PENTAIR

ERICO SYSTEM 3000

LIGHTNING PROTECTION PRODUCTS

ERICO

Central Plaza,
Hong Kong,
P.R. China

Centrepoint
Tower,
Sydney,
Australia

Skytower,
Aukland,
New Zealand

LIGHTNING STRIKES

again and again and again...

ERICO SYSTEM 3000 ERICO DYNASPHERE Air Terminals

Lightning can be devastating. Besides the danger to people, it is a major cause of expensive electronic equipment failure and costly business disruption.

In general, the highest point of a facility is the most vulnerable to a direct lightning strike. Lightning rods or air terminals are needed to capture the strike to a preferred point and to safely conduct the energy to ground to minimize the risk.

Pentair has developed the ERICO SYSTEM 3000 advanced lightning protection system. This innovative system has been used in over 15,000 installations around the world. The Skytower in Auckland New Zealand is an example of the suitability of the system for a wide variety of structure types.

On July 21st, 1999, the ERICO SYSTEM 3000 ERICO DYNASPHERE captured as many as 16 lightning strikes to the Skytower in a period of 30 minutes during a fierce thunderstorm. Video footage of this spectacular event shows the ERICO DYNASPHERE capturing the lightning strike. As the lightning bolt approaches the tower, the ERICO DYNASPHERE can be seen to launch a continuous upward leader to intercept the approaching lightning bolt (downward leader).

The Bank of China in Hong Kong has been protected by the ERICO SYSTEM 3000 from more than 100 direct strikes since 1989. Mt. Tangkuban Perahu Communications Tower in West Java, Indonesia, installed the ERICO SYSTEM 3000 and has experienced 56 lightning strikes over a period of 3 years without damage or downtime.

The ERICO SYSTEM 3000 installed on the Centerpoint Tower, Sydney has recorded more than 40 strikes since November 1995 and the Central Plaza, Hong Kong has been protected from more than 20 lightning strikes since the installation of the system.

Pentair is dedicated to providing the best lightning-protection solution for any given application, whether this involves the use of the standards compliant ERICO SYSTEM 2000, the ERICO SYSTEM 3000 or a hybrid design utilizing a combination of both system types.

Various Air Terminals

Pentair manufactures lightning protection systems in full accordance with more than twelve national and international standards, as well as non-conventional systems based on enhanced air terminals and insulated conductors for applications where these provide an advantageous solution for the customer.

Pentair's approach is solutions driven. The aim is to provide the best solution for a given application. Some structures are more suited to the traditional conventional lightning protection – designs that require protection via complete building structure bonding. Other structures are more suited to a method that utilizes protection via isolation. Whatever the application or protection problem presented, Pentair offers a solution.

ERICO SYSTEM 3000

What is the ERICO SYSTEM 3000?

The ERICO SYSTEM 3000 is a technically advanced lightning protection system. The unique features of this system allow the achievement of reliable lightning capture and control.

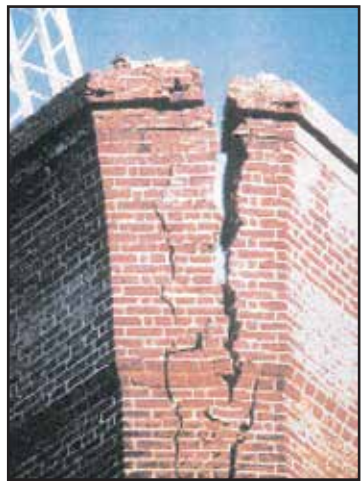
The ERICO DYNASPHERE air terminal provides a preferred point for lightning discharges which would otherwise strike and damage an unprotected structure and/or its contents. The ERICO DYNASPHERE is optimally connected to an ERICO ERICORE downconductor and low impedance grounding system in such a way as to provide a totally integrated system.

