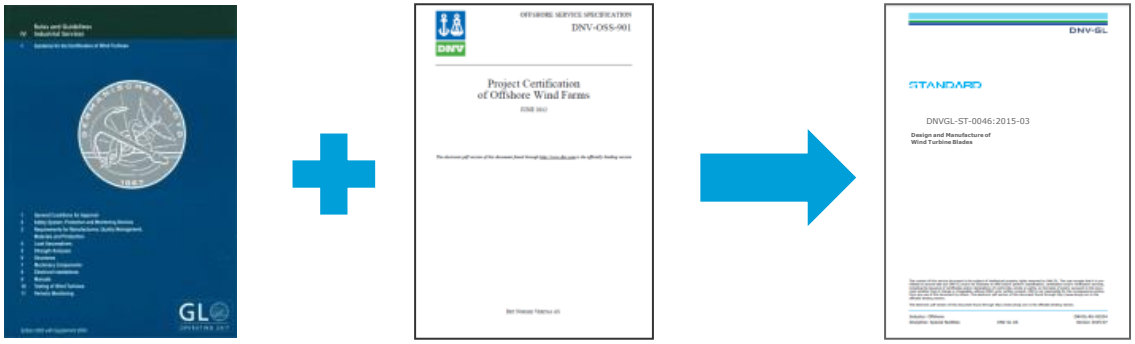
DNV GL: A Merger of Guidelines and Standards



- We want to profit from the knowledge and documents from both legacy organizations

- All legacy documents will be transferred to DNV GL system by end 2016
  - Legacy documents will be maintained to the absolute minimum required
  - All documents (legacy and new) shall be available by rules homepage

  http://www.dnvgl.com/rules-standards/default.aspx
- DNV GL will have service specifications in the fields of wind, tidal, wave and solar energy

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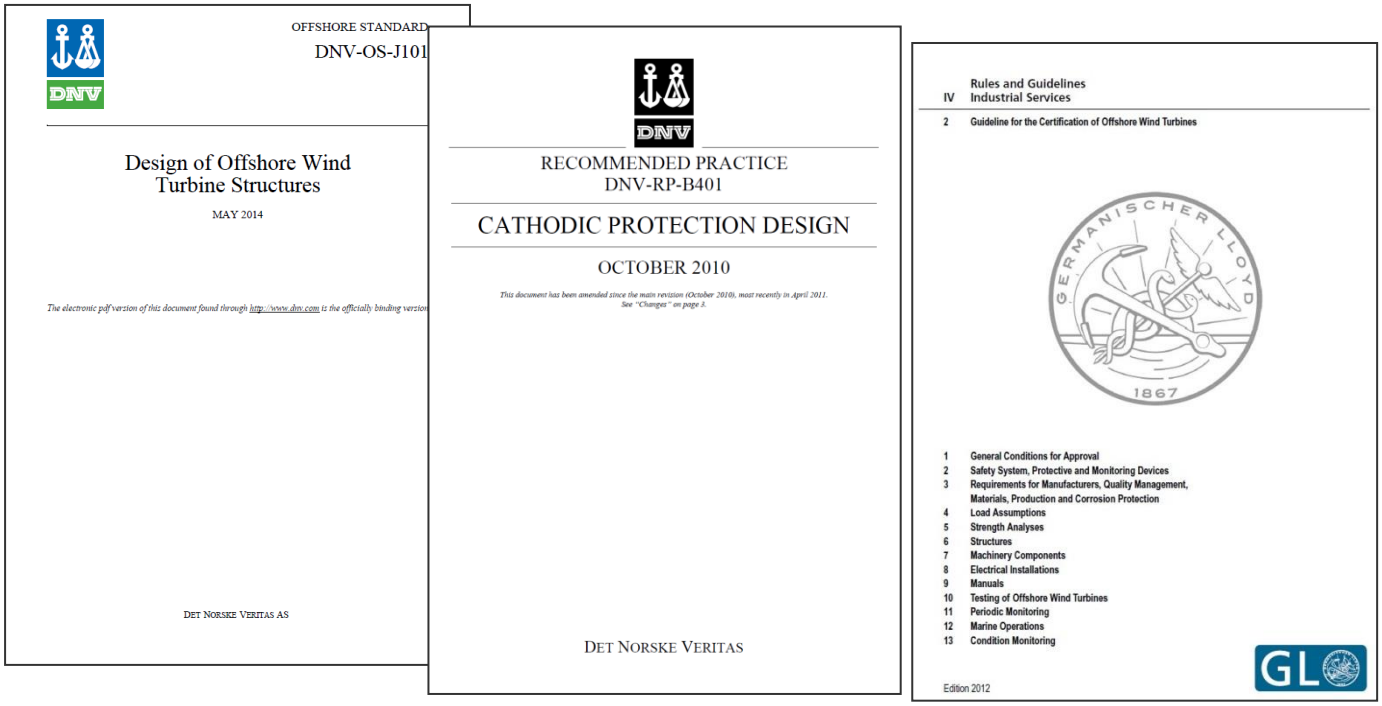
New Recommended Practice on Corrosion Protection

