

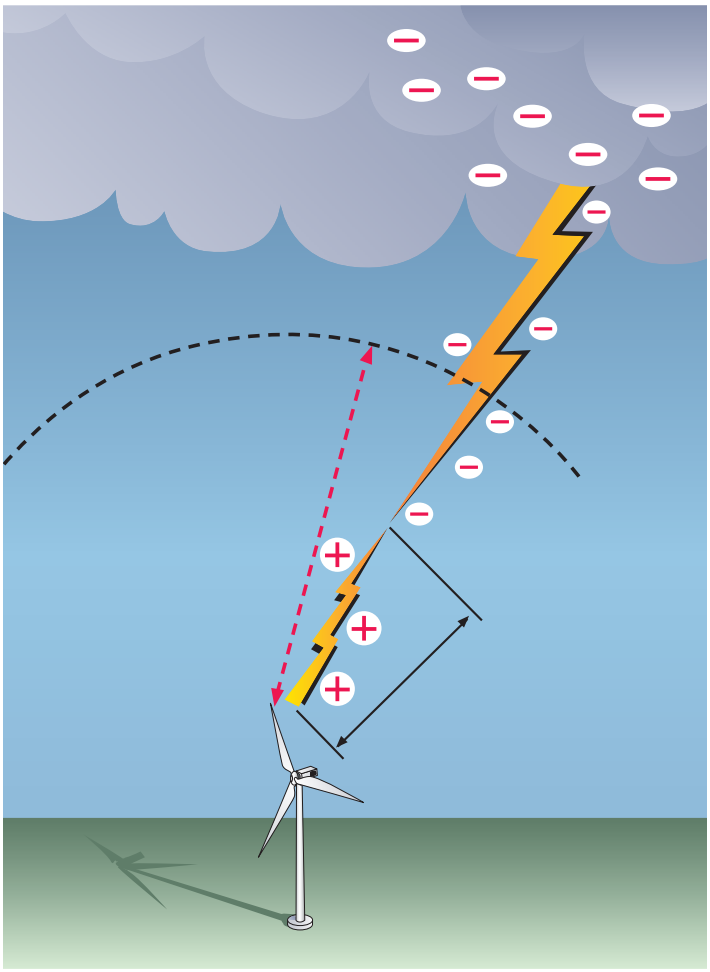
CONNECT AND PROTECT

Blade Lightning Protection for Wind Turbines

nVent

ERICO

The Dynamics of Lightning



The dynamic phase of lightning commences in the form of a downward leader from the base of a cloud and grows into a series of steps and branches toward the ground. The protrusion of ground objects, such as wind turbine blades, into the ambient electric field of the lightning downward leader increases the electric field at the tip of the blade and/or other protruding parts of the turbine.

As the downleader approaches the tip of the ground objects, the electric field increases rapidly and small upward streamers form from the elevated points. Under the right conditions, these upward streamers compete as they propagate toward the approaching downleader. In order for one point on the turbine structure to develop an upward intercepting leader and become the preferred strike point, it must complete an ionized path between cloud and ground.

This main lightning discharge is characterized by a rapidly rising current (averaging about 30,000 Amps) with maximum values exceeding 200,000 Amps (Table 1). The whole process is extremely rapid and typically occurs within milliseconds. The average energy released in a single discharge may be 55 kW hours. The danger lies in the extremely high rate of current rise, which can generate very high voltages within and along the blade, and also from the continuing current following the peak.

