Technical Description

Lightning protection system

TSD 4000175-01 EN

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1 Lightning protection system

1.1 System overview

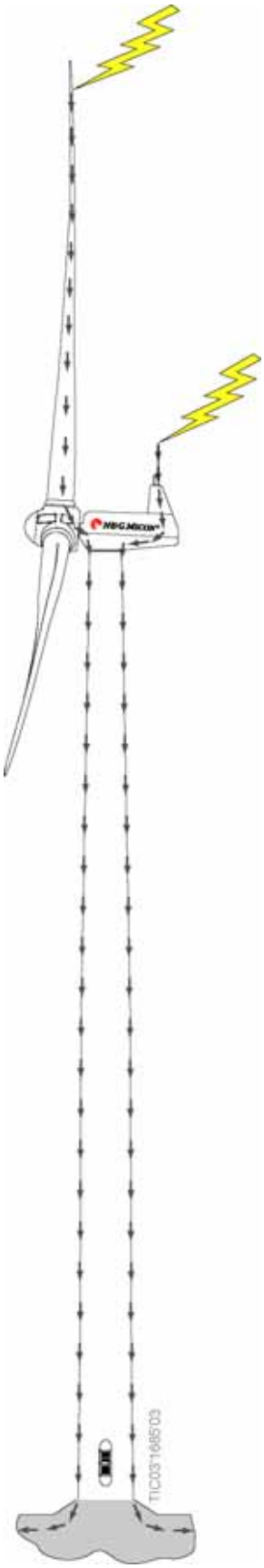
The objective of the lightning protection system is to provide equipotential bonding of all components and to ensure that lightning energy is conducted to earth in a simple and safe manner. Hereby, the build-up of large energy levels, which could cause extensive damage, is avoided

Experience has shown that the lightning protection system transfers high voltages and currents without any effect on turbine operations.

Mainly the machine base frame provides safe protection of the components in the nacelle. The components, which are not directly mounted to the base frame, are connected by the means of earthing cables. At the rear end on the outside of the nacelle a lightning conductor is mounted through the radiator cover. The lightning conductor extends considerably higher than any other equipment which is mounted on the nacelle and radiator cover.

The machine base frame is connected to the tower wall through earthing cables. The tower wall and the power cabinet are connected by cables to the earthing system.

A copper brush and a spark gap arranged at the main bearing housing makes up the lightning connection to the rotor. In the case of lightning strike an electric arc will occur over the spark gap. The metal brush which connects the shaft and the base frame transmits the voltage shock. As a result the lightning is conducted to the base of the nacelle without any risk of destroying the main bearing.

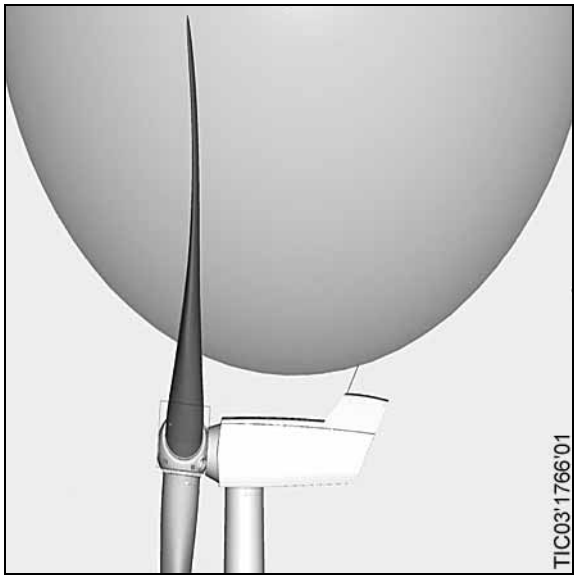


1.2 Total concept for lightning protection of NM72 and NM82

The lightning protection system has been designed according to EN/IEC 61024 Class 1 and under observation of DEFU Recommendation 25,

To assess possible strike points on the wind turbine, the "Rolling Sphere" method is used. An imaginary sphere is rolled over the wind turbine. Wherever the sphere touches the wind turbine, lightning strike is possible. The method takes into consideration the fact that lightning does not always strike the highest point. The diameter of the imaginary sphere is determined by the desired protection level. Here protection level 1 is applied, which is the highest level under IEC 61024. At protection level 1 the radius of the imaginary sphere is 20 m. All points on the wind turbine which the sphere can touch are possible strike points, and these points are classified as lightning protection zone 0. Within lightning protection zone 0, components must be able to withstand a direct lightning strike.