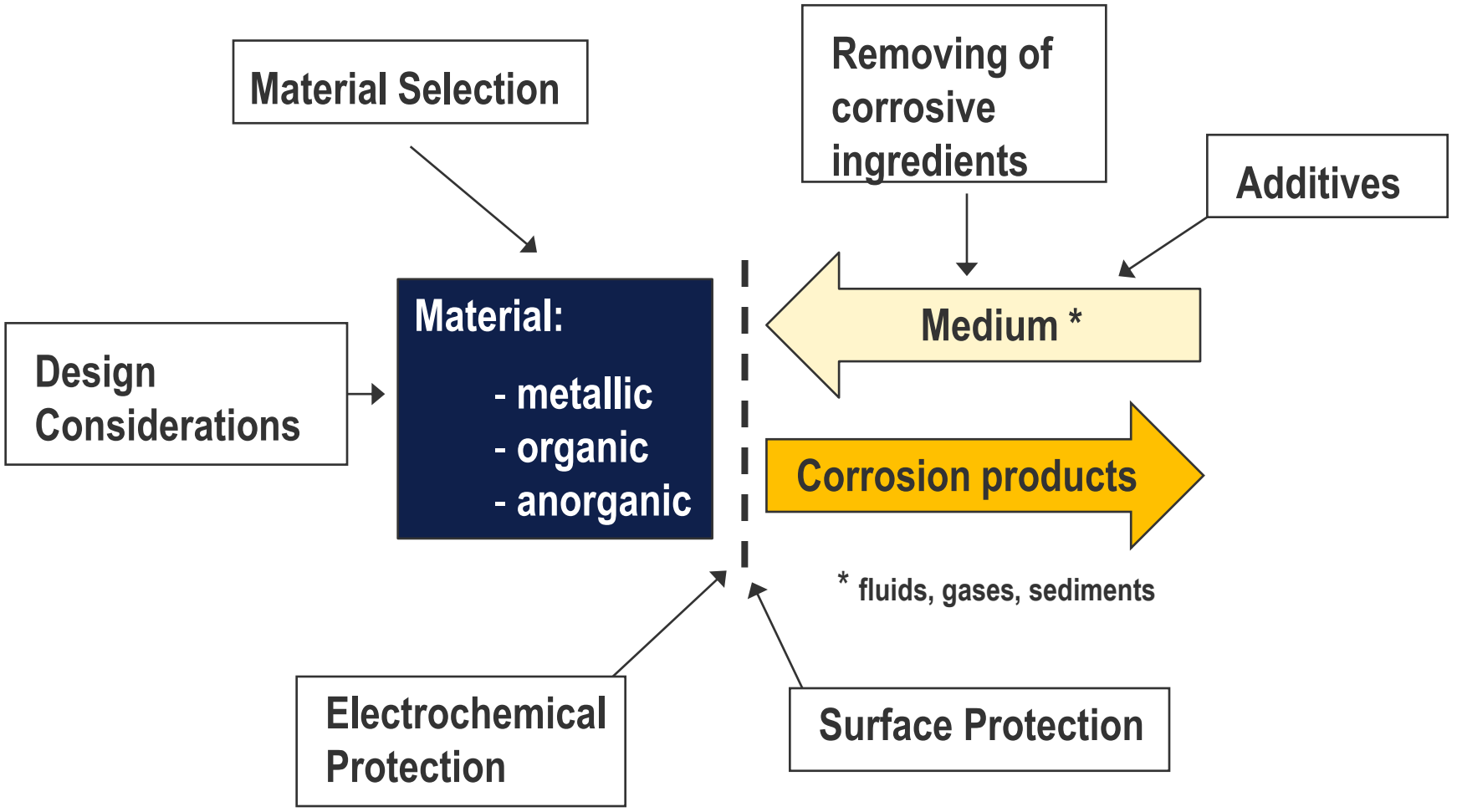
- Guidance on corrosion protection is currently being provided in DNV GL Guideline for the Certification of Offshore Wind Turbines, Edition 2012, DNV-OS-J101, or DNV-RP-B401. This guidance is updated and summarized in the upcoming DNV GL Recommended Practice on Corrosion Protection of Offshore Wind Farms.



Corrosion Protection Offshore

- Methods for corrosion protection of offshore wind farms shall include a holistic approach. They include corrosion allowance, cathodic protection, corrosion protective coatings and use of corrosion resistant materials.

Strategies of Corrosion Protection

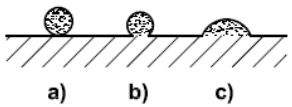
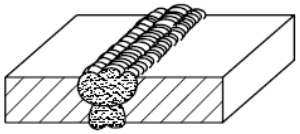
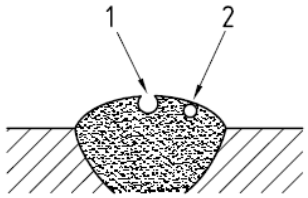
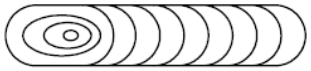


Corrosion Protection Offshore

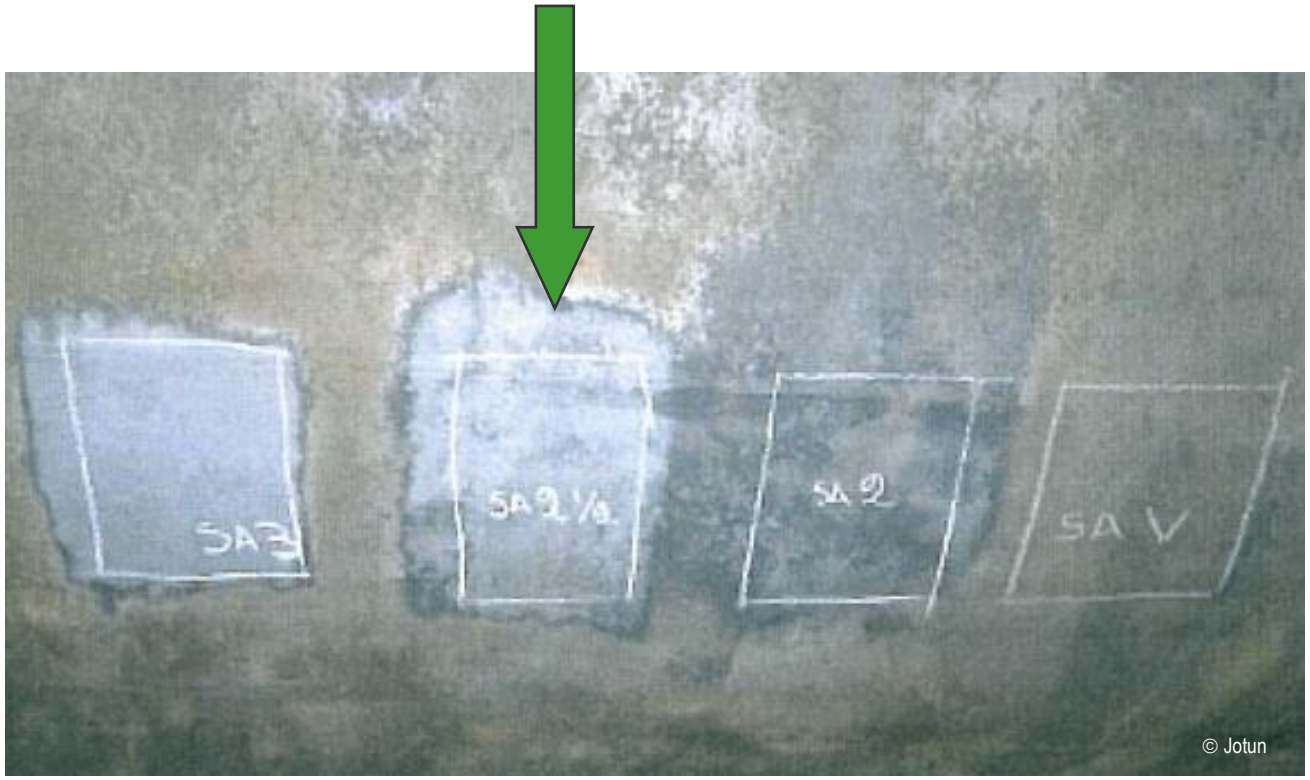
- The majority of coating failures on offshore wind turbines results from poor craftsmanship, often due to insufficient surface preparation. The structure shall be designed in such a way that the surface preparation and coating application can easily be performed.
- Minimum requirements for preparations of surfaces of offshore steel structure foundations acc. to ISO 8501-3 Table 1 shall be defined