ERICO SYSTEM 3000 includes the following elements:

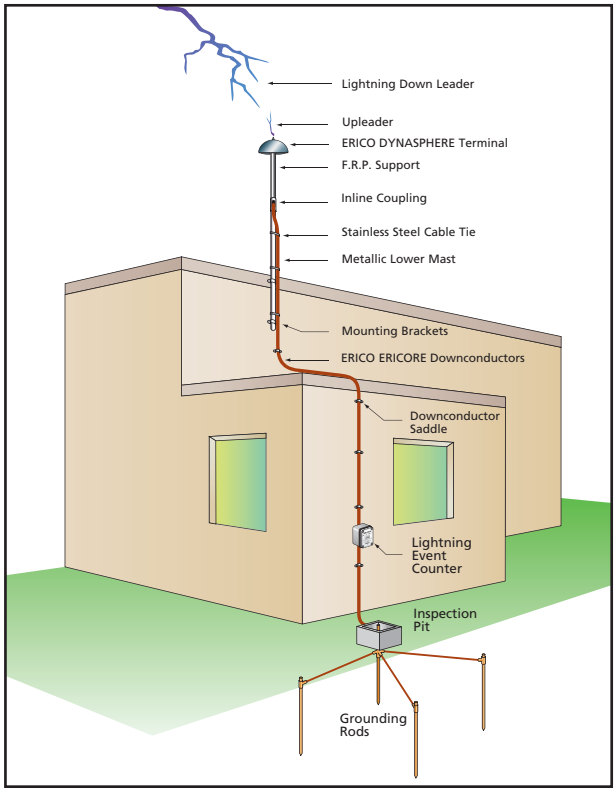
- ERICO DYNASPHERE air terminal
- ERICO ERICORE downconductor
- Lightning event counter
- Purpose designed low impedance grounding system.

These components form an integral part of the Pentair Six Point Plan of Protection. Each component must be considered independently and ultimately integrated together to form the complete lightning protection system. Without such integration there is limited protection.

While it is possible to implement a hybrid system using other components, it is important to realize that inefficiencies in any substitute represents an inefficiency in the protection system as a whole.



There is no known method of preventing the occurrence of a lightning discharge. The purpose of a lightning protection system therefore, is to control the passage of a discharge in such a manner that prevents personal injury or property damage. The need to provide protection should be assessed in the early stages of the structure design.



1. The Air Terminal

The primary function of an air terminal, or air termination system, is to capture the lightning strike to a preferred point, so that the discharge current can be directed via the down-conductor(s) to the grounding system.

2. The Downconductor

The function of a downconductor is to provide a low impedance path from the air termination to the ground system so that the lightning current can be conducted to earth, without the development of excessively large voltages.

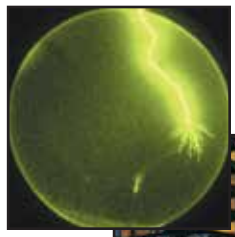
In order to reduce the possibility of dangerous sparking (side-flashing), the downconductor route(s) should be as direct as possible with no sharp bends or stress points where the inductance, and hence impedance, is increased under impulse conditions.

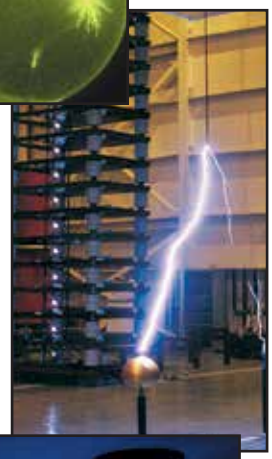
3. The Grounding System

The grounding system must have a low impedance to disperse the energy of the lightning strike. Because the lightning discharge consists of high frequency components, we are particularly concerned with the frequency-dependent electrical parameter of a grounding system – impedance – as well as low resistance grounding.

Grounding systems are highly variable from site to site due to geographical considerations. The grounding grid should minimize the ground voltage potential rise and minimize the risk of injury to personnel or damage to equipment.

Pentair Involvement in Lightning Protection Research





Pentair has investigated the lightning protection process through years of research involving long term field studies. Laboratory testing, using some of the largest outdoor test laboratories, and countless research study programs, including joint ventures with accomplished scientists in the field have also been used in the research process. This extensive research has resulted in some of the most up-to-date published technical papers and journals. Pentair is committed to the development of a range of lightning protection standards around the world.

The ERICO SYSTEM 3000 has evolved from this research activity, with earlier versions of the ERICO SYSTEM 3000 providing a building block for the latest advancements through extensive field studies, leading edge indoor and outdoor high voltage testing and computer modeling research support.