The rolling sphere method



Components in lightning protection zone 0 must be able withstand the full lightning current at 200 kA 10/350 µs.

In the areas in which the imaginary sphere forms shadows there will be no direct lightning strikes but the components in these areas must be able to tolerate the full electro-magnetic field.

These areas are classified as zone 0E. An example of a Zone 0E area is the area where the meteorological equipment is mounted.

The nacelle and glass fibre housing can then be considered as being in zone 1. In zone 1, possible lightning transients are further reduced. The level is 6 kV 1.2/50µs or 3 kA 8/20 8µs.

The wind turbine tower is also lightning-protected to level 1.

Metal electrical cabinets in lightning protection zone 1 should be regarded as lightning protection zone 2 internally. The level for lightning transients in lightning protection zone 2 is 0.5-2 kV 1.2/50 µs, depending on signal type.

Components in the individual lightning protection zones are over voltage-protected at the levels indicated.

1.3 Overvoltage protection of components mounted in lightning protection zone 2

Electronic components and other electronic equipment installed in the turbine have been tested to EN 61000-4-5. Supply cables have been tested to 2 kV common mode and 1 kV differential mode.

For communication purposes, optical cables are used, so here lightning arresters are not relevant.

1.4 Overvoltage protection of components mounted in lightning protection zone 1

Items in lighting protection zone 1 are items such as the main panel, phase compensation panel and control panel placed in tower, and panels placed in the nacelle and hub. Supply intake in the main panel is over voltage-protected by lightning arresters with a nominal discharging current of 15 kA 8/20µ/s and a limit discharging current of 40 kA 8/20µ/s.

Signal cables are protected by screens. In addition, signal cables from the control panel are protected by varistor clamps, capable of dealing with discharging current of 2.5 kA 8/50µ/s.

Various control transformers also have lightning arresters on the primary side.

If IGC system (power transformer) is installed inside in the tower. The power transformer has lightning arresters on the primary side.

1.5 Over voltage protection of wind measurement equipment in zone 0E

Wind measurement equipment is mounted where no direct lighting strike can reach it. This is done by placing a lightning conductor on the boom on which the wind measurement equipment is mounted. Cables from the wind measurement equipment are led by pipes to the control panel in to the nacelle, where the individual conductors are overvoltage-protected by varistor clamps capable of dealing with a discharge current of 2.5 kA 8/20µs.

