





Managing Blade Integrity – Guidance on Allowable Defects

13/02/2019 | Kirsten Dyer

CATAPULT Offshore Renewable Energy

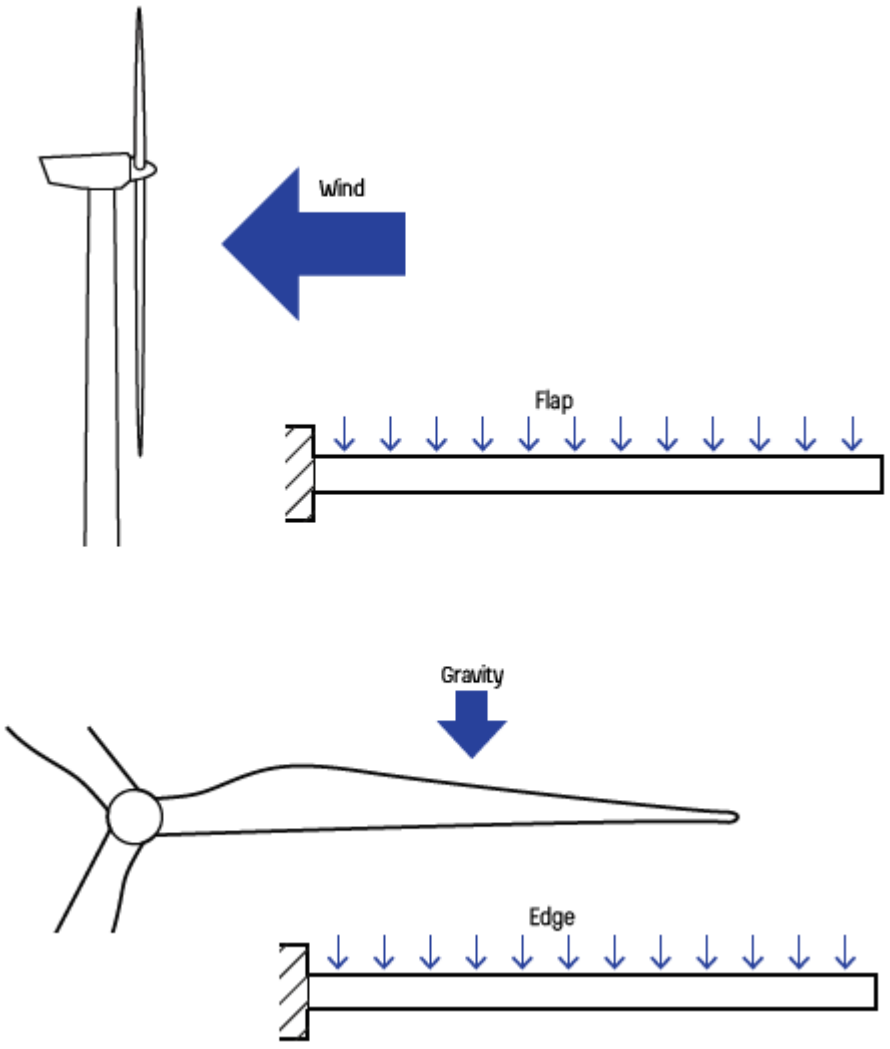
Agenda

- Introduction
- Blade anatomy and structure
- Failure modes
- Root causes
- Defects
- Allowable defects
- Summary

Introduction

- This presentation will explain the different types of defects which can occur on wind turbine blades, and touch on ways to determine if it is safe to continue operation of the turbine
- This presentation borrows heavily from the *Wind Turbine Blades Handbook* developed by Bladena – www.bladena.com
- The handbook can be obtained in digital form if you email Bladena – it is an excellent resource which covers much more than what is in this presentation!