ISO 8501-3 – preparation grades

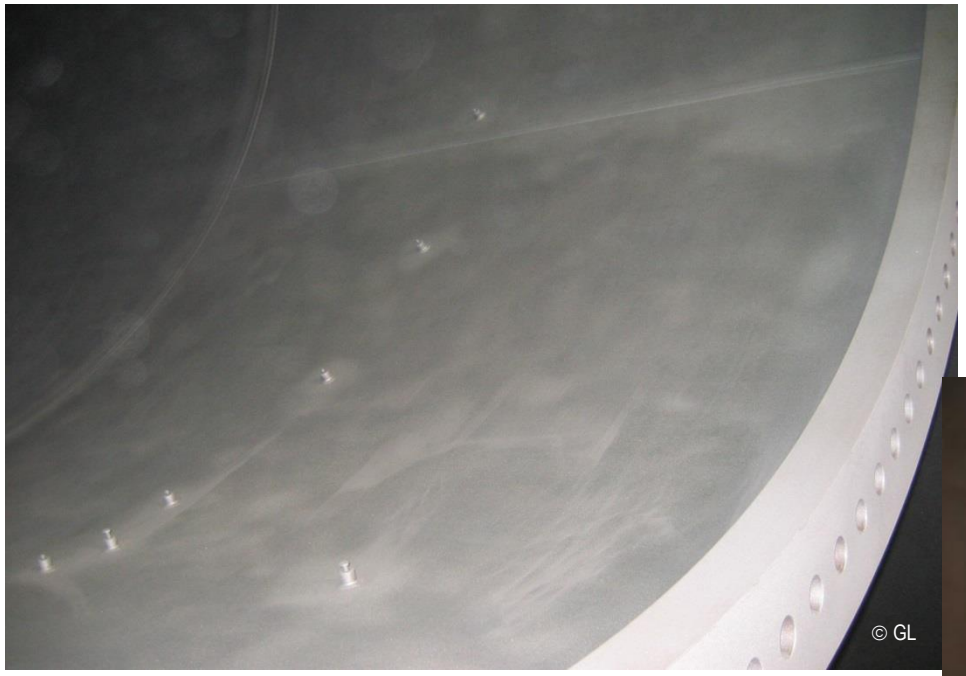
Table 1 — Imperfections and preparation grades

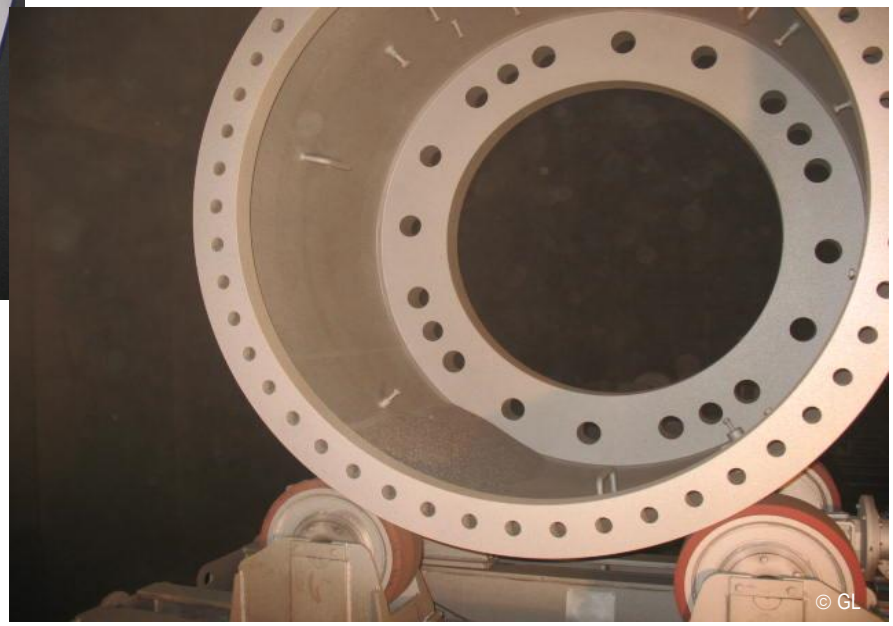
Type of imperfection		Preparation grades		
Description	Illustration	P1	P2	P3
1 Welds				
1.1 Welding spatter		Surface shall be free of all loose welding spatter [see a)]	Surface shall be free of all loose and lightly adhering welding spatter [see a) and b)] Welding spatter shown in c) may remain	Surface shall be free of all welding spatter
1.2 Weld ripple/profile		No preparation	Surface shall be dressed (e.g. by grinding) to remove irregular and sharp-edged profiles	Surface shall be fully dressed, i.e. smooth
1.3 Welding slag		Surface shall be free from welding slag	Surface shall be free from welding slag	Surface shall be free from welding slag
1.4 Undercut		No preparation	Surface shall be free from sharp or deep undercuts	Surface shall be free from undercuts
1.5 Weld porosity	 **Key** 1 visible 2 invisible (might open after abrasive blast cleaning)	No preparation	Surface pores shall be sufficiently open to allow penetration of paint, or dressed out	Surface shall be free from visible pores
1.6 End craters		No preparation	End craters shall be free from sharp edges	Surface shall be free from visible end craters

