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Lightning Protection System

V90 – 3.0 MW

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Vestas Wind Systems A/S
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1. Introduction to Vestas Lightning Protection

All Vestas wind turbines are equipped with a lightning protection system in order to minimise damages on mechanical components, electrical systems and control systems.

In general, the lightning protection system is based on external and internal protection solutions.

The external protection system is designed to handle a direct lightning stroke and to conduct the lightning peak current down into the earthing system at the tower bottom.

By use of equipotential bonding, overvoltage protection and electromagnetic co-ordination, the internal protection is designed to minimise the damage and interference of electrical and electronical components inside the wind turbine.

2. Protection Level

Vestas wind turbines are installed worldwide in both coastal and mountain areas where the lightning density is high. In order to avoid local risk assessments and to handle differences in protection systems from project to project, Vestas has decided to design a standard lightning protection with a high protection level.

The design basis for Vestas lightning protection is protection level I, in accordance with the standard IEC61024-1, which means that the system must be able to handle lightning strokes with high specific energy.

Table 1 below gives numeric values of the lightning current.

Lightning parameter			Protection level I
Current peak value	i_{max}	[kA]	200
Total charge	Q_{total}	[C]	300
Impulse charge	$Q_{impulse}$	[C]	100
Specific energy	W/R	[kJ/Ohm]	10.000
Average steepness	$di/dt_{30/90\%}$	[kA/s]	200

Table 1 Numeric values of the lightning current

3. Definition of Stroke Points

By use of the “Rolling Sphere Method” and in accordance with IEC 61024-1, lightning stroke points are defined. It has been defined that the blade tips from radius 20m to 45m and the weather station (and the aviation lights, if any) at the rear end of the nacelle are the areas with the highest risk of lighting strokes.

For these areas, special protection measures are taken.

4. Protection of Blades

The blades are equipped with a lightning protection air termination system designed to handle the reception of lightning strokes on the blade. The system is based on 7 individual lightning receptors positioned at radius R44.7 m (close to the tip), R42m, R39m, R35m, R30m, R25m, and R20m measured from the rotating axis.

Inside the blade, a $50mm^2$ flexible copper down conductor is installed to connect the individual receptors to the blade root.

The blade spar is made of glass fibre combined with carbon fibre, and equipotential bonding is established between the down conductor and the carbon fibres. This ensures that the lightning current is conducted to the blade root, without building up too high electrical potentials.

The wire is terminated by a stainless steel band on the outside of the root of the blade. This plate is electrically isolated from the blade bearing and the hub.

Figure 1 Blade receptors

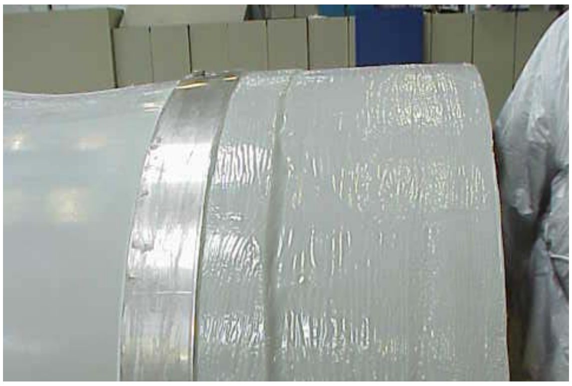

Figure 2 Steel band in blade root

A connection is made directly from the steel band to the nacelle chassis by use of a Lightning Current Transfer Unit (LCTU). The LCTU is described in section 6 Protection of Bearings and Gearbox.

5. Protection of the Nacelle

At the rear end of the nacelle, two ultrasonic anemometers and optionally 2 aviation lights are mounted. These components will be exposed to direct lightning strokes. For that reason, each of the anemometers is lightning protected by a steel ring as seen in figure 3. The protection rings are in direct contact with the interior steel structure of the nacelle. A Franklin rod is installed beside the aviation lights in order to protect the lamp.

Figure 3 Ultrasonic anemometers and aviation lights on the rear end of the nacelle roof.

The hook-up railing, the grilles above the cooling system and the support frame carrying the anemometer and aviation lights are all bonded to the crane beams inside the nacelle with 50 mm^2 Cu conductors.

Those components constitute an effective air termination system on the nacelle.

6. Protection of Bearings and Gearbox

In order to conduct the lightning peak current from the individual blades to the nacelle base without penetrating the hub and the gearbox bearings, a rotating LCTU is introduced.

The down conductor from each individual blade is kept isolated from the hub chassis and connected to the nacelle chassis via the LCTU.