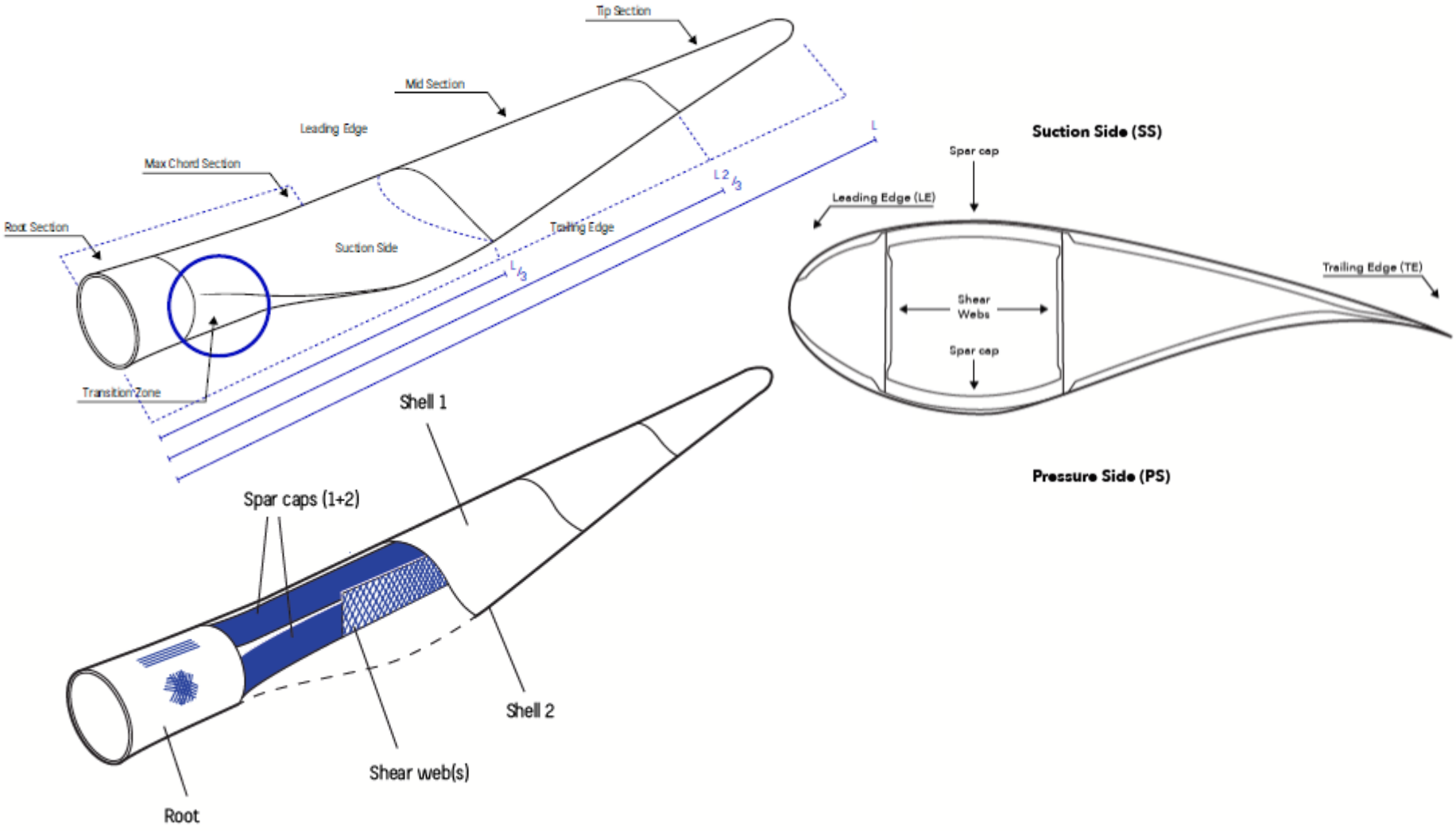
Anatomy of a Blade



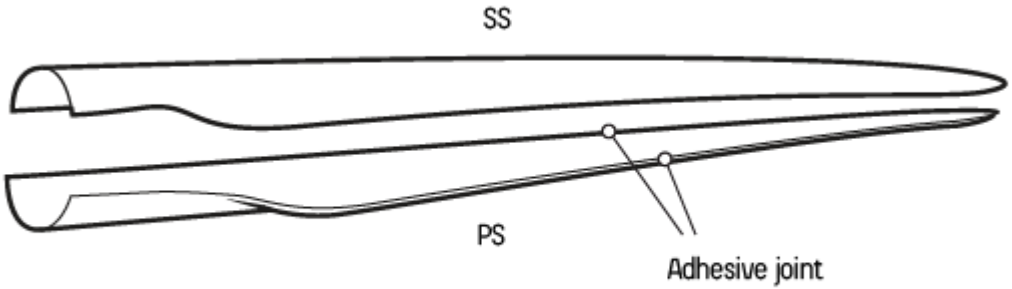
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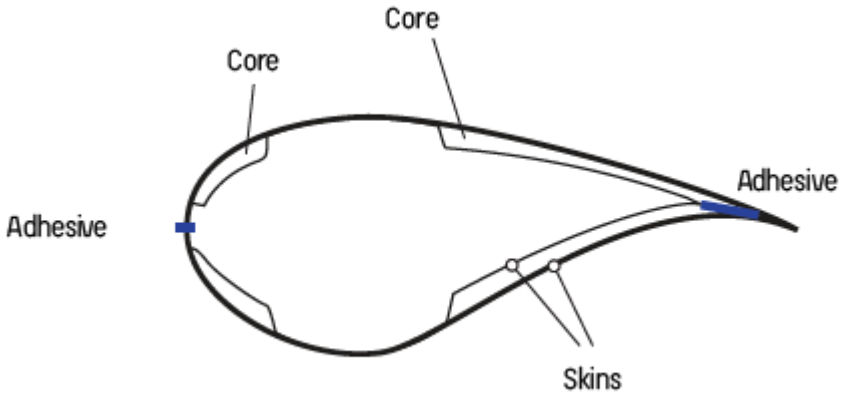
BLADE SECTIONS