Pentair is involved in the lightning protection industry in many countries around the world and acknowledges the diverse protection methods that exist today.

LONG-TERM STUDIES DEMONSTRATE THE EFFECTIVENESS OF ERICO SYSTEM 3000

Pentair has conducted two unprecedented, long-term field-validation studies of the Collection Volume Method of lightning protection with the ERICO SYSTEM 3000 lightning-protection system. The Collection Volume Method (CVM), also known as Eriksson's Attractive Radius Model, defines the lightning "capture volume"of potential strike points on a structure. CVM considers the physical criteria for air breakdown together with a knowledge of the electric field intensification created by different points on a structure.

The first study, conducted from 1988 through 1996 in Hong Kong, demonstrated that it is possible to dimension the interception efficiency or performance of a lightning protection system using real field data. This method circumvents the problems associated with laboratory testing, where scale-size issues are difficult to resolve and faithful replication of the electric field wavefronts observed in nature can be troublesome.

The number of strikes to the protection system of the structures in this study were obtained from "lightning event counters" (LEC) placed around the lightning current downconductor cable. Overall, estimates of the strike "yield" demonstrate that the interception rate predicted by the CVM is in excellent agreement with the observed capture frequency. This means that the lightning-interception rate is at least as high as the claimed protection levels, which lie in the 85 – 98% range.

The second study, conducted from 1990 through 2000 in Malaysia, quantified interception efficiency. The study consisted of a statistically valid sample of buildings mainly in the Klang Valley region of Kuala Lumpur. The 47 sites had between 1 and 5 buildings per site with a mean structure height of 58 m (190 ft). The mean actual protection level was 78%, confirming that up to 22% of low-intensity flashes under 10 kA could bypass the lightning protection system (LPS). Mitigating factors such as budget constraints and subsequent changes to the structures (e.g. the addition of antennas and extensions) impacted the initial design and prevented the protection level from being higher. At the end of the study, the actual interception efficiency was 86%, ten percent better than predicted.

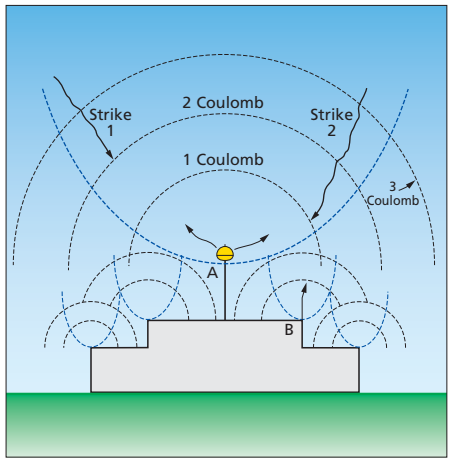
Both of these long-term field studies are now published in independently peer-reviewed scientific journal publications.

ERICO SYSTEM 3000 Supported by Collection Volume Method Placement

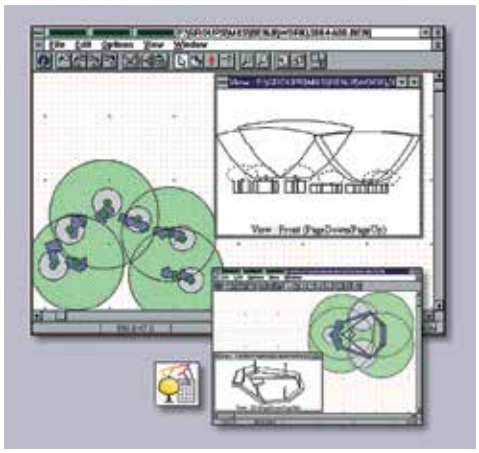
The placement of air terminals on structures is often performed with the Rolling Sphere Method (RSM), which is based on the simple Electro Geometric Model (EGM) for striking distance. The simple EGM does not account for the physical basis of the upward leader inception process and the importance of the structure height or the geometry of objects on the structure. The RSM uses a fixed striking distance, typically 45 m, irrespective of the structure height or width. This means that a structure of height 5 m is assigned the same capture area and strike probability as a 100 m communications tower.