1.6 Component-specific requirements

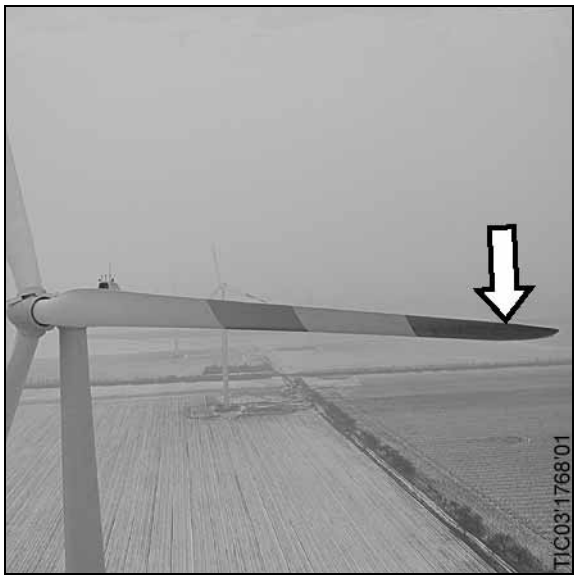
1.6.1 Blade protection

1.6.1.1 AL blades

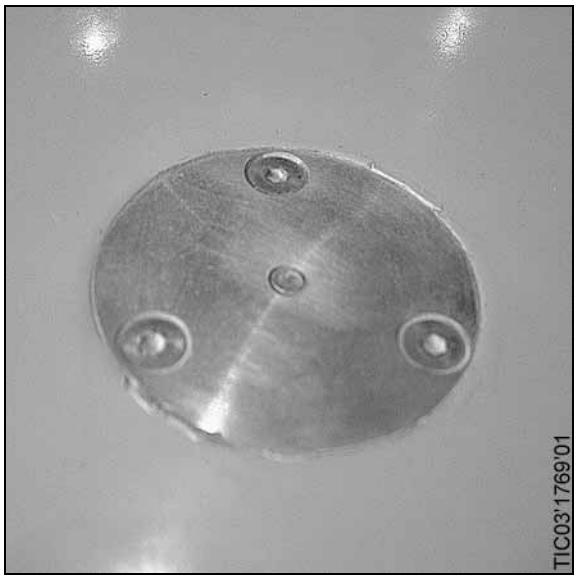
The AL blades are lightning-protected with AL's standard solution. The blade structure is protected from lightning strike by means of lightning receptors placed on both side of the blade tip, and a conduction system, which dissipates energy discharge through the blade by means of a metallic mesh laminated into the blade skin. The mesh is laminated under the gel coat layer covering sections of the blade and is doubled up at the blade tip. This design also protects the blade from the low probability strikes along the length of the blade.

The mesh is in direct contact with an aluminium alloy sheet across the root of the blade which provides a conductive path, via the blade bearings and the hub to main shaft bolt connection, to the main bearing house.

Blade (arrow indicates position of lightning receptor)



Close-up picture of lightning receptor on blade



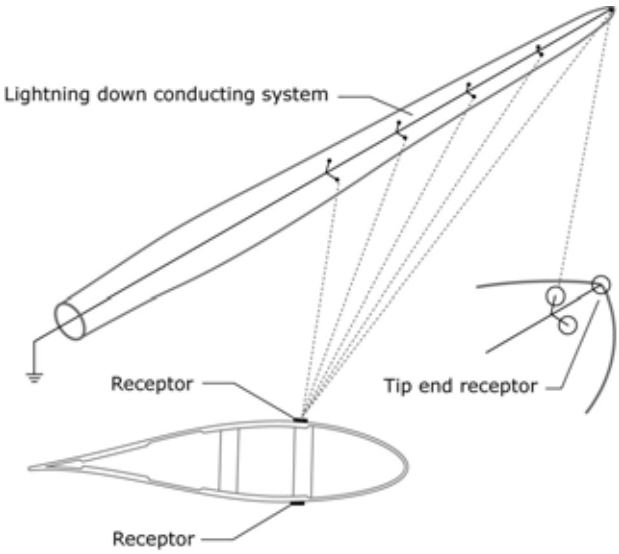
1.6.1.2 LM blades

The LM blade protection system comprises a patented tip end receptor with an integrated drain called a DrainReceptor, a series of special receptors called MultiReceptors on each side of the blade, and a conductive cable connected to the turbine's other lightning protection system, and located in the middle of the blade. In the event of a lightning strike, this conducts the lightning charge from the blade to the turbine tower, which is earthed.

1.6.1.3 Connection to engine bed

Electrical continuity of the rotor to the engine bed is made by a metal brush and spark gap placed on the main bearing housing. When lightning strikes, an electric arc will occur over the gap. The voltage surge is transmitted by a metal brush, which connects the shaft and the housing.