ISO 8501-1 – Examples

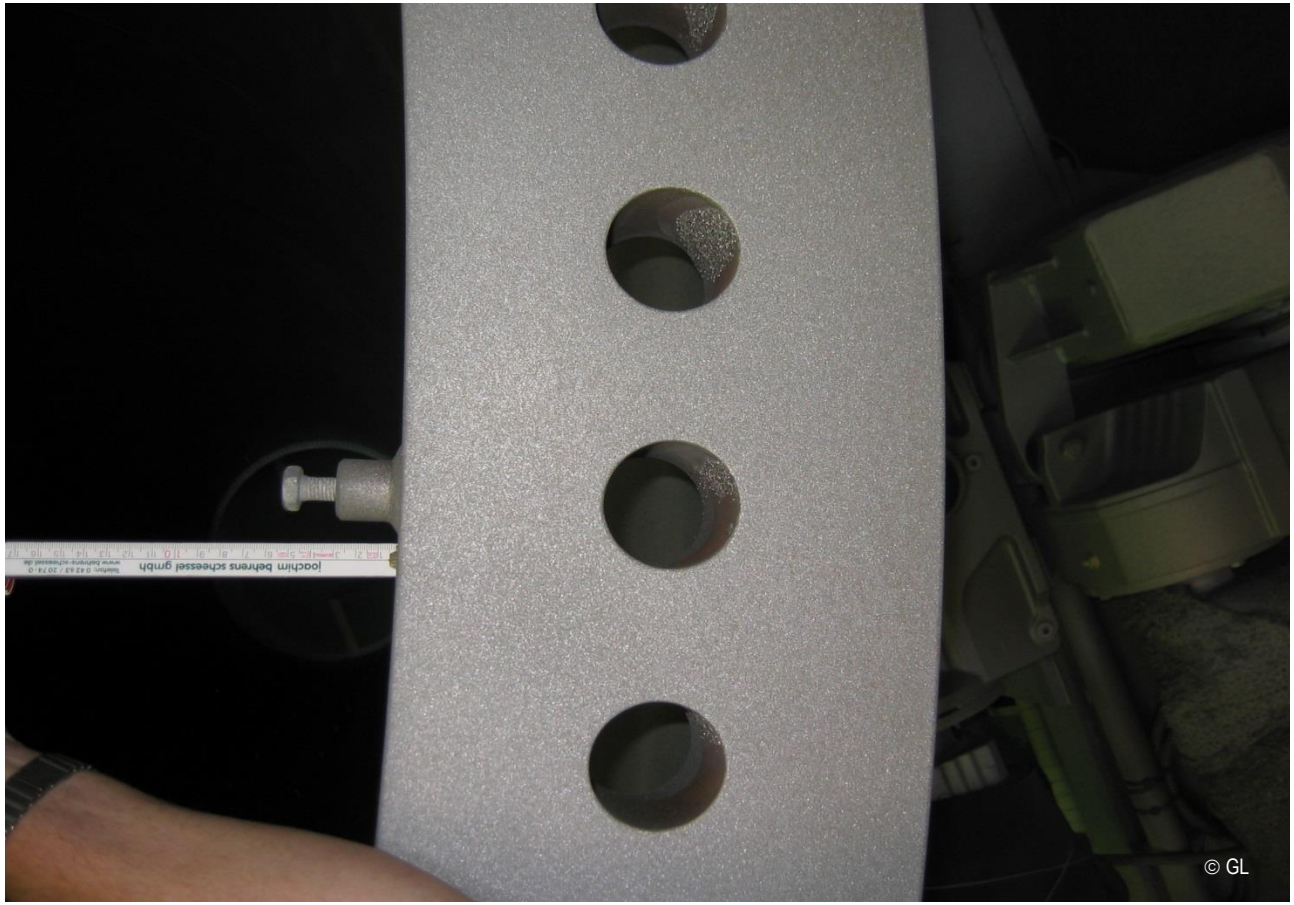


ISO 8501-1 – Examples

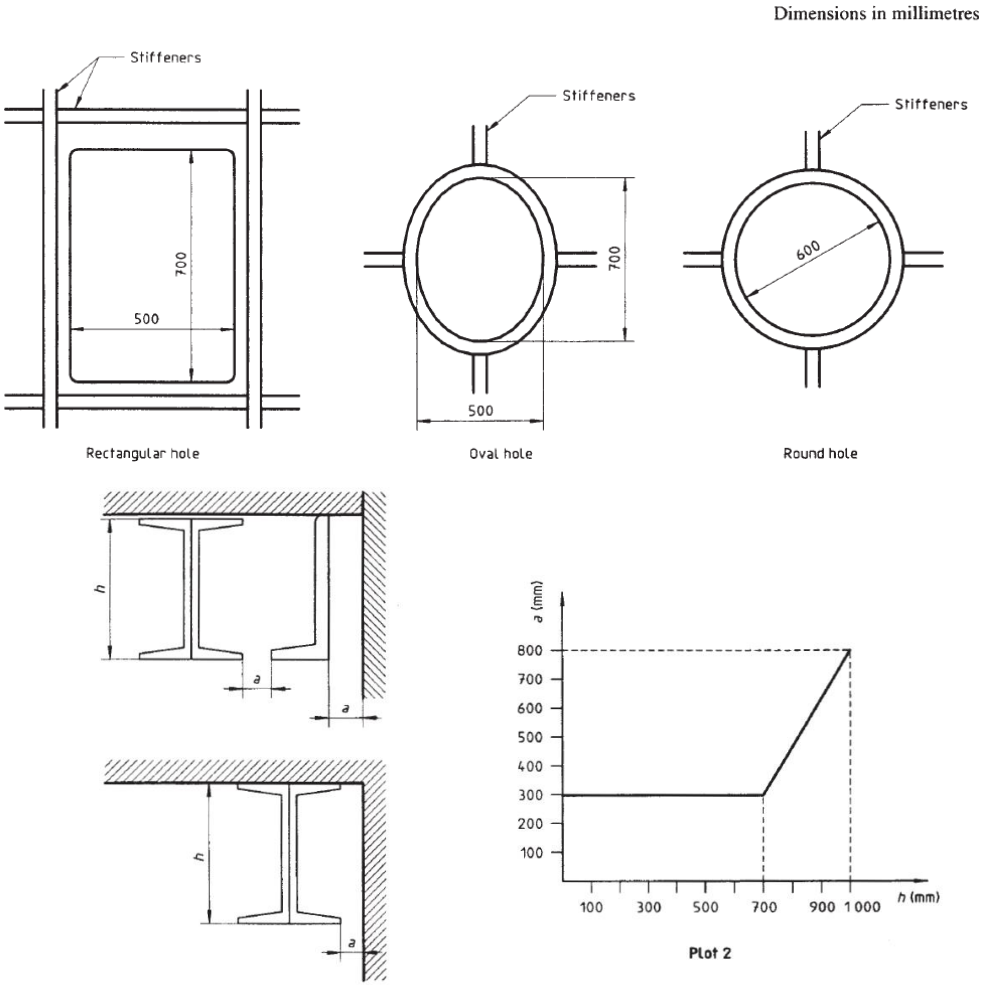




ISO 8501-1 – Examples