An improved electro geometric model was initially developed by Dr A.J. Eriksson (1979, 1980, 1987). Beginning in the late 1980's, Eriksson's basic model was extended by Pentair scientists and engineers for application to practical structures. This has been done through computer modeling of electric fields around a wide range of 3D structures and by application of the concept of "competing features," to determine whether a structure is protected. This new method has been known worldwide for many years as the Collection Volume Method (CVM). The CVM considers the physical criteria for air breakdown, together with a knowledge of the electric field intensification created by different points on a structure. CVM then uses this information to provide the optimum lightning protection system for a structure, i.e., the most efficient placement of air terminals for a selected protection level.

Using the modern risk management approach, the CVM output depends on user-selected protection levels. Typical protection levels are in the range 84-99%. These values are taken from a standard distribution of peak lighting stroke currents.



The Collection Volume Method defines the lightning "capture volume" of potential strike points on a structure. This method is used in conjunction with the ERICO SYSTEM 3000 lightning protection system but is equally applicable for the placement of conventional terminals.



Design Support

The placement and application of the ERICO SYSTEM 3000 is critical to ensure optimal protection is provided.Pentair's unique computer aided design program enables easier, reliable application of the ERICO SYSTEM 3000, taking into account individual site parameters and the variables required to complete an optimal design using the CVM. Please contact your nearest ERICO office for applications engineering support.

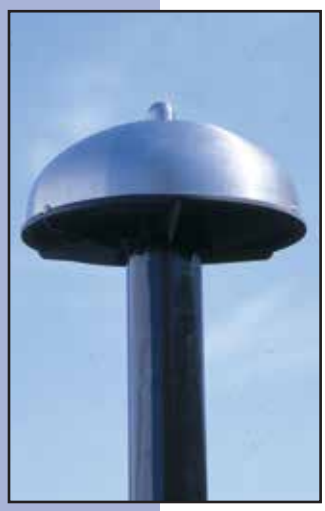
ERICO DYNASPHERE Air Terminal

The ERICO DYNASPHERE Enhanced Air Terminal

The patented ERICO DYNASPHERE is an enhanced air terminal.

Features include:

- Non-radioactive technology
- No external power required
- No moving parts
- Selection of tip radii and variable impedance to adjust for optimum performance at different installation heights
- Dynamic response to the approach of a lightning downleader



During the dynamic phase of the thunderstorm, on closer approach of the downward leader, the semi-sphere or dome of the ERICO DYNASPHERE will rise in voltage via capacitive coupling. When the voltage is high enough, a triggering arc is created across the air gap between the sphere and grounded rod.

The triggering arc has two effects:

(i) it produces the large number of free electrons needed to initiate an upward streamer

(ii) it causes a sudden "snap" increase in the electric field above the air terminal, which provides the additional energy to initiate and convert a strong propagating upward leader.

These two effects develop stable leader propagation to help ensure reliable lightning capture. The size of the air gap is optimized so that a triggering arc only occurs when the ambient electric field is high enough to ensure a stable upward leader can be developed to successfully intercept the downward leader.

Principles of the ERICO DYNASPHERE

For more than 200 years, little improvement was made in lightning protection systems. However, modern research and recording methods have led to an improved understanding of the lightning discharge process, and various advancements have been achieved in the simulation of lightning electric-field conditions. Two fundamental concepts have emerged from these advancements in the lightning attachment process and air terminal performance:

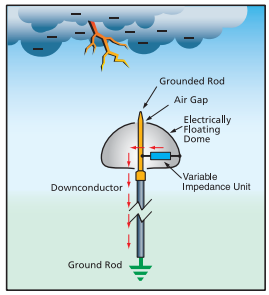
- Air terminals that produce copious quantities of corona (space charge) are less efficient strike receptors.
- An optimum air terminal is one which launches an upward streamer when the ambient electric field is at a level to support the continual propagation of the leader.

The ERICO DYNASPHERE has been developed with these two concepts in mind. The ERICO DYNASPHERE is an enhanced Franklin rod with a semi-spherical dome which is capacitively coupled to the electric field of an approaching lightning downleader.