First short positive stroke			LPL			
Current parameters	**Symbol**	**Unit**	**I**	**II**	**III**	**IV**
Peak current	I	kA	200	150	100	
Short stroke charge	*Q* short	C	100	75	50	
Specific energy	W/R	MJ/Ω	10	5,6	2,5	
Time parameters	T_1 / T_2	µs / µs	10 / 350			
Subsequent short stroke			**LPL**			
Current parameters	**Symbol**	**Unit**	**I**	**II**	**III**	**IV**
Peak current	I	kA	50	37,5	25	
Average steepness	*di/dt*	kA/µs	200	150	100	
Time parameters	T_1 / T_2	µs / µs	0,25 / 100			

(Source: IEC 61400-24)

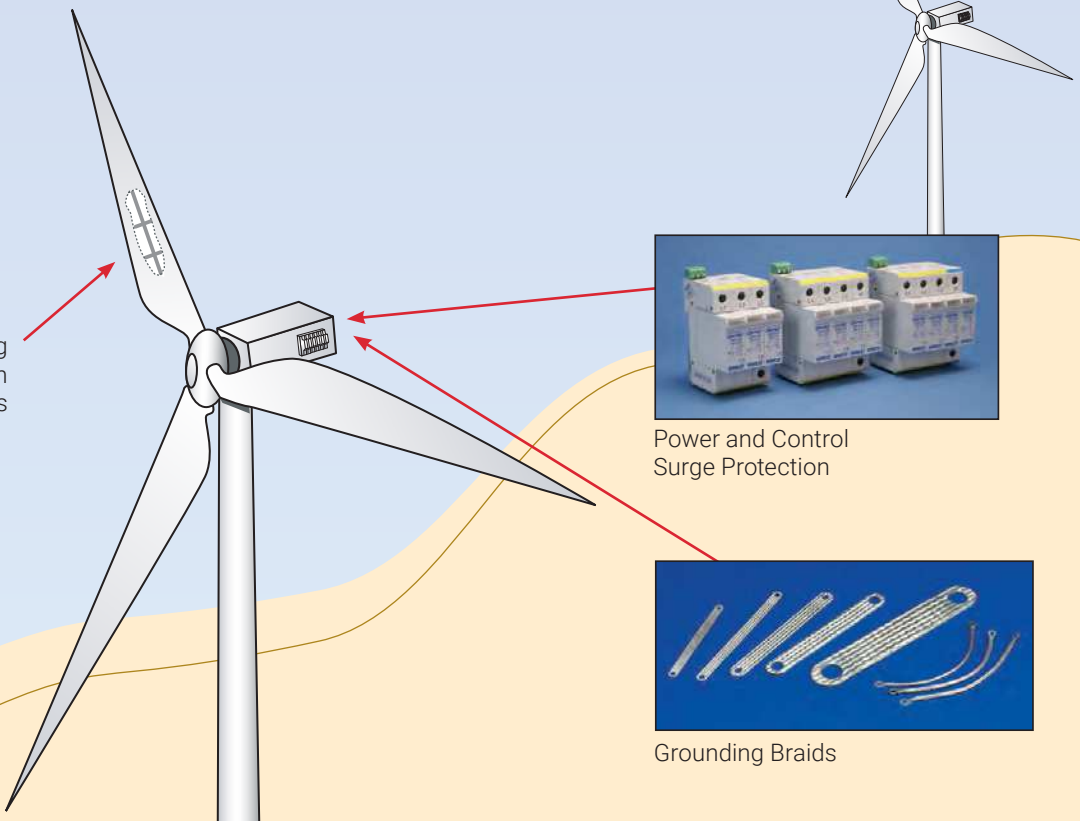
Blades with ineffective lightning protection design can sustain catastrophic damage. A coordinated system is critical to help ensure effective capture and to control the passage of lightning energy to ground.

The most effective techniques to provide reliable protection for wind turbine blades remain the subject of international research and standardization. nVent ERICO's role in this research, in addition to years of service on related lightning-protection standards, have helped make the company a trusted authority within the industry.

Grounding, Bonding, Surge Protection and Lightning Protection

WE FOCUS ON BLADE PROTECTION AS PART OF THE ENTIRE LIGHTNING PROTECTION SYSTEM FOR THE WIND TURBINE.

nVent ERICO offers a complete range of grounding, surge and lightning protection products for the wind energy industry. In addition to our extensive product offering, our engineers and designers are ready to provide design assistance for grounding and lightning protection for your facilities worldwide.