EN ISO 12944-3 Design considerations



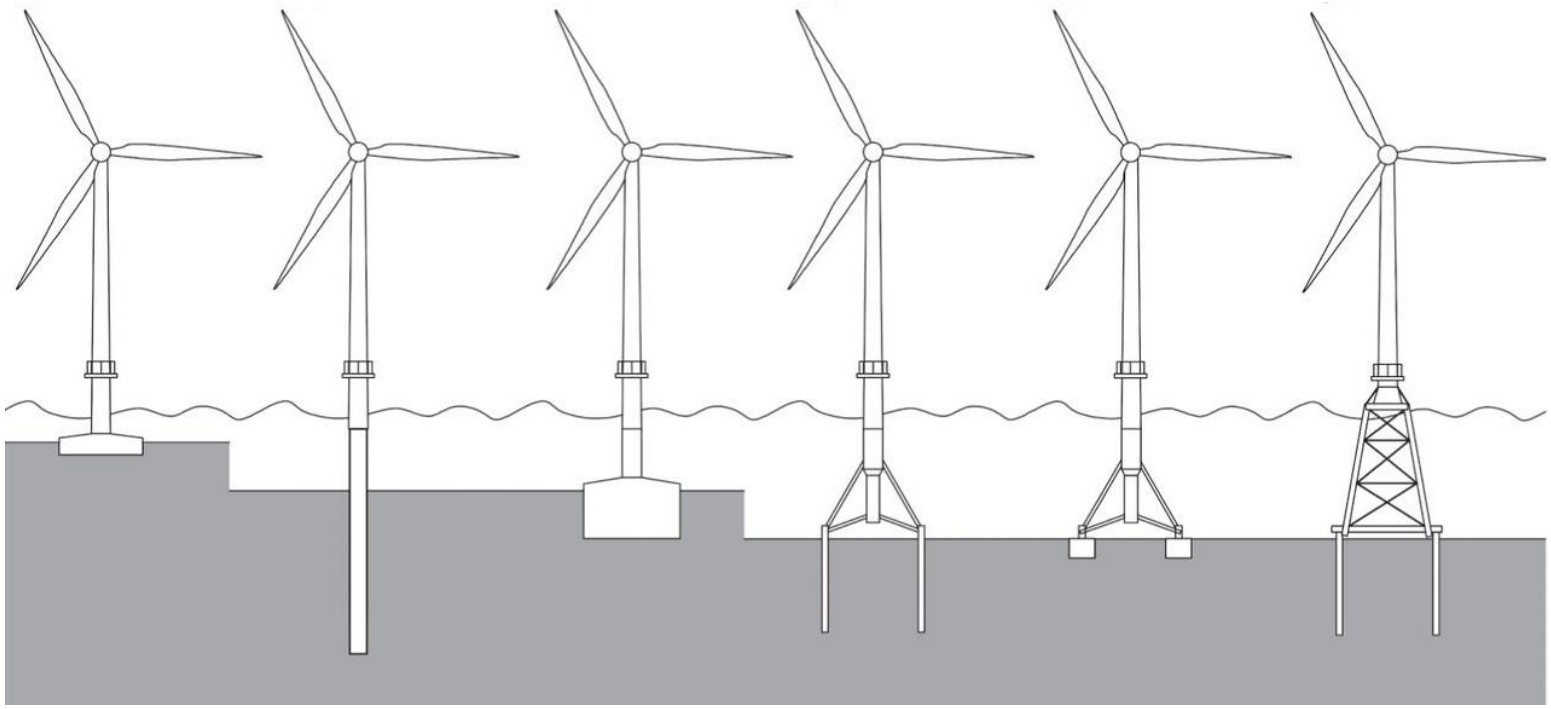
The minimum permitted distance *a* between the section and the adjacent surface is given by plot 2.

