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Replacing GB/T 19072-2010

Wind turbines - Tower

风力发电机组 塔架

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1 Scope

GB/T 19072-2022 is the Chinese national standard on wind turbines - tower, in the field of energy and heat transfer engineering. The /T suffix marks it as a recommended standard: it is not compulsory by itself, but it becomes binding as soon as a contract, a tender or a customer specification calls it up - which in practice is how most foreign buyers meet it. It was issued on 12 October 2022 by the State Administration for Market Regulation; Standardization Administration of China, and has been in force since 12 October 2022. Classification: ICS 27.180, CCS F11. This page is published from the official record of the standard held by the Chinese standards administration: the identification, the dates, the classification and the issuing body are taken from there. The clause text, the tables and the numeric limits are in the document itself, which is delivered complete in English translation.

This document specifies the design principles, design requirements, process requirements, test methods, inspection rules, completion data and accompanying documents, marking, packaging, storage and transportation requirements of wind turbine towers. This document applies to the design, manufacture, construction and acceptance of horizontal-axis wind turbine towers.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the version corresponding to that date is applicable to this document; for undated references, the latest version (including all amendments) is applicable to this document.

GB 175, Common Portland Cements GB/T 470, Zinc ingots

GB/T 700, Carbon structural steels

GB/T 709, Dimension shape weight and tolerances for hot-rolled steel plates and sheets

GB/T 985.1, Recommended joint preparation for gas welding, manual metal arc welding, gas-shield arc welding and beam welding

GB/T 985.2, Recommended joint preparation for submerged arc welding

GB/T 1228, High strength bolts with large hexagon head for steel structures

GB/T 1231, Specifications of high strength bolts with large hexagon head, large hexagon nuts, plain washers for steel structures

GB/T 1591, High strength low alloy structural steels

GB/T 3098.1, Mechanical properties of fasteners - Bolts, screws and studs

GB/T 3098.2, Mechanical properties of fasteners - Nuts

5 Design principles

5.1 The design service life of the tower shall not be less than the design service life of the wind turbine.

5.2 The tower shall meet the following functional requirements within the specified design service life. -- During normal construction and use, it shall be able to withstand various loads and effects that may occur; -- During normal use, it shall have good working performance; -- Under normal maintenance, it shall have sufficient durability; -- In case of accidence, the structure shall be able to maintain overall stability.

5.3 The tower load shall be calculated and analyzed in accordance with the relevant provisions of GB/T 18451.1.

5.4 In addition to the calculation and analysis of tower loads in accordance with 5.3, additional loads caused by the inclination of the tower and foundation shall also be considered. The tower inclination caused by factors such as installation, manufacturing and temperature should be calculated at 5 mm/m, and the tower inclination caused by factors such as foundation deformation and uneven settlement shall be calculated at 3 mm/m.

5.5 The modal damping ratio of the tower shall be obtained through testing or analysis, and can be selected by referring to Appendix A during design.

5.6 The tower design shall be calculated and analyzed by selecting the most unfavorable load condition combination among all design conditions.

5.7 The tower design shall consider the influence of vortex-induced vibration on the tower when the tower is hoisted, shut down or out of wind. The calculation and analysis can be carried out according to the method in Appendix E of EN 1991-1-4.2005 or other methods

of the same safety level. The first-order vortex-induced vibration of the tower shall be considered in the calculation and analysis, and the second-order and higher- order vortex-induced vibration shall be considered when necessary. Aerodynamic damping shall not be considered when calculating vortex-induced vibration.

5.8 When the cumulative fatigue damage caused by vortex induction is not greater than 0.1, its influence can be ignored; when the cumulative fatigue damage caused by vortex induction is greater than 0.1, it shall be superimposed with the cumulative damage caused by fatigue load. A vortex-breaking structure can be added to the tower to destroy the vortex induction formation or a damper can be added to reduce the influence of vortex-induced vibration. materials meet the design requirements. It can only be implemented after confirmation by the design unit.