Sketch of the new LM Lightning Protection System



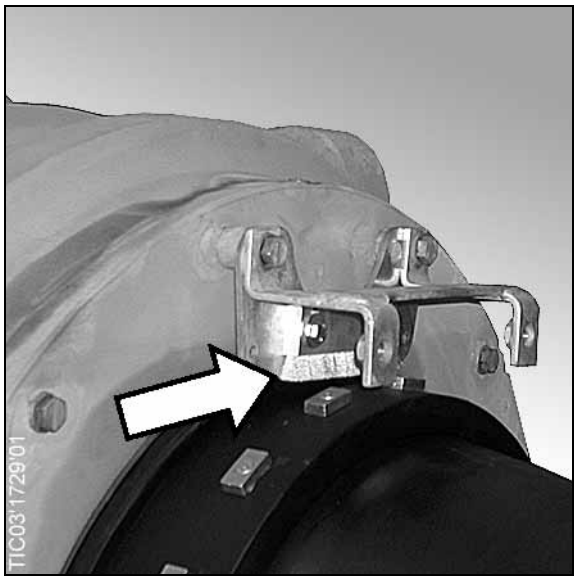
1.6.2 Blade turning system

Lighting current passing through blade bearings will not cause any significant damage, as there is extremely good electrical contact through the blade bearing because either it is not in motion or it is moving slowly, so there is no lubricant film.

1.6.3 Spinner, main bearing and transmission system

The gearbox is partially insulated, as it is suspended on rubber mountings. NEG Micon uses a discharge system placed at the main bearings, thus minimising lightning current through the main bearing. The discharge system consists of combs/collector shoes with replaceable copper brushes.

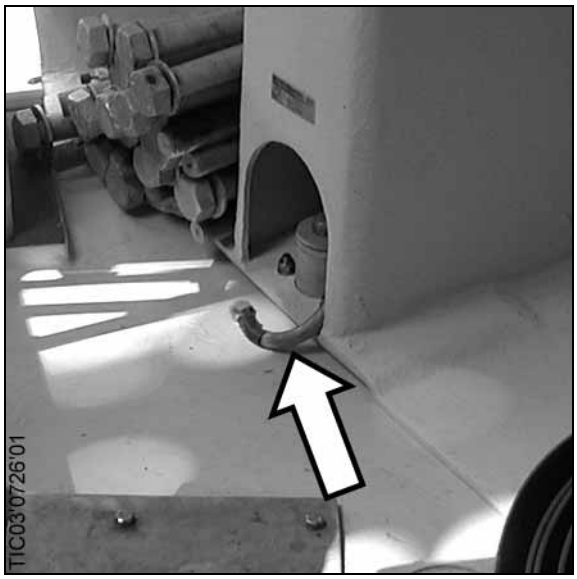
Copper brush



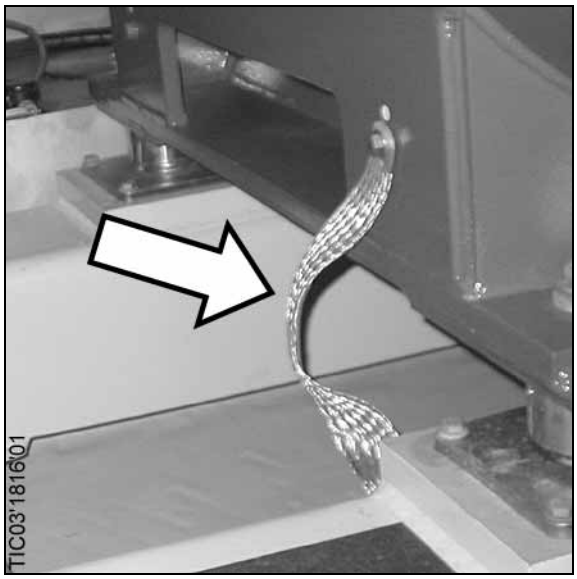
1.6.4 Nacelle

The nacelle cover is made of glass fibre. All major components in the nacelle are equipotentially bonded with the base frame.