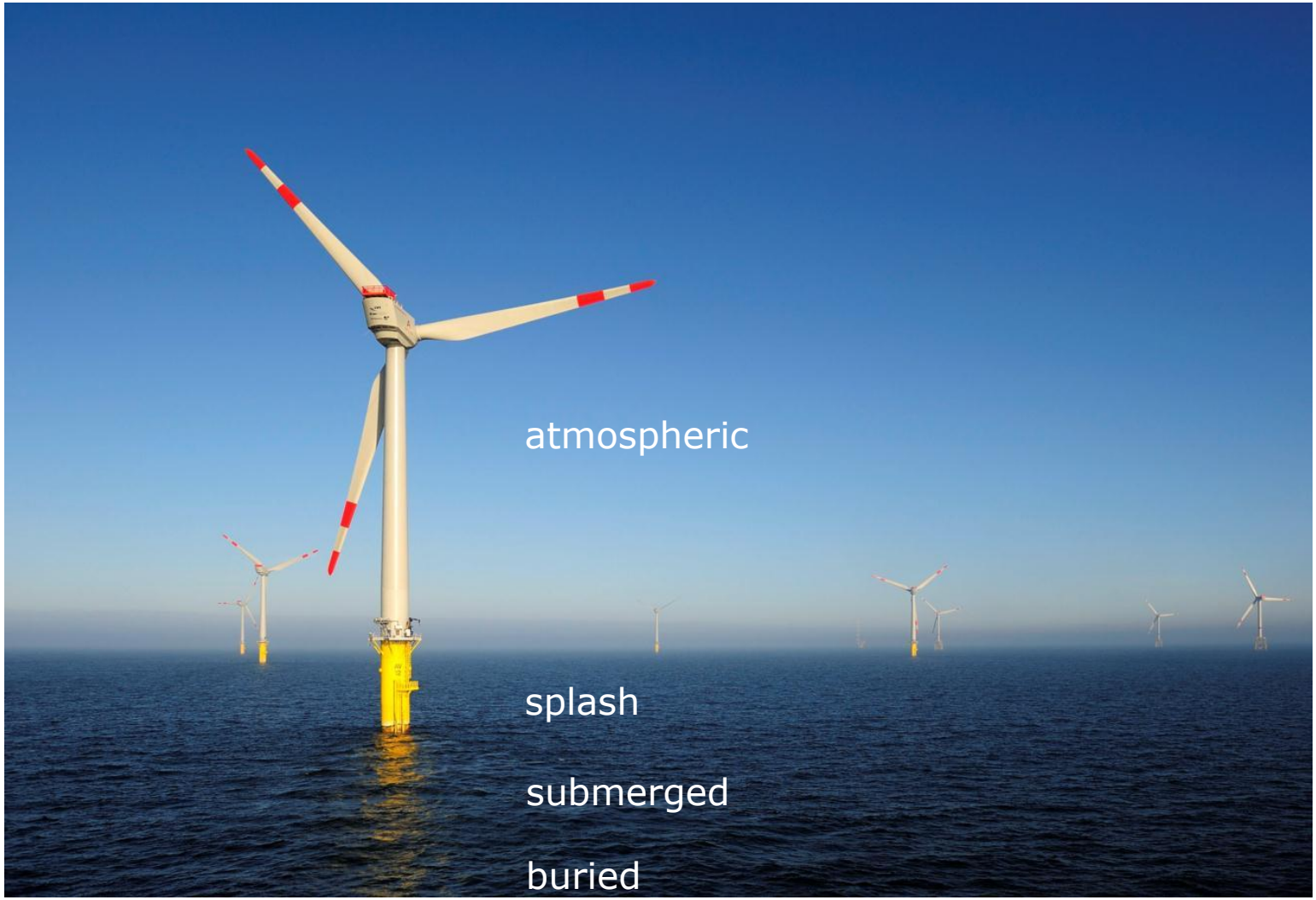
Empfohlene Minimalabmessungen für Öffnungen und Abstände von Oberflächen

© ISO

COATING SELECTION AND PRE-QUALIFICATION

- The offshore wind turbine structure can be divided into the following zones to help in understanding its relationship with the marine environment:
  - atmospheric;
  - splash;
  - submerged;
  - buried.