Blade Lightning Protection Assemblies

Power and Control Surge Protection

Grounding Braids

Tower Lightning Protection Assemblies



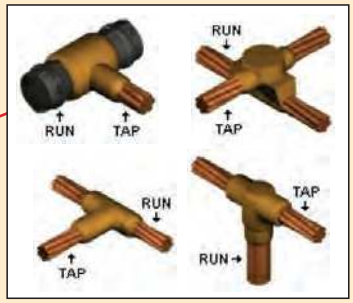
Copperbonded Galvanized Stainless Steel

Ground Rods



nVent ERICO Ground Enhancement Material (GEM)

Cable to Rebar
Cable to Cable
Cable to Ground Rod



nVent ERICO Cadweld Connections

Critical Elements of a Blade Lightning Protection System





CONDUCTOR TECHNOLOGY

Lightning protection conductors are designed and manufactured to meet specific criteria for an effective and reliable conduction of lightning currents. For optimal performance, the conductors must maintain the following characteristics:

- Low inductance per unit length
- Low surge impedance
- Current-carrying capability to withstand, without degradation, the thermal and mechanical effects of lightning
- Resistance to environmental effects

When applied to applications with wind turbine blades, the construction and design of the blade may require additional characteristics for the conductors:

- Insulation, splicing and termination methods adequate to contain the lightning energy under current impulse conditions
- Ability to withstand mechanical fatigue over time

The application of optimal conductors within wind turbine blades is both unique and often complicated, and varies from one blade design and construction to another. nVent ERICO®'s extensive knowledge and experience within this industry make it ideally suited to face these challenges. By manufacturing a wide selection of lightning conductor solutions in multiple facilities around the world, nVent ERICO can provide the high-quality, innovative products and services you require to consistently meet your needs.





Critical Elements of a Blade Lightning Protection System

PERMANENT, LOW-IMPEDANCE CONNECTIONS IT IS WHO WE ARE

Connections are often considered the weakest point of an electrical circuit and this is especially true in the protection scheme within a wind turbine blade. They are subject to constant vibration and corrosion, as well as the thermal and mechanical stresses that are present during a lightning event. In addition, it is difficult to inspect or test the electrical connections within a blade after the system has been installed.

Experience has shown that the most effective protection schemes over time are designed and manufactured with permanent connections, which helps to ensure the system can handle a variety of adverse conditions.





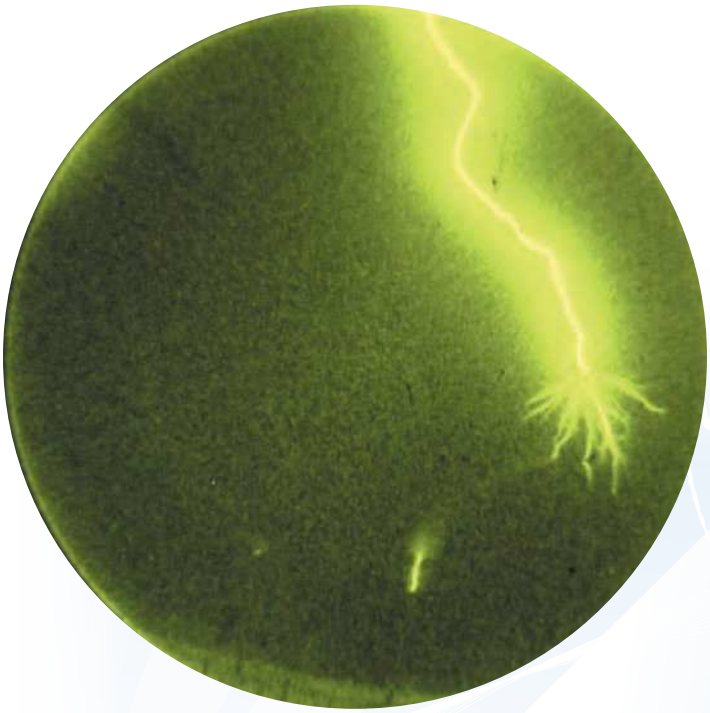
Since 1938, nVent ERICO has specialized in making electrical connections that will never loosen, corrode or increase in resistance. Because of the affordability, success and superiority of the Cadweld welded electrical connection, nVent ERICO is considered a world leader in the development of high-current electrical grounding connections that are suitable for the harshest environments.