A wind turbine blade is divided into different sections as shown

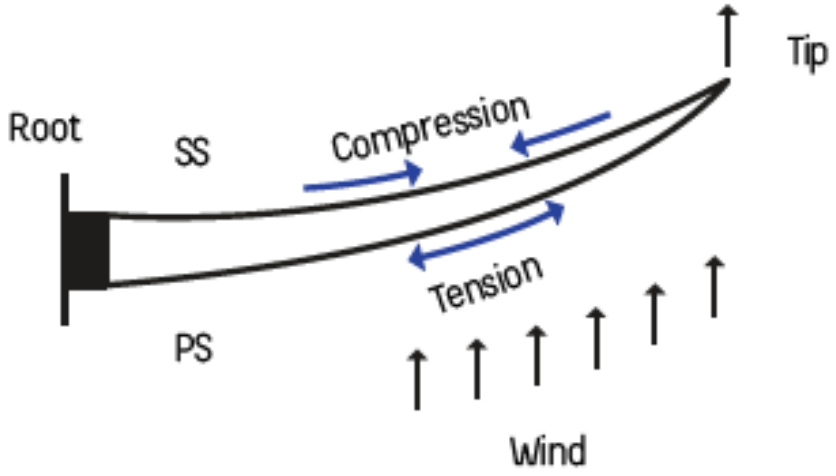


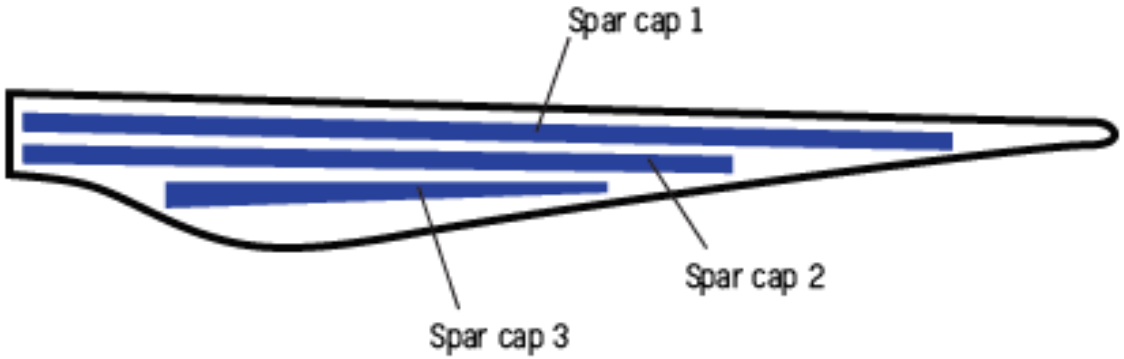
Anatomy of a Blade - Shells



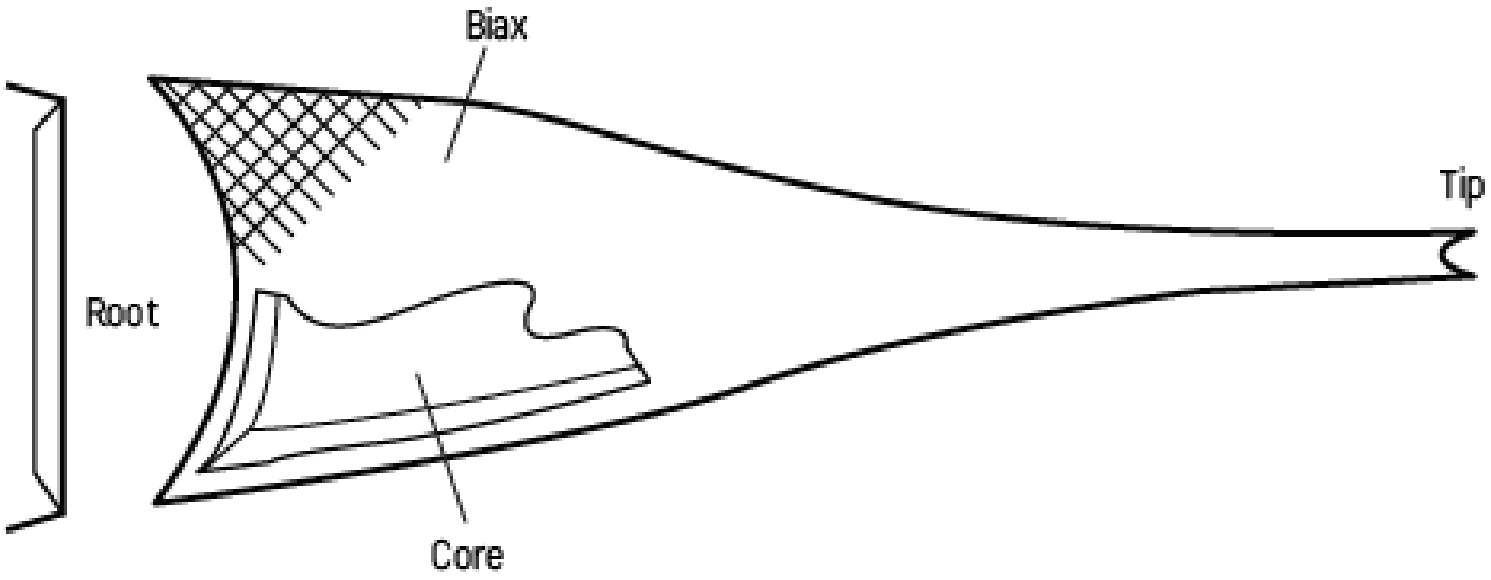


Anatomy of a Blade – Spar Caps

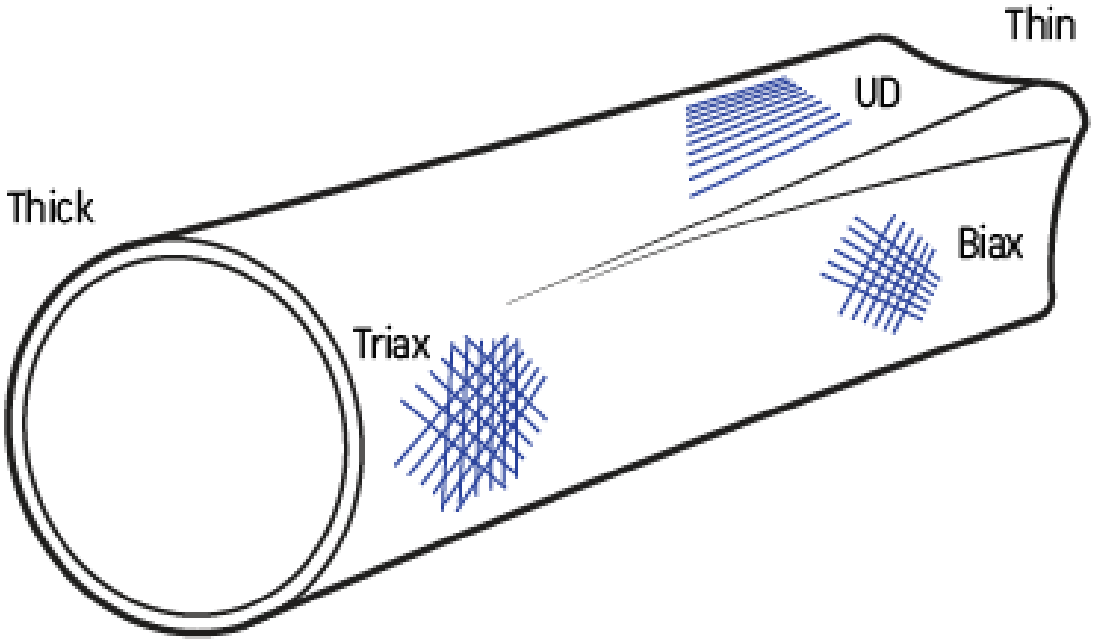




Anatomy of a Blade – Shear Webs

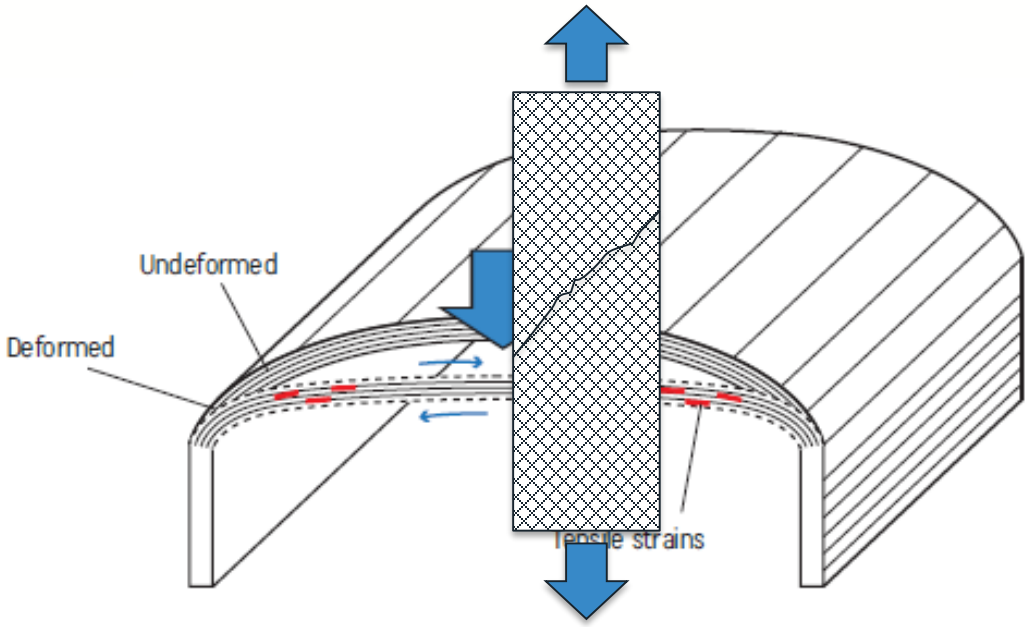


