IEC 61400-8: Design of wind turbine structural components

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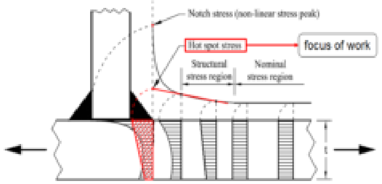
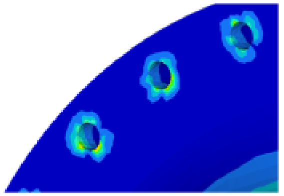
IEC 61400-8 Overview

Overview of the Content of the Standard

The standard focuses on
- Ferrous structural components of the Nacelle and adjoining connections
- Nacelle covers
- Cast, forged, bolted or welded connection design.
- Reliability levels for major components
- Load application methods
- Strength Assessment
- Material testing
- Model Validation





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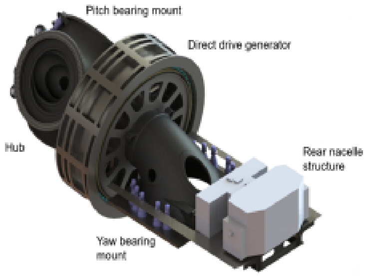


IEC 61400-8 CD

General Comments

1. Many ambiguous requirements – not objectively verifiable
2. Significant amount of textbook material
3. Significant number of repeated requirements from IEC 61400-1 and others
4. Considerable mention of probabilistic design methods – It may make sense to exclude this in -8 and transfer methods and processes around probabilistic design to the upcoming -9 standard

Recommendation

1. Provide comments on or before 9 April 2021
2. Propose either a significant rewrite of the CD or propose that the current document become a TR

Poorly defined requirements

1. 17 “shall be considered” requirements
2. Repeated requirement from other standards

5.2 Partial Safety Factors and Reliability Targets

In a semi-probabilistic approach, partial safety factors may follow those specified in recognized standard codes or may be calibrated to a specific reliability level through a reliability-based approach i.e. Annex K of IEC-61400-1 Ed. 4 or ISO 2394.

Target levels for reliability index β shall be based on annual failure probabilities. Different target reliability levels should be considered based on its component class classified as in **Table 1**. The minimum recommended annual reliability targets are presented in **Table 2**.

Table 1 – Component class classification as in IEC-61400-1 Ed. 4.

Component Class	Description
1	"fail-safe" structural components whose failure does not result in the failure of a major part of a wind turbine.
2	"safe-life" structural components whose failures may lead to the failure of a major part of a wind turbine
3	"safe-life" mechanical components that link actuators and brakes to main structural components for the purpose of implementing non-redundant wind turbine protection functions

6.1.2 Load components

The load components applied on the analysis model shall be determined using an aeroelastic model. A load component may be represented by a force, moment, deformation or similar at a specific location with a specific direction.

Relevant load components and proper approaches for load effect calculations shall be considered for structural component verification. (e.g. loads at main bearing for the verification of the nacelle front structure). This cross-section load shall be connected to a supporting component to avoid deviation effects from boundary conditions.

Load components which contribute to the damage of the component shall be included. Load components may be omitted by introducing an additional safety factor as described in section 6.3.

6.2.2 Ultimate load analysis

The ultimate limit state of nacelle and hub components, also referred as extreme analysis, shall be simulated with contemporaneous load components for each load case. Guidance for the derivation of extreme design loads from contemporaneous loads can be found in Annex I of IEC 61400-1 Ed. 4. Superposition and linear extrapolation of load components shall only be used for structures with a linear behaviour at the expected load levels for extreme analysis.

All relevant loading scenarios according to IEC 61400-1 Ed. 4 shall be considered for each component.