Connection from top of nacelle to base frame

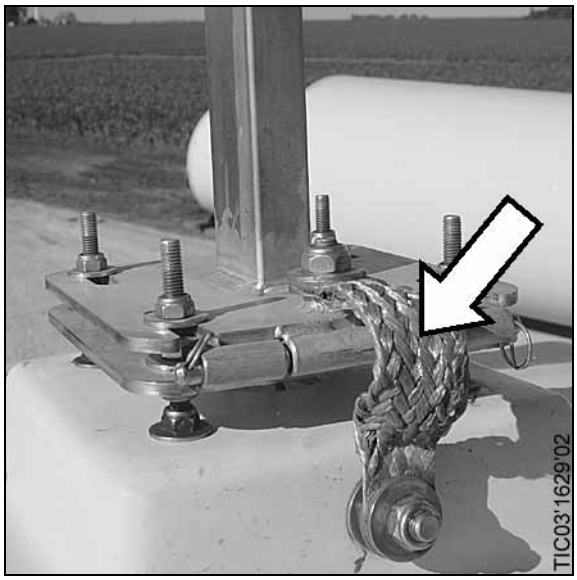


Connection between generator and base frame

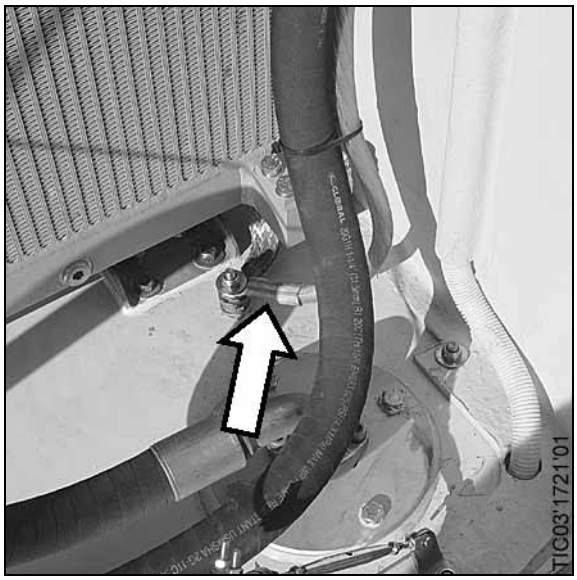


The meteorological equipment on top of the radiator cover is fitted with lightning conductors. The lightning conductor is equipotentially bonded with the base frame.

Ground cable on meteorological console



Ground cable from meteorological console to nacelle



Lightning current from the blades is conducted to the base frame via the discharge system on the main shaft with copper brushes.

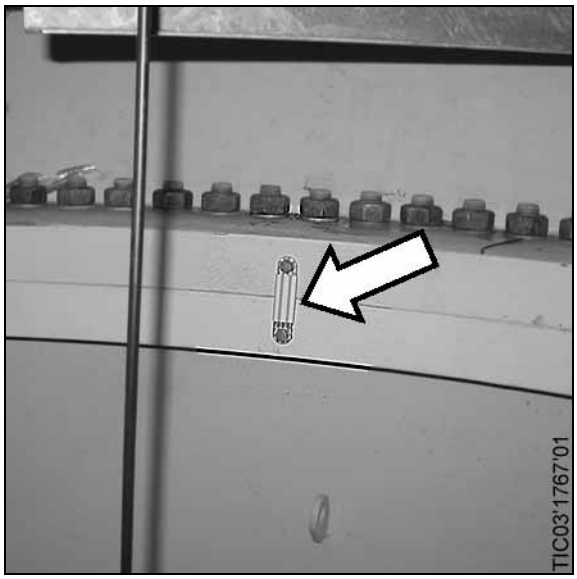
1.6.5 Yaw system

The lightning current is conducted through the yaw bearing. The yaw bearing is pretension and moves only very slowly, so for these reasons and due to its large dimension, there is good electrical contact through the yaw bearing. The yaw bearing is dimensioned to 300,000 rpm at a much higher rotational speed. The yaw bearing is expected to undergo approx. 10,000 rotations during the lifespan of the wind turbine. An equaliser connection, PE connector 95 mm² is connected from the nacelle frame to the tower through the cable loop.

