Recommendations for visual wind turbine blade inspections (draft).

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Summary

Recommendations for visual wind turbine blade inspection procedures are drafted in this document. Particular attention is paid to classification of the blade damage information that is possible to obtain from visual blade inspections and that can be used for better evaluation of blade structural health and remaining lifetime.

Areas of interest in wind turbine blades

A number of areas of interest are distinguished on a blade surface for the purpose of visual inspections. These areas are where typical blade damages can occur and become apparent at the blade surface, or areas where damages will most probably lead to blade failure. The areas of interest are hereby classified by radial position, cross-section position and by structural features as given below.

By **radial position**, see Figure 1:

- *Root* – as area with highest loads, mostly bending moments
- *Maximum chord* – as area with largest chord and strongest shape variations (tapering)
- *Maximum deformation* – as area with highest deformation strains. Its position strongly depends on design and operation, often at ca. 50%-60% of span
- *Tip* – as area with strongest erosion damages.

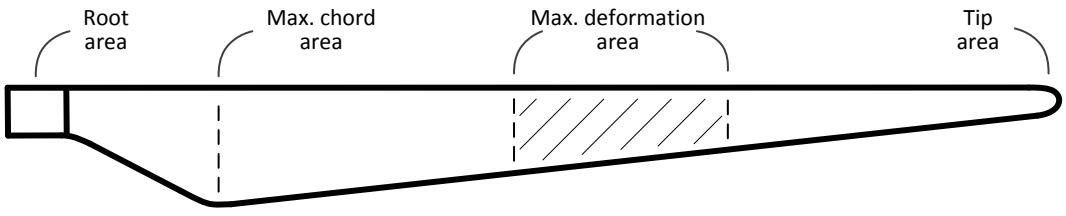

Figure 1 Areas of interest by radial position.

By **cross-section position**:

- *Leading edge (LE)* – subject to erosion, impact
- *Trailing edge (TE)* – subject to cracks, delaminations
- *Spar* – subject to cracks.

By **structural features** (these mostly act as stress concentration points), see Figure 2:

- *Bond lines* – e.g. at LE, TE
- *Transition regions* – junctions of structural components e.g. spar and sandwich panels, TE and sandwich panels, etc.
- *Significant ply-drops* – e.g. near root and maximum chord area.

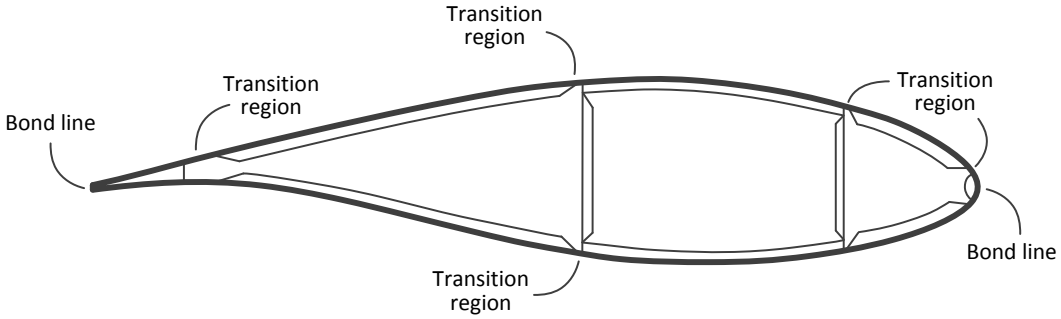

Figure 2 Areas of interest by structural features.

Blade damage classification

Blade damages discovered during visual inspections can be grouped by a number of criteria. This is done to facilitate root-cause analysis and evaluation of the current blade health state and remaining life time. The grouping principle is described below:

- by **cross-section position**:
  - LE
  - Between LE and spar
  - Spar
  - Between spar and TE
  - TE
- by **damage type**:
  - Crack – come from internal damage
  - Mechanical damage – done by external exposure (scratches, impact, lightning, etc.)
  - Erosion – originates from high-speed interaction with air
- by **damage depth**:
  (This is often a subjective evaluation, unless special procedure is established)
  - Surface damage – stays within coating layer, e.g. gelcoat, primer
  - Structure seen – load carrying components are exposed but not damaged
  - Structure damaged – load carrying components are damaged (e.g. torn fibers)
  - Hole – through damage
- by **damage orientation**:
  (This is mostly for cracks to distinguish longitudinal, transverse and shear cracks)
  - Orientation in degrees with respect to blade pitch axis
- by **damage singularity**:
  - Single damage, like a crack or a hole

- Area with similar damages, e.g. area with multitude of similar cracks

Blade inspection procedures

Particular attention

Generally more attention should be paid to the areas of interest described above.

Damage information format

Each discovered damage should be registered and the following information provided:

- Inspection date
- Inspecting person
- Turbine/blade ID
- Damage position (radial and chord) and size
- Damage classification
- Damage photo: Clear picture, damage is in focus, with good light conditions
- Damage ID (if it is an old known damage)
- Comment

Damage tracking

It is further recommended to establish a procedure for identification of older damages that have been discovered in previous inspections. This is in order to track the damage development in time and facilitate estimation on when the damage may become important and/or critical to the blade structure.

Recommendations to blade manufacturers

Blade manufacturers can largely facilitate blade inspection process and also improve the inspection quality by providing the following information to the wind turbine operators/inspection bodies:

- **Reference points** applied on the blade surface in systematical manner to improve damage location accuracy. These can designate e.g.:
  - Radial position (marks at R10m, R20m, R30m)
  - Location of spar (cap leading/trailing side)
  - Location of essential structural features (bond lines, transition regions, significant ply-drops)
- **Classification by importance** of known/expected operational blade damages with respect to blade structural health and remaining life time.