atmospheric
splash
submerged
buried

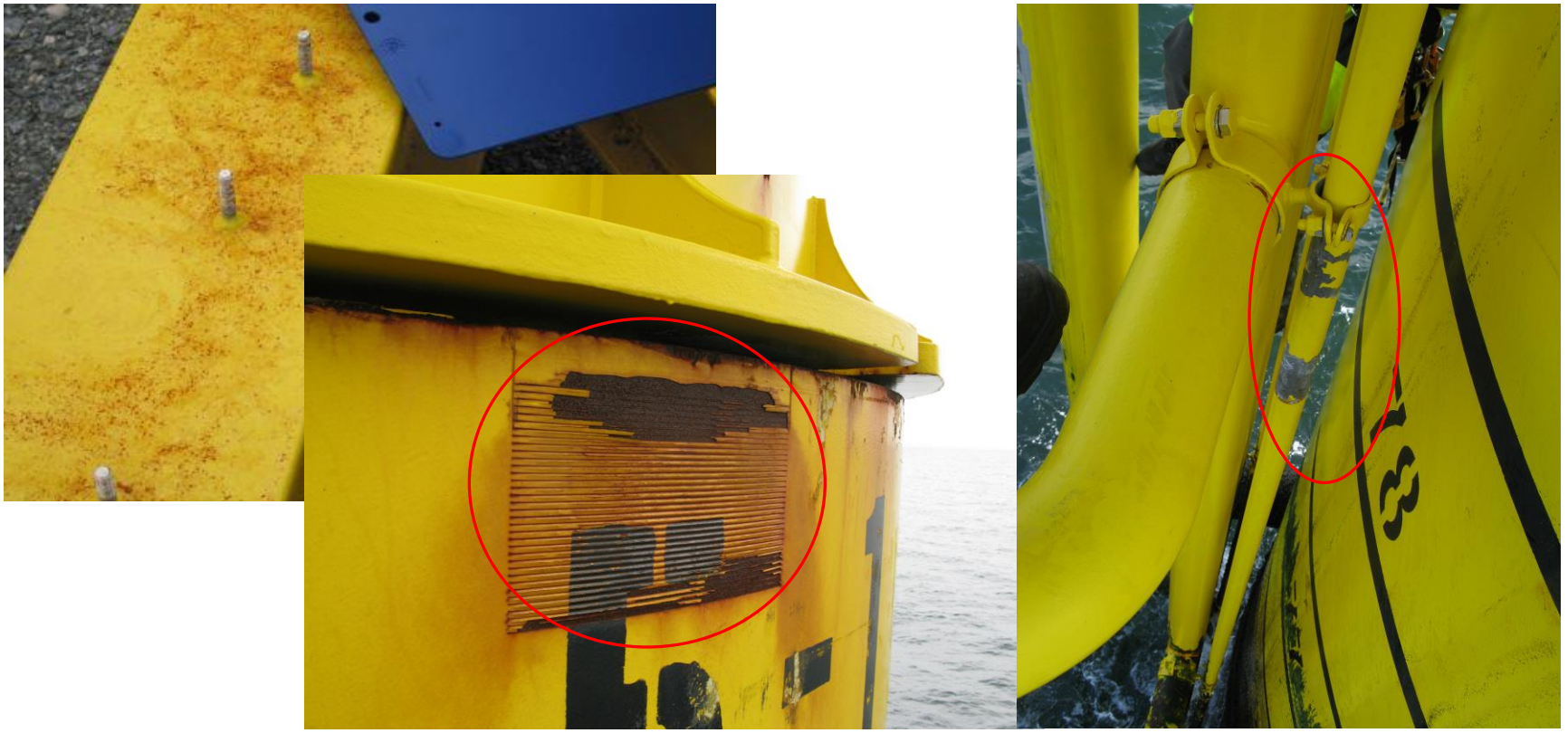

atmospheric
splash
submerged
buried

COATING SELECTION AND PRE-QUALIFICATION

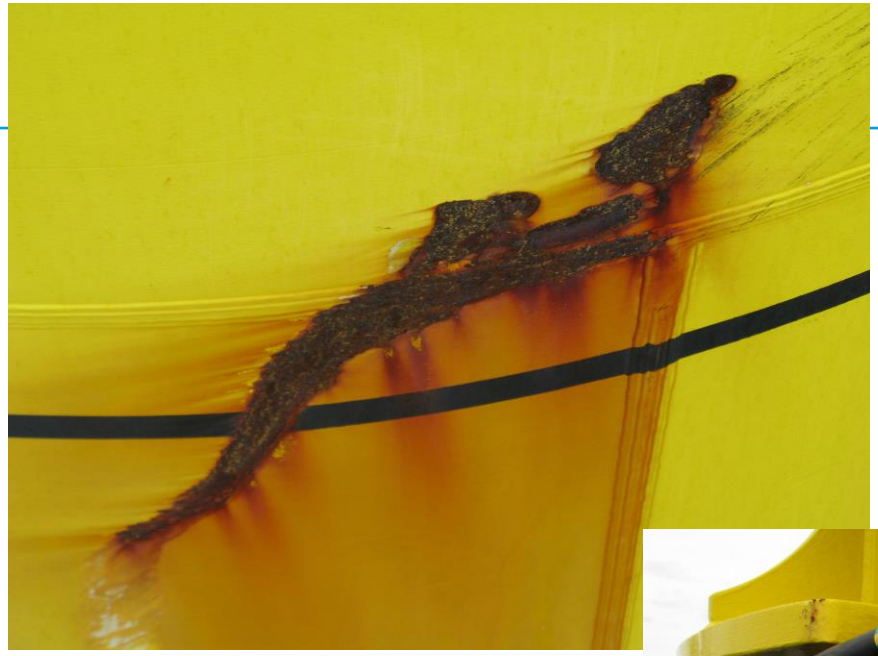
- For structural parts in each of these zones the selection of coating systems as defined in, for example, NORSOK M-501 or ISO 12944 shall be specified. Also the requirements for the qualification of manufacturer specific coating materials and of personnel to carry out coating work shall be clearly defined at the beginning of the project.

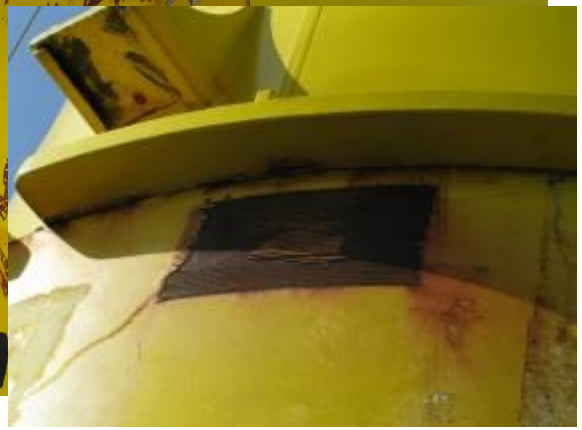
Test	Scribe line	Environment of corrosivity category C5-M	Environment of combined corrosivity category C5-M and Im2 (splash and tidal zones)	Environment of corrosivity category Im2
Ageing resistance (see Annex A)	Yes (see 8.1.8)	4 200 h	4 200 h	—
Cathodic disbonding (ISO 15711:2003, method A, unless otherwise agreed)	No (artificial holiday used instead — see Table 5)	—	4 200 h	4 200 h
Sea water immersion (ISO 2812-2)	Yes (see 8.1.8)	—	4 200 h	4 200 h

Examples for coating failures



Insufficent surface preparation and protection during transport and installation lead to an early coating breakdown.





Coting Systems are frequently damaged during transport and installation.

INNER AND OUTER CORROSION PROTECTION

- External and internal surfaces of steel structures in the splash zone shall be protected by a corrosion control system (coating + corrosion allowance)
- It is considered best practice that external surfaces of the submerged zone shall have cathodic protection (CP)
- Coating of the external submerged zone is recommended