Anatomy of a Blade – Blade Root



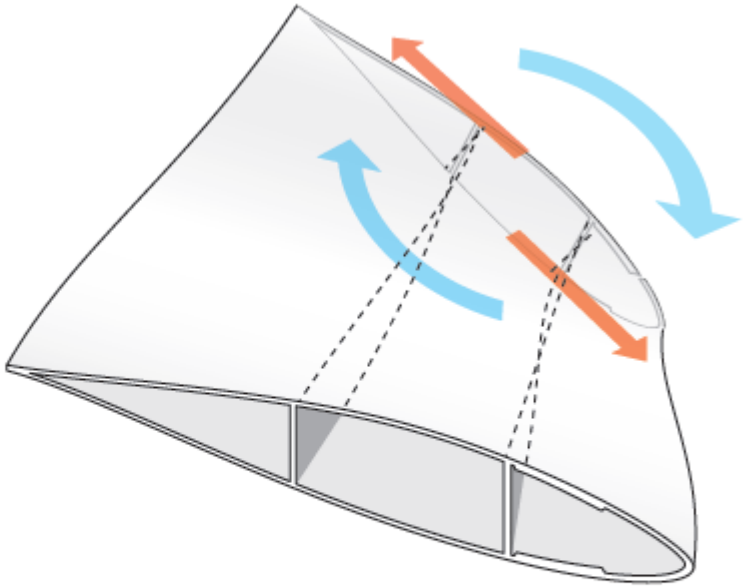
Failure Modes

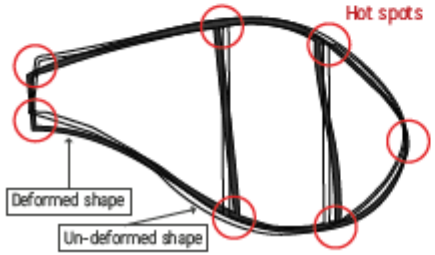
- There are 5 main failure modes which occur on wind turbine blades:
    1. Buckling
    2. Bondline failure
    3. Skin debonding
    4. Interlaminar failure
    5. Strain based failure



Root Causes

- Typically, the blade will be very strong in-plane along the axis of loading because of the high proportion of oc fibres.
- However, bending of the blade induces non-linear transverse stresses which cause the panels to 'breathe', causing failure of the bondlines and skin debonding on panels.
- Highly concave aerodynamic shapes and flatback aerofoils with low resistance to shearing exacerbate this issue.