6.1.2.2 Flange The flange steel shall comply with the provisions of GB/T 1591, and the thickness direction performance (if required) shall at least comply with the Z25 requirements specified in GB/T 5313-2010.The ultrasonic testing requirements shall at least comply with the quality classification level I requirements in NB/T 47013.3-2015. The quality grade of flange steel shall not be lower than that of tower tube steel. Flanges shall be forgings. Forging steels shall be steel ingots refined outside the furnace, vacuum degassed or continuous casting round billets. Continuous casting slabs are not allowed. The ordering content, technical requirements, sampling, test methods, inspection rules, markings, labels and accompanying documents as well as packaging, transportation and storage of flanges shall comply with the provisions of JB/T 11218.

6.1.2.3 Welding materials The welding materials (welding rods, welding wires, welding flux) used in tower manufacturing shall comply with the regulations and design requirements of GB/T 5117, GB/T 5118, GB/T 5293, GB/T 8110, GB/T 10045, and shall have a valid quality certificate. The welding materials (welding rods, welding wires, welding flux) used in tower manufacturing shall match the base material, and the impact absorption energy shall not be lower than the base material requirements.

6.1.2.4 Fasteners The steel and performance grade of fasteners used for tower connections shall be selected by the design unit in accordance with GB/T 5782, GB/T 1228, GB/T 1231, GB/T 3098.1, GB/T 3098.2, GB/T 32076 (all parts) and NB/T 31082, and the performance requirements shall be clearly stated in the design documents.

6.2 Analysis of the inherent characteristics of the tower The analysis of the inherent characteristics of the tower shall take into account. -- In general, there shall be an appropriate interval between the natural frequency f0,n and the excitation frequencies fR, fR,m, which can be calculated according to Formula (1) and Formula (2). The stability analysis of the tower shall take into account the relevant failure mode of the specific type of structure, namely the buckling of the tower. If the two ends of the tower section are L-shaped or T-shaped flanges, only the stability of each tower section can be analyzed; if the two ends of the tower section are of other types, it shall be confirmed that the two ends

of the tower section can provide the necessary boundary conditions in order to analyze the stability of each tower section, otherwise the stability of the entire tower frame shall be analyzed.

6.3.2.2 Analysis methods The buckling analysis of the tower tube take into account the geometric, structural and material defects that may occur during the manufacturing and installation process. The buckling analysis shall be carried out using any of the following methods. -- Analysis is performed based on relevant industry-recognized standards and specifications, such as EN 1993-1-6. -- Computer-aided buckling analysis. The effects of material nonlinearity (MNA), material and geometric nonlinearity (GMNA), and material and geometric nonlinearity taking into account imperfections (GMNIA) on buckling shall be considered.

6.3.2.3 Door frame/reinforcement structure For openings on tower sections with or without reinforced structures, buckling analysis shall be performed using any of the following methods. -- numerical buckling analysis including material and geometric nonlinearity taking into account imperfections (GMNIA). -- analysis and verification performed according to the method recommended in Appendix B. For openings with door frames, the door frame cross section shall be aligned with the center of the tower tube wall at the 3 o'clock and 9 o'clock positions (as shown in Figure 1). -- If other alternative methods can ensure the safety of opening buckling, modifications, simplifications or extensions of the alternative methods may be adopted. The material of the gasket or other filler shall have a similar elastic modulus and compression strength to the flange material. Perform filling near each bolt or between each bolt and the tube wall. The filler shall ensure that the flange is fully in contact with the filled area before the bolts are pre-tightened or after applying 10% of the design pre-tightening force. If the inclination angle alphas of the flange outer surface exceeds 2° after the bolts have applied the pre-tightening force, a conical gasket with strength not less than that of the flange shall be used to fill it. In the following cases, it can be assumed that the welding between the flange and the tube wall is not affected by the edge-error of the tube wall. -- The radius r between the flange surface and the weld neck is at least 10 mm; -- The distance between the circumferential weld and the upper surface of the flange shall meet the requirements of 6.4.1; -- The distance requirement between weld toe and the upper surface of the flange applies to production and repair welding; -- The maximum limit of the internal taper of a single flange is 0.7°. If the flange meets the above requirements, only the fatigue strength of the bolts and circumferential welds needs to be analyzed. If the above requirements are not met, detailed ultimate strength and fatigue strength analysis of the flange, the weld between the flange and the tube wall, and the tube wall near the weld shall be performed. The weld fatigue detail classification shall select the value of the non-weld neck flange connection structure.

6.7.2 Raw material inspection

6.7.2.1 After the raw materials enter the factory, the tower manufacturing unit shall conduct