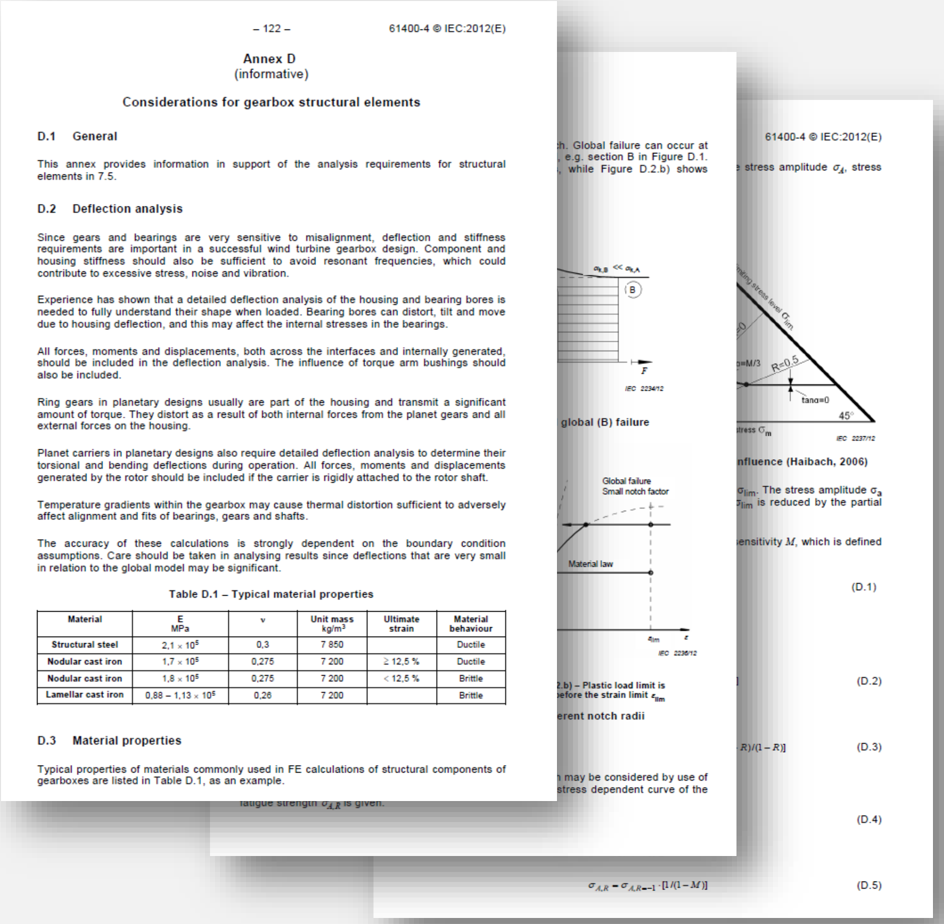
6.3 Safety factor

Load effect uncertainty i.e. stress tensor, computed analytically, empirically or numerically shall have a coefficient of variation not greater than 5%, compared to results from validated model. Simplified models/methods may be implemented, however, load effect evaluation from simplified models should be checked against a verification model which strictly follows modelling conditions mentioned in IEC-61400-1 Ed. 4. i.e., accounts for non-linear effects, mesh convergency of numerical models, among other.

In case of using simplified model, the material safety factor shall be considered a function of factors $\gamma_{mt} = \gamma_m \cdot \gamma_{modelling}$, where γ_m represents the material partial safety factors and its value is as in IEC-61400-1 Ed. 4., $\gamma_{modelling}$ is a partial safety factor which accounts for the load effect deviations. A list describing the potential source of load effect deviations are presented in **Table 3**.

Connection to IEC 61400-4ed2

- IEC 61400-4ed2 clause 7.6 Structural elements was reduced from 12 pages of normative language to 3 pages
  - Replaced duplicate requirements with reference to -1 where appropriate
- Intention was to reference IEC 61400-8 as a normative reference depending on timing
- Annex D: Consideration for structural elements has been recommended for deletion provided to -8 group for inspiration



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Annex D
(informative)

Considerations for gearbox structural elements

D.1 General

This annex provides information in support of the analysis requirements for structural elements in 7.5.

D.2 Deflection analysis

Since gears and bearings are very sensitive to misalignment, deflection and stiffness requirements are important in a successful wind turbine gearbox design. Component and housing stiffness should also be sufficient to avoid resonant frequencies, which could contribute to excessive stress, noise and vibration.

Experience has shown that a detailed deflection analysis of the housing and bearing bores is needed to fully understand their shape when loaded. Bearing bores can distort, tilt and move due to housing deflection, and this may affect the internal stresses in the bearings.

All forces, moments and displacements, both across the interfaces and internally generated, should be included in the deflection analysis. The influence of torque arm bushings should also be included.

Ring gears in planetary designs usually are part of the housing and transmit a significant amount of torque. They distort as a result of both internal forces from the planet gears and all external forces on the housing.

Planet carriers in planetary designs also require detailed deflection analysis to determine their torsional and bending deflections during operation. All forces, moments and displacements generated by the rotor should be included if the carrier is rigidly attached to the rotor shaft.

Temperature gradients within the gearbox may cause thermal distortion sufficient to adversely affect alignment and fits of bearings, gears and shafts.

The accuracy of these calculations is strongly dependent on the boundary condition assumptions. Care should be taken in analysing results since deflections that are very small in relation to the global model may be significant.

Table D.1 – Typical material properties

Material	E MPa	ν	Unit mass kg/m³	Ultimate strain	Material behaviour
Structural steel	$2,1 \times 10^5$	0,3	7 850		Ductile
Nodular cast iron	$1,7 \times 10^5$	0,275	7 200	≥ 12,5 %	Ductile
Nodular cast iron	$1,8 \times 10^5$	0,275	7 200	< 12,5 %	Brittle
Lamellar cast iron	$0,88 – 1,13 \times 10^5$	0,26	7 200		Brittle

D.3 Material properties

Typical properties of materials commonly used in FE calculations of structural components of gearboxes are listed in Table D.1, as an example.

Classification: Internal
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