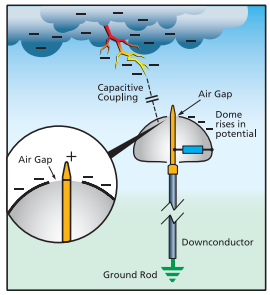
This spherical conductive dome surrounds a central earthed lightning rod. The dome is insulated from the rod but connected to ground via a dynamic variable impedance with DC conduction.

The ERICO DYNASPHERE is isolated from the structure using an insulated support mast. The mast also helps enable the safe connection of the ERICO ERICORE downconductor to the air terminal.

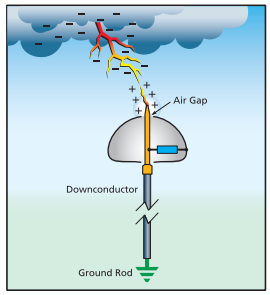
ERICO DYNASPHERE MKIV complete with ERICO ERICORE assembled.



Static Thunderstorm Phase



Dynamic Thunderstorm Phase



Controlled Triggering Streamer Phase

The ERICO DYNASPHERE has been designed to meet the criteria necessary for the controlled emission of a streamer. The concept of "controlled" is important because it is not effective to launch a streamer too early – the ambient field will not be large enough to convert the streamer to a leader and so the streamer will cease to propagate. This will leave a space charge behind which can inhibit future initiation attempts.

Characteristics of an optimum air terminal:

- Minimal pre-strike corona / space charge.
- Streamers released only when the ambient field can sustain leader initiation and propagation.

Both of these characteristics require a blunt configuration.

The ERICO DYNASPHERE Enhanced Air Terminal Capture point of the ERICO SYSTEM 3000 initiates an upward leader during thunderstorm conditions.

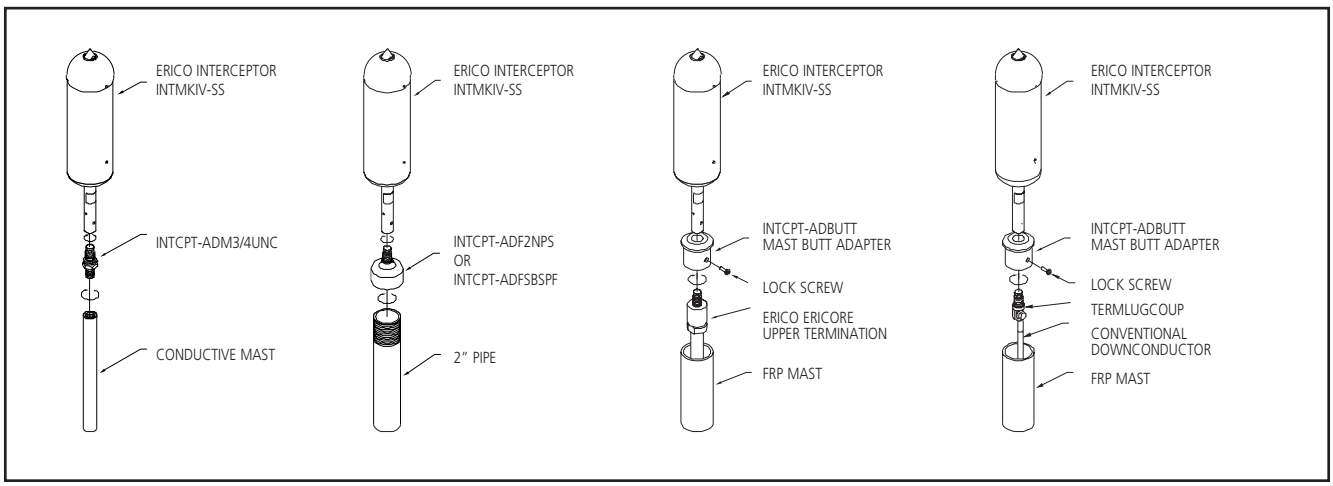
Various mounting options.

The ERICO INTERCEPTOR MKIV.

The ERICO INTERCEPTOR Air Terminal is specifically designed for smaller installations that do not require the larger protection radius offered by the ERICO DYNASPHERE. The ERICO INTERCEPTOR is based on similar technology to the ERICO DYNASPHERE, but its smaller shape limits its applications to those structures with a smaller footprint such as a cluster of antennae or those that are less than 20 m tall (65 ft).