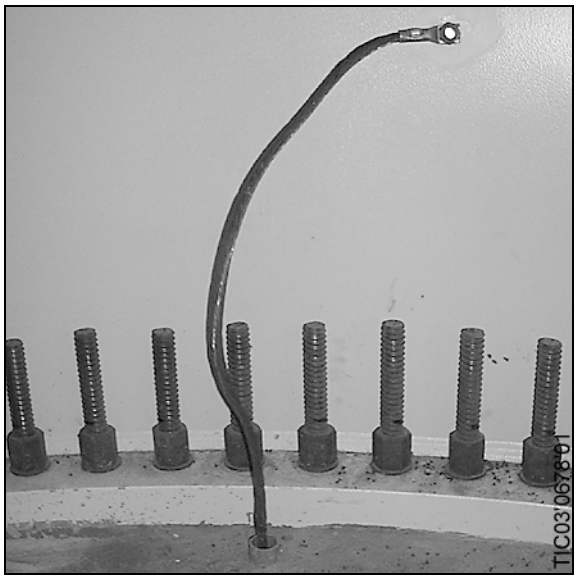
1.6.6 Tower

The lightning current is conducted down through the tower. The tower itself is used as conductor. Joints between tower sections are zinc-coated and 4 equaliser connections, PE connector 50 mm² are connected between tower sections, giving good metallic contact all the way round.

Connector between tower sections



Example of conductor between tower and foundation



1.7 Medium voltage system

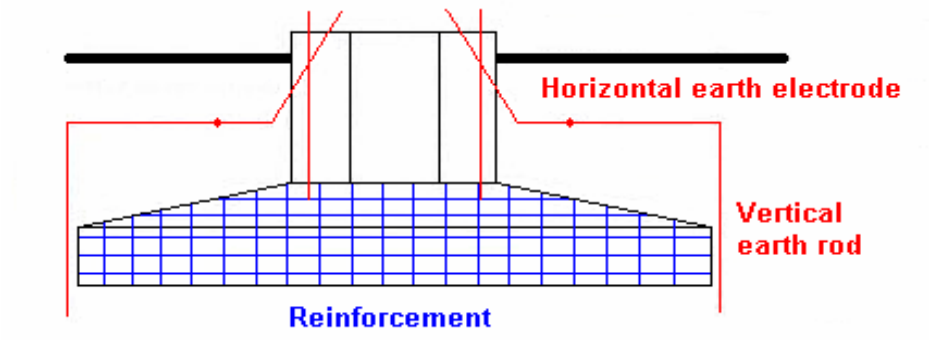
If IGC is installed the power transformer has a lightning arrester on the high-voltage side.

1.8 Earthing/grounding system

As standard the turbine is fitted with an earthing system that has a transient resistance of less that 10 Ohm. The earthing system at the turbine shall be made as 50 mm² copper conductors (horizontal earth electrode) laid around the turbine foundation with a distance of approx 1 meter and with a depth of approx 1 below the surface. Two vertical earthing rods, 50mm² copper shall be connection to the ring and located opposite each other (180 deg.)

The ring shall be connection to earthing arrangements inside the tower. In parks with more than one turbine, a main equaliser 50 mm² copper connection between the turbines shall be established.

The lightning protection earthing system is carried out to IEC norm 1024-1



The wind turbine generator with corresponding control panels and boxes are protected against indirect touch.

The protection against indirect touch is executed as a TN-S system. The TN-S system has a point in the supply system, the power transformer's star point, connected directly to earth, while exposed parts of the wind turbine are also connected to earth. Throughout the whole installation the TN-S system has separate neutral and earth conductors.