nVent ERICO also manufactures a vast array of methods that are used to connect conductors within wind turbine blades. These methods are designed and tested to meet the CENELEC EN50561 standard and other national standards, such as UL® 96. Whether the protection scheme requires an insulated connection, connections to receptors, or connections from conductor to conductor, you can trust nVent ERICO to have the right connection method for your specific application.



Critical Elements of a Blade Lightning Protection System





RECEPTOR ATTACHMENT

To continuously enhance its lightning protection process, nVent ERICO has conducted years of research involving long-term field studies and has performed laboratory testing using some of the largest outdoor test laboratories available. Countless research study programs, including joint ventures with accomplished scientists in the field, have also been used in its research process. This extensive research program has resulted in some of the most up-to date, published technical papers and journals, including patents in this area. nVent ERICO is also committed to the development and harmonization of lightning protection standards around the world.

The placement of receptors on structures, such as wind turbine blades, is performed using statistical models. A risk management approach is required to determine the receptor number and placement to provide optimum protection. The design of the receptor itself also influences its ability to capture lightning. nVent ERICO can provide receptors based on the material type, design and size of the blade.

Years of experience and knowledge in the field of lightning protection, combined with global manufacturing capabilities, make nVent ERICO a premier source for providing comprehensive protection solutions. nVent ERICO can also manufacture the required products and hardware to update existing systems.

Timeline

1998

- Development of multi-conductor insulated lightning conductor for protection of structures

1999

- Publish/present at the Fifth International Symposium on Lightning Protection (V SIPDA), Salvador, Brazil: A new high-voltage, arbitrary waveform generator that can simulate the electric fields due to an approaching lightning downward leader

2000

- Published the first long-term field study on lightning attachment – HK and May

2002

- Published long-term field study, "Assessment of protection system positioning and models using observations of lightning strikes to structures," Proc. Roy. Soc. Lond. A, 458, 723-742
- Began design and manufacturing of blade lightning protection systems for Europe
- Began design and manufacturing of blade lightning protection systems for North America

2003

- Pubish within IEEE Trans. Dielectr. Electr. Insulat., 10, 641-654. "Quantification of the probability of lightning strikes to structures using a fractal approach"
- Experimental testing in Russia – long sparks 26 m "Experimental study of lightning rods using long sparks in air," published IEEE Trans. Dielectr. Electr. Insulat., 11, 638-649

2004

- Presentation of research, "Guidelines for the placement of air terminations near vulnerable points on structures," Proc. 27th ICLP, Avignon, France, pp. 363-368

2005

- Awarded the Product Line Strategy Leadership Award in an international market study by market research firm Frost & Sullivan

2006

- Presented at ICLP, Proc. 28th ICLP, Kanazawa, Japan, "Software modeling of a special insulated downconductor"

Today, nVent ERICO has the experience, knowledge and capability necessary to provide optimum lightning protection solutions for the wind turbine blade industry. nVent ERICO can effectively design and manufacture lightning protection systems, including custom systems for specific blade configurations, in accordance with international or national standards.

2008

- Began design and manufacturing of insulated lightning protection systems for carbon-fiber blades

Our powerful portfolio of brands:

CADDY ERICO HOFFMAN RAYCHEM SCHROFF TRACER

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