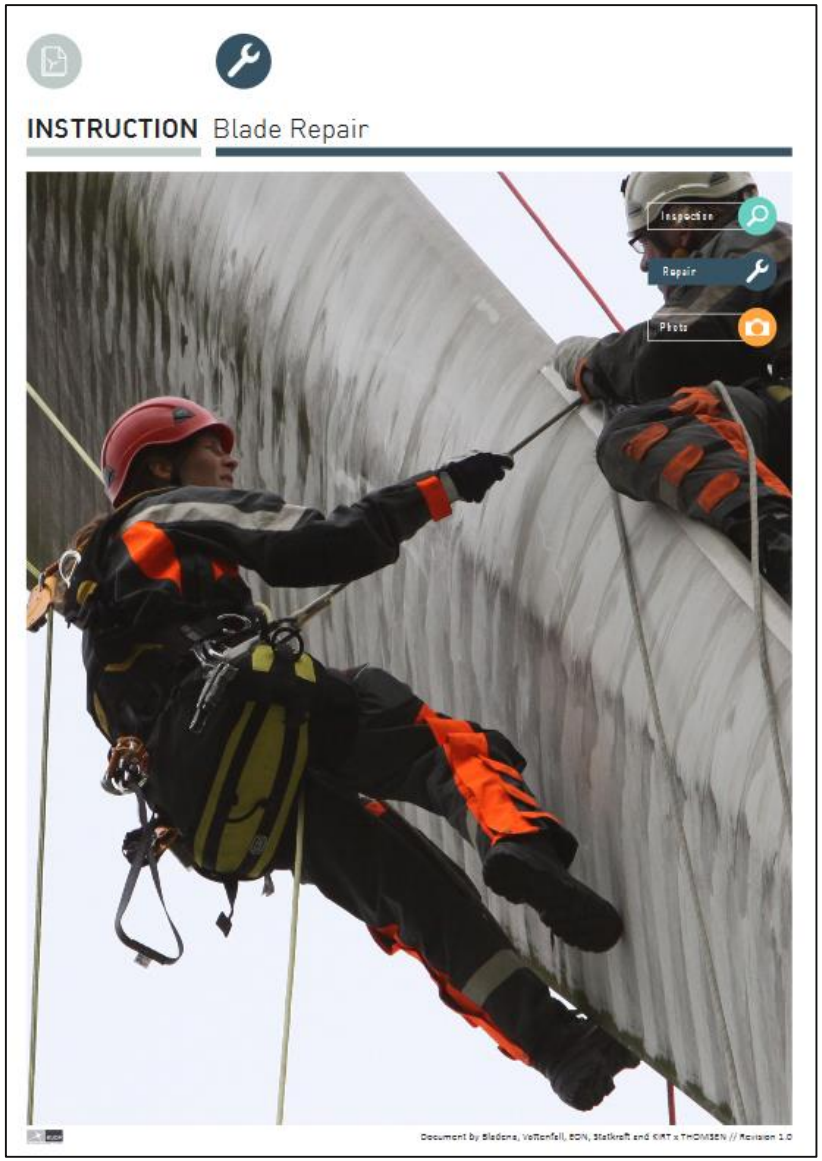


Peeling stresses appear in the adhesive bondlines along the blades in certain hot spots

Damage, Defects and Failure

- **Damage** - Harm or physical change that impairs the normal function of a blade. This could be from an impact, and extreme load or fatigue.
- **Defect** - A flaw or a weakness in a blade that cause failure
- **Failure** - The loss of an intended function due to a defect
- The following are some examples describing how these terms are used:
    - Defects are faults in the blade that might come from manufacturing
    - Failures are faults in the blade that have occurred during the lifetime of the blade, due to outside events such as excessive loads
    - The failure of a root bolt creates a defect in the root
    - A dry spot in an adhesive joint is a manufacturing defect
    - The failure of an adhesive in a joint due to an excessive load is a defect in a blade, and a failure of the adhesive joint

