



Note on Engineering Details

- No:** DWM-Schl-extern-003
- Title:** Usage of Bolts inside the area of Material Yielding (Plastification)
- Ref.:**
- GL Wind "Guideline for the Certification of Wind Turbines", Edition 2003 with Supplement 2004, Section 5.3 and 6.5
 - GL Wind Note on Engineering Details no. DWM-Schl-extern-002 "Partial Safety Factor γ_M for Bolts" dated 7.4.2006
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The technique of tensioning bolts beyond the area of the elastic material behaviour into the area of material yielding is used in the wind turbine branch more and more.

Germanischer Lloyd WindEnergie GmbH sets up the requirements for certification of bolts which are loaded into the area of material yielding as follows. These requirements are valid for both the case of yielding during the tensioning process (at the installation/mounting) and the case of yielding due to an extreme load during the operational life of the bolted connection.

1. Section 6.5 "Bolted Connections" of Guideline /1/ is to be observed.
2. Additional to the design calculations according to /1/ the amount of plastic deformation during the tensioning process is to be determined in that section of the bolt where the yielding occurs most heavily (mostly the tensioned part of the free thread). For this the most unfavourable values of all data (data of the tensioning process, frictional coefficients, material data of the bolts material, etc.) are to be considered.
3. Additional to this the amount of plastic deformation during the occurrence of a possible extreme load is to be determined if the calculations show that such plastification is to be expected. For this the most unfavourable values of all data (data of the bolts material, etc.) are to be considered.

4. The plastification during the tensioning as per item 2 above is to add to the additional plastification during an extreme load as per item 3 above. This sum (total plastification) shall be lower than or equal to 1 % of the length of that section of the bolt exposed to yielding (mostly the tensioned part of the free thread).
In this context the partial safety factor for materials shall be: $\gamma_M = 1.0$.
5. The minimal pre-tensioning force in the bolt is to be determined (calculations or tensioning tests/measurements) according to the tensioning procedure. A possible occurrence of an additional plastification during an extreme load (see item 3 above) might reduce the tensioning force in the bolt and is therefore to be considered accordingly. For this the most unfavourable values of all data (data of the tensioning process, frictional coefficients, material data of the bolts material, etc.) are to be considered.
6. The minimal pre-tensioning force determined as per item 5 above is to be reduced by 10 % to account for inaccuracies. This reduced pre-tension is to be used for the bolts fatigue calculation and the considerations of proper function of the bolted connection.
7. When choosing the detail category as per section 5.3.3.4.1 Para 9 of /1/ the values for “bolts rolled before heat treatment” (detail category 50 or 71) are to be used, because the positive influence of the residual stress in bolts which are rolled after the heat treatment disappears during the plastification process.

/1/ Germanischer Lloyd WindEnergie GmbH “Guideline for the Certification of Wind Turbines”,
Edition 2003 with Supplement 2004

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