As the ERICO INTERCEPTOR tip is limited to small areas or structures under 20 m tall, it is supplied with one standard tip shape. Various mounting arrangements for the ERICO INTERCEPTOR are shown below:

ERICO INTERCEPTOR



ERICO ERICORE Downconductor

Cutaway diagram showing the composite layers of ERICO ERICORE Downconductor. Inset: ERICO ERICORE upper termination.

Technical and Design Characteristics of ERICO ERICORE

The ERICO ERICORE downconductors have been designed to meet criteria for an effective and reliable downconductor, with the following key characteristics:

- low inductance per unit length
- low surge impedance
- carefully controlled internal electric field distribution to minimize field stresses under current impulse conditions
- carefully designed, stress reducing upper termination

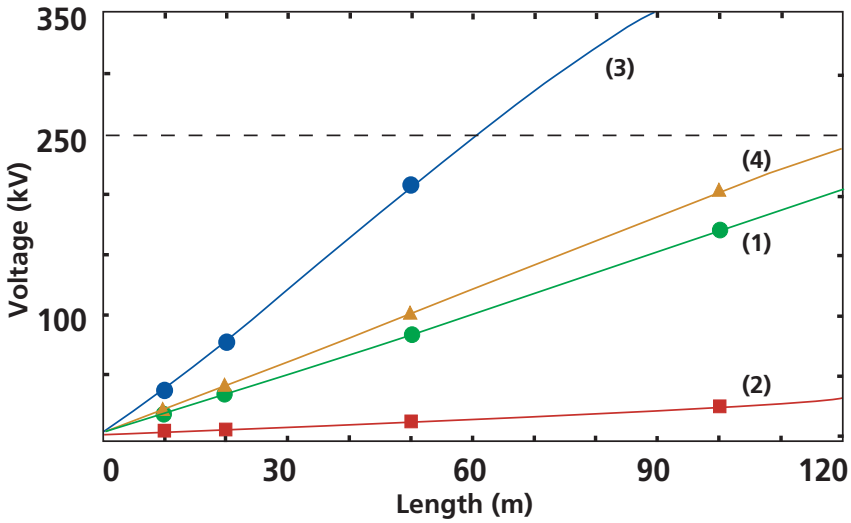
The ERICO ERICORE Downconductor is easily retrofitted to existing structures. Inset: ERICO Lightning Event Counter (LEC IV) installed to register strikes to ERICO SYSTEM 3000.

The ERICO ERICORE Downconductor

As an integral part of the ERICO SYSTEM 3000, the screened, insulated ERICO ERICORE downconductor conveys the lightning discharge current to ground with minimal danger of sideflashing. A unique semi-conductive outer sheath allows electrostatic bonding of the building through cable securing saddles.

The ERICO ERICORE downconductor evolved after extensive studies of potential voltage rise in structures due to lightning injection. This cable is comprised of carefully selected dielectric materials, which create capacitive balance and help ensure insulation integrity under high impulse conditions.

The unique ability of ERICO ERICORE to confine a discharge current and simultaneously support electrical bonding helps ensure minimal risk to building, occupants and sensitive electronics.

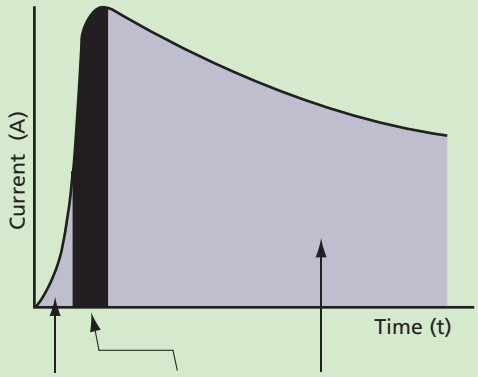


	Type Discharge	% less than	Waveshape (µs)	*di/dt* (max) (kA/µs)	Peak Current (kA)
● 1	-ve	50	5.5/75	24.3	70.1
■ 2	+ve	50	22/230	2.4	28.7
● 3	-ve	95	1.8/30	65.0	51.9
▲ 4	+ve	95	3.5/25	32.0	59.1

Statistics taken from IEC 62305 Part 1.