Damage Categorisation



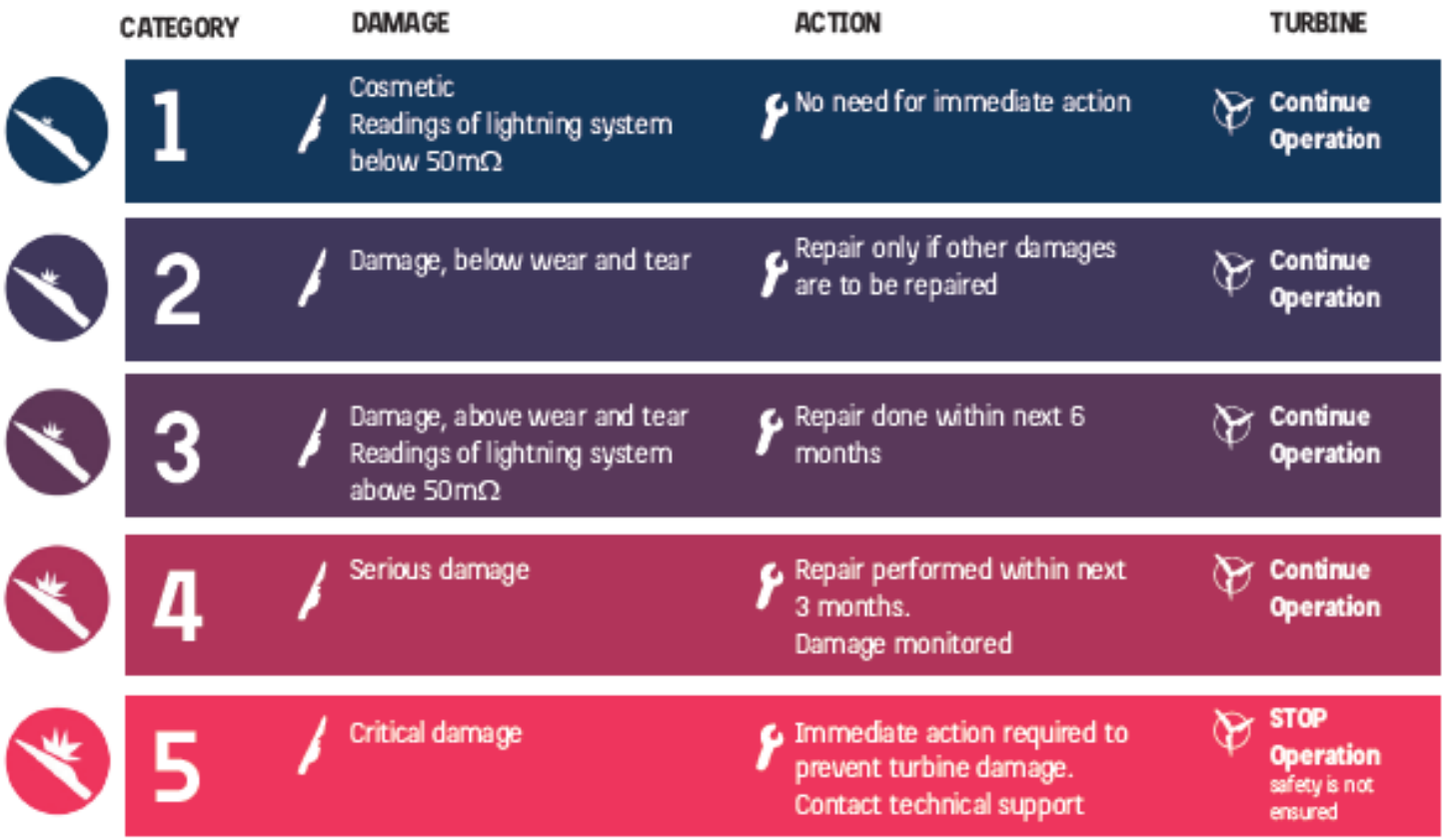
- This document was compiled by Bladena, Vattenfall, EON, Statkraft and KIRT x THOMSEN
- It was compiled as part of the EUDP Project LEX (2014-16) and EUDP Project RATZ (2016-18)
- It aims to create an industry standard for categorisation and documentation of blade damage.
- Damages are given a rating of 1