Selection of cathodic protection systems

Selection of cathodic protection systems

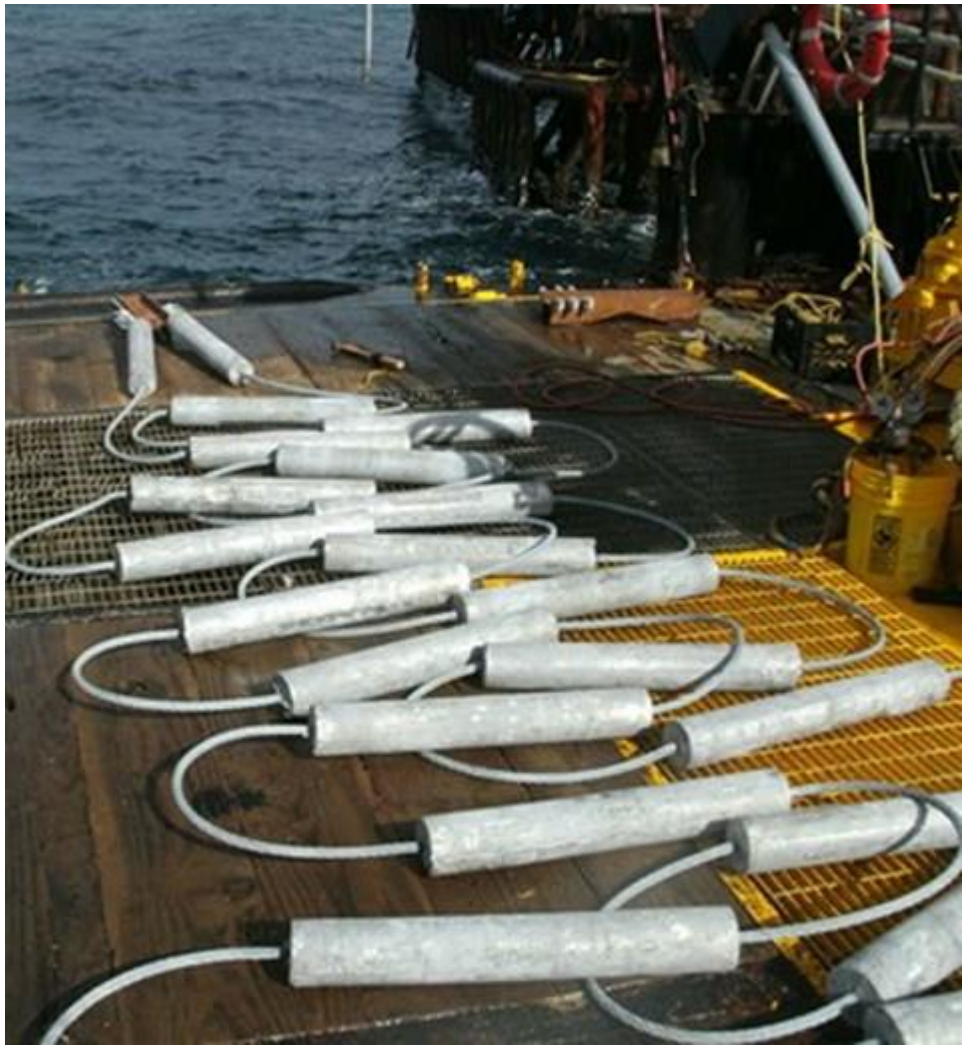
INNER AND OUTER CORROSION PROTECTION

- If CP is used on the inside of monopiles GACP system with zinc anodes are to be preferred over aluminum. Zinc will not tend to alter the pH value of the inside significantly and will also evolve less hydrogen.

- In case of galvanic anode strings are used the resistance within the string, the attenuation down the string, and a possible corrosion of this suspension system above the water line shall be considered with special care.

- When corrosion allowance is part of the required corrosion protection, the corrosion allowance shall be considered in the structural design for all limit state analyses by appropriate reduction of nominal thicknesses. In this case special consideration shall also be paid to selection of applicable S-N curves for fatigue design

Selection of cathodic protection systems



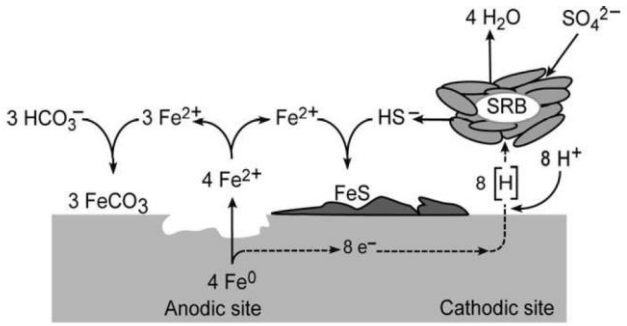
Characteristic Features of CP

- Requires metallic and electrolytic conductivity
- Prevents corrosion independent of mechanism and form
- Prevents fatigue to be initiated by corrosion
- May cause damage to coatings (blistering)
- May cause cracking of certain materials (HISC)
- Essentially maintenance free if galvanic anodes are used

- It is strongly recommended that the structure be protected by the CP system as soon as possible after installation of the structure

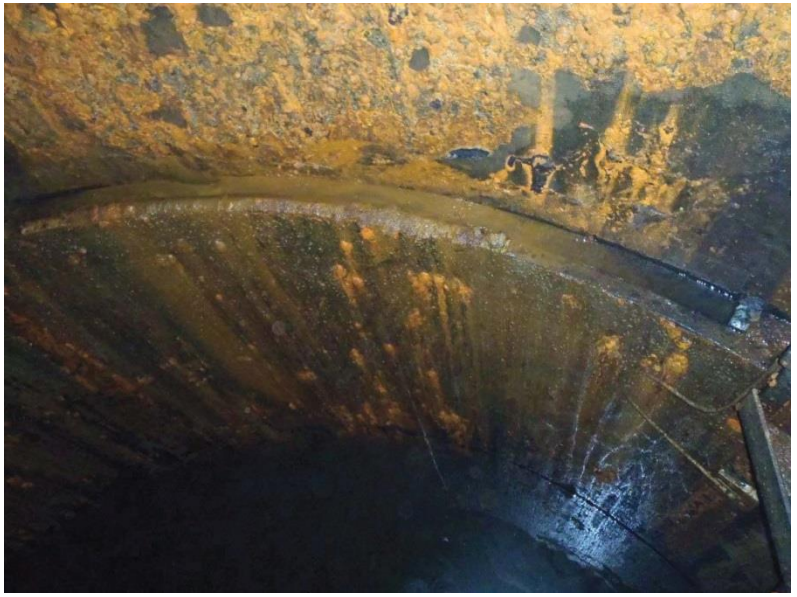
MICROBIOLOGICALLY INDUCED CORROSION

- MIC is an acronym for microbiologically influenced corrosion, a mode of corrosion incorporating microbes that react and cause corrosion or influence and accelerate other corrosion processes of metallic materials.
- MIC is usually linked to the problem of "souring" caused by sulfate-reducing bacteria (SRB) that produce corrosive hydrogen sulfide and thereby reduce the pH level as well.
- Cathodic protection systems inducing a negative potential lower than –900 mV rel. Ag/AgCl/seawater can prevent MIC to cause relevant problems in most existing offshore wind farms. The use of coatings with high resistance in the presence of bacteria can be necessary.



INNER AND OUTER CORROSION PROTECTION

- Coating of internal surfaces in the submerged zone is recommended if the compartments are not welded airtight. It is difficult to obtain compartments that will be completely sealed and airtight.



Insufficient inner corrosion protection

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Outlook

- The upcoming DNV GL Recommended Practice on Corrosion Protection of Offshore Wind Farms will provide guidance for the design of corrosion protection systems. Together with the harmonization of the DNV-RP-B401 and the upcoming standard for design of wind turbine support structures DNVGL-ST-0126 the latest experiences from worldwide projects will be considered in the available standards and recommendations.

Thank you for you attention!

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