To understand the technical value of the cable, it is first necessary to review the problems associated with normal downconductors. A value of inductance of 1.6 µH/m is normally regarded as quite small. However, when a current is impressed which is rising at the rate of 10^{10} Amperes per second, the effect of this inductance becomes dominant. As an example, a single 60 meter downconductor will rise to a value in excess of 1,000,000 volts with the application of an average discharge. It is for this reason that the ERICO ERICORE downconductor has a significant advantage over conventional downconductors.

ERICO ERICORE DOWNCONDUCTOR



Stage 1 - Impedance (Z)
$Z_0 = \sqrt{\frac{L}{C}}$ Cable voltage determined by Z_0

Stage 2 - Inductance (L)
$V \propto L \frac{dI}{dt}$ Cable voltage determined by inductance and its rate of change

Stage 3 - Resistance (R)
IR. Cable voltage determined by L&R but L is small or negative due to small dI/dt.

Summary of the three main stages of ERTIECH ERICORE operation

ERICO ERICORE offers purpose-designed performance in each phase of the lightning control process to help convey the energy safely to the grounding system.

As an example, consider the following comparison between the same 50 m length of conventional downconductor (25 mm x 3 mm copper tape) and ERICO ERICORE downconductor, using the air breakdown electric field (nominally 3 MV/m) and cable termination voltage (250 kV) as the criterion for "failure" of the downconductors.

The conventional downconductor will, conservatively, cause a flashover or structure dielectric breakdown when carrying lightning currents of only ~ 30 kA. On the other hand, the ERICO ERICORE screened/insulated downconductor can easily handle far greater lightning currents. This magnitude of lightning current is exceeded in only ~ 5% of lightning events or approximately once every 30 years in a region with a ground flash density of 5 strikes/km^2/yr (approximately 80 thunder days/yr).

Main Benefits

- Lightning impulse is contained within the cable and the semiconductive outer sheath is bonded to the structure via metallic saddles, which means that the risk of sideflashing is negligible
- The low characteristic impedance of the cable minimizes internal dielectric failure
- The cable is able to be routed away from sensitive equipment, electrical wiring, structural steel and human work areas
- Use of a single downconductor as opposed to multiple downconductors
- Ease of installation
- Minimal maintenance

ERICO ERICORE Characteristic	
Characteristic impedance (Ω)	<12
Inductance (nH/m)	37
Capacitance (nF/m)	0.75
Cross Sectional Area of Conductor - mm^2	55
Resistance R_{DC} (mΩ/m) Resistance $R_{impulse}$ (mΩ/m)*	0.5 6
Upper Termination Voltage withstand (kV)	250
Weight (kg/m)	1.2
Diameter (mm)	36

Characteristics of ERICO ERICORE downconductor.
** Due to skin effect*

Why Use ERICO ERICORE?

The ERICO ERICORE downconductor cable is purpose-designed low inductance, low impedance cable designed to minimise voltage build-up due to lightning impulses. This cable provides significantly higher performance than any normal HV cable and is specially designed for the control of lightning impulses.

The main danger in controlling lightning impulses is the very fast voltage and current rise times following the capture of the lightning strike.

To further understand the technical value of the cable, it is necessary to review the lightning mechanism and resulting voltage build-up. The voltage between inner conductor and outer sheath is determined by three different parameters. These are dominant at different stages during the operation of the cable in conveying lightning energy to ground (as shown in The Typical Lightning Waveform Table.)

ERICO SYSTEM 3000

ERICO DYNASPHERE

DSMKIV-SS (702085) 5 kg
Air terminal

Stainless Steel Mounting Bracket

700025OS4 (702065) 1.2 kg Bracket for cantilevered mounting of Aluminum masts.

ERICO INTERCEPTOR

INTMKIV-SS (702089) 2 kg
Air terminal for smaller protection areas or structures <20 m tall.

U Bolt

UBOLT (701460) 0.4 kg
Pair of UBOLTs for mounting Aluminum masts.