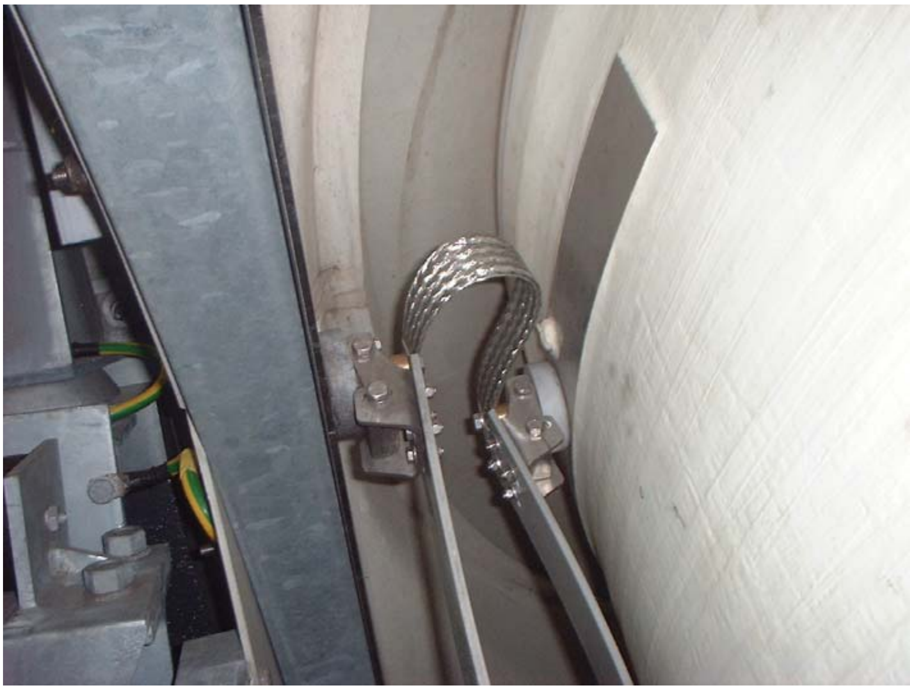

Figure 4 LCTU between blades and nacelle chassis

The LCTU is tested to ensure that it is able to handle the lightning current as defined in table 1.

7. Down Conducting from Nacelle to Tower Base

From the nacelle, there are structural steel connections to the top yaw flange. In order to avoid current penetration through the yaw gears and bearing, brass lightning current transfer contacts are installed in the yaw bearing.

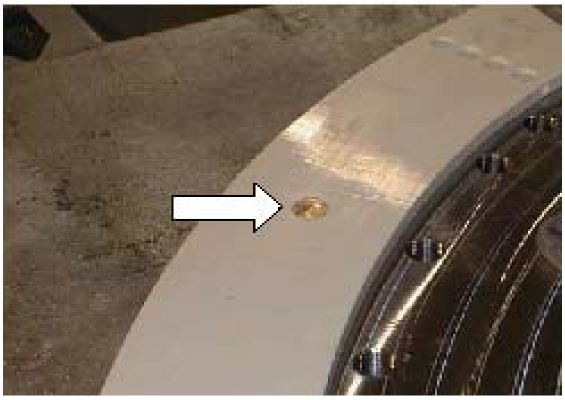

Figure 5 Yaw bearing protection

8. Protection of Electrical and Control Systems

8.1 Medium, Low and Control Voltage

All electrical and control systems are protected by means of equipotential bonding, cable shielding and installation of surge arrestors.

The surge protection system is based on protection on each individual voltage level, starting from the high voltage side of the main transformer, on the 1kV generator circuit in the 400V distribution panels and on all control voltage levels and communication interfaces.

The high voltage transformer is located in a separate switch room in the rear end of the nacelle. On the high voltage transformer terminals (6-33 kV), silicone rubber surge arrestors are installed (component type F79A-C).

Surge arrestors are protecting the terminals of the 1000V generator stator winding (component type F10A-C). The rotor winding (400V) is protected by functional equal components (component type F9A-C).

The controllers are power supplied by 400V/230V and 230V/24V transformers. The 230V and 24V levels are over voltage protected (component type F40 and F46A-B).

The hub controller is power supplied by a 690V/23V rotating transformer, where the 23V level is over voltage protected (component type F46A-B).

The over voltage protectors used are described in table 2.

Component	Type
F9A-C	DEHNguard 320 FM
F10A-C	DEHNguard 600/1000 FM
F11A-C	DEHNguard 600 FM
F40	DEHNguard 275 FM
F46A-B	DEHNguard 75 FM
F79A-C	
6-12 kV	Bowthorpe HSRA15
12-24 kV	Bowthorpe HSRC30
24-33 kV	Bowthorpe HSRC45

Table 2: Over voltage protector types and description.

8.2 Remote Control Systems

For the V90 turbine (VMP6000 controller), Vestas offers a remote control system with interface to the turbine controller.

9. Earthing Systems

9.1 General

The earthing system in the wind turbine´s low voltage system is as a standard designed to be a TN-S system with separated earth and neutral in the entire system.

The main earthing system outside the wind turbine is specified by Vestas, but design, installation and control measurements are performed under the responsibility of the customer. National regulations must always be followed and in case of deviations, Vestas must be informed in order to clarify if the changes have any negative impact on the efficiency of the lightning protection system or on personal safety.

9.2 Earth Distribution in the Wind Turbine

In a fundamental view, the nacelle base is serving as the common earth reference for all electrical and control systems in the nacelle. All equipotential bonding including surge protection is referring to this potential.

From the nacelle, earthing conductors are installed in order to establish necessary safety connections to the tower base and the external main earthing system.

Figure 6: Bonding of down conductor from the nacelle to the base of the top tower section.

2 parallel 1x50mm^2 copper cables are installed from the nacelle to the bottom of the tower.

The cables are connected to the base of the top tower section in order to make potential equalization.

In the tower bottom, the cables are connected to the tower and to the external earthing system.

Figure 7: Connection between the earth distribution cables, tower and external earthing system.

9.3 Foundation Earthing

The tower is connected to the steel parts of the tower foundation section. The foundation section is bonded to the reinforcement of the foundation. This will constitute an important part of the main earthing system.

10. Drawings

Drawing..Page

Earthing System in Modular Tower. VMP