Damage Categorisation

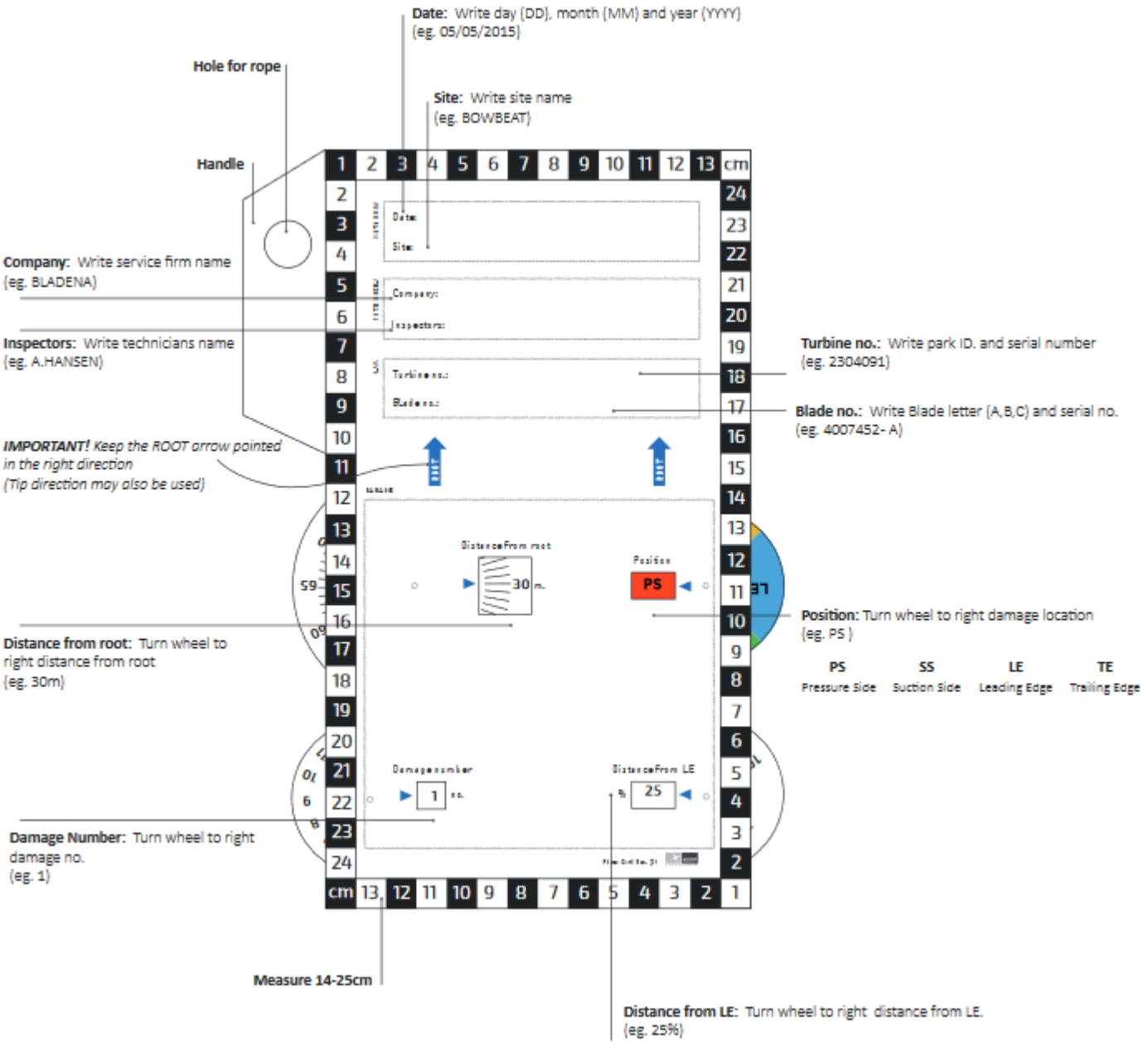
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LOCATION	DAMAGE	CATEGORY	BOX SPAR CONCEPT	LOAD CARRYING SHELL	CLOSED SHELL
Tip	Open tip	5	X	X	X
	Damage that penetrates the laminate layers	4	X	X	X
	Surface damage, not in the laminate	3	X	X	X
	Coat/paint damage, surface. Missing more than 15 cm2	3	X	X	
	Coat/paint damage, surface. Missing less than 15 cm2	2	X	X	
	Paint damage, surface. Missing more than 10 cm2	3			X
	Paint damage, surface. Missing less than 10 cm2	2			X
	Chip in paint/coat	2	X	X	X
Trailing edge (TE)	Open TE more than 10 cm within 5 meters of the tip	5	X	X	
	Open TE less than 10 cm within 5 meters of the tip	4	X	X	
	Open TE more than 20 cm beyond 5 meters of the tip	5	X	X	
	Open TE less than 20 cm beyond 5 meters of the tip	4	X	X	
	Cracks parallel to the TE longer than 1 meter	5	X	X	X
	Cracks parallel to the TE shorter than 1 meter	4	X	X	X
	Surface damage, not into the laminate	3	X	X	X
	Coat/paint damage, surface. Missing more than 20 cm2	3	X	X	
	Coat/paint damage, surface. Missing less than 20 cm2	2	X	X	
	Paint damage, surface. Missing more than 10 cm2	3			X
	Paint damage, surface. Missing less than 10 cm2	2			X
	Chip in paint/coat	2	X	X	X
	TE discoloration	1	X	X	X

Decision Making



Industry Standard Photocard



Summary

- We covered:
  - Blade structural design 101
  - What structural failures are common?
  - Why do they occur?
  - How can they be categorised and documented?
  - How do we take decisions on when to stop the turbine?
- More Information is available in:
  - Bladena Wind Turbine Blades Handbook
  - Next Generation Inspection Report

Contact us

GLASGOW
Inovo
121 GeorgeStreet
Glasgow
G1 1RD

T +44 (0)333 004 1400

BLYTH
National Renewable Energy Centre
Offshore House
Albert Street
Blyth, Northumberland
NE24 1LZ

T +44 (0)1670 359 555

LEVENMOUTH
Fife Renewables Innovation Centre (FRIC)
Ajax Way
Leven
KY8 3RS

T +44 (0)1670 359 555

HULL
O&M Centre of Excellence
Room 241, 2nd Floor
Wilberforce Building
University of Hull
HU6 7RX