ERICO ERICORE

ERICO ERICORE (701875) 1.2 kg per meter Insulated downconductor.

Guy Ring

GUYRING (710280) 0.1 kg
Allows guys to attach between FRP mast and Air Terminal.

ERICO ERICORE Upper Terminations

ERICORE/TRM/OS (701915) 1.5 kg
Factory upper termination to outside of cable drum.

ERICORE/TRM/IS (701815) 1.5 kg
Factory termination to inside of drum.

ERICORE/UTKITA (702025) 1.0 kg
Kit for field upper termination.

ERICO ERICORE Lower Termination

ERICORE/LTKITA (702005) 1.5 kg
ERICO ERICORE connection to grounding grid.

Guy Kit

GUYKIT4MGRIP (701305)
4 m 0.4 kg

GUYKIT7MGRIP (701315)
7 M 0.7 kg
Guy kits for 4 m and 7 m vertical guy heights.

Downconductor Fixings

CONSAD/E2*(701990**) Saddle 0.19 kg
CONSADFX (701410) Screw 0.01 kg
Stainless steel fixings to mount ERICO ERICORE.
*Supplied in USA/Asia as 1 pack of 5 saddles.
*Supplied in Europe each, order in multiples of 5.

Inline Coupling

I/LCOUPL (701320) 2.25 kg
Connects FRP mast to lower Aluminum mast. Provides guy attachment points and ERICO ERICORE exit point.

Tower Saddles

CR37-2 (336430) Cable Clamp 0.04 kg
CR20-2 (336130) C Clip 0.1 kg

For fixing ERICO ERICORE to steel tower legs.

CR37-2 supplied in boxes of 50, CR20-2 in boxes of 100.

ERICO SYSTEM 3000

Cable Tie

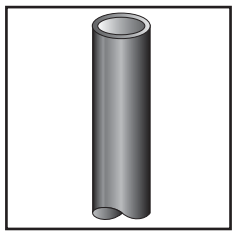
CABTIE-SS (701420) 0.05 kg
520 mm stainless steel cable tie for strapping ERICO ERICORE to masts and other structures.

Adapter to ER Series Masts

INTCPT-ADM116UN (702301) 0.1 kg
Adapter to mount Air Terminal to ERICO ER2-xxxx-SS non insulated masts.

Lightning Event Counter

LEC-IV (702050) 2.0 kg
Installed on downconductor to record number of lightning strikes.



FRP Masts

FRP2MBLACK (702040) 2 m Black 5 kg
FRP2MWHITE (702030) 2 m White 5 kg
FRP4.6MBLACK (*) 4.6 m Black 11.5 kg
Insulated upper mast section for air terminals.
* Not available in Europe.

Adapter for Conventional Cable

TERMLUGCOUPL (701840) 0.1 kg
For connection of conventional downconductors to air terminals.

Base Plate

MBFRP4.6M (*) 5 kg
Welded steel base plate for guyed installation of FRP4.6MBLK.
* Not available in Europe.

Mast Butt Adapter

INTCPT-ADBUTT (702296) 0.05 kg
Required to mount the ERICO INTERCEPTOR Air Terminal into the FRP mast.

Aluminum Mast

ALUM3M (502000) 3 m 8.25 kg
ALUM4M (701370) 4 m 11 kg
ALUM5M (701380) 5 m 13 kg
ALUM6M (701390) 6 m 16 kg
Masts for cantilevered installations.

Water Pipe Adapter

INTCPT-AD2BSPF* (702297) 0.1 kg
INTCPT-ADF2NSP** (702298) 0.1 kg
For mounting Air Terminals to non-insulated water pipe masts
* 2" British thread
** 2" USA thread

Aluminum Mast with Base

MBMAST3M (502040) 3m 9.6 kg
MBMAST4M (701340) 4 m 12 kg
MBMAST5M (701350) 5 m 15 kg
MBMAST6M (701360) 6 m 17 kg
Mast with base for guyed installations.

Adapter to 3/4 thread

INTCPT-ADM3/4UNC (702299) 0.1 kg
Adapter to mount Air Terminal to conventional 3/4" lightning protection hardware.

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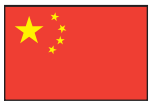

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