



Isolated and insulated lightning protection

Correct design
and dimensioning





Avoid uncontrolled flashovers

Space is limited on modern roofs. For this reason, isolated or even insulated lightning protection is often the only option for maintaining the required separation distances.

IEC 62305-3 describes the requirements for a lightning protection system. This system is subdivided into external and internal lightning protection. An external lightning protection system has the task of capturing the lightning with the aid of air-termination systems and directing it into the ground in a controlled manner via a down conductor. This protects buildings from direct lightning strikes and possible fires. The distance between the air-termination system or down conductor and metal and/or electrical installations of the system to be protected must be sufficient to prevent dangerous flashovers. Such flashovers harbour the risk of sparks and potential fires. It is therefore important that separation distances are calculated in advance.

These requirements are a particular challenge in modern commercial and industrial facilities. The roof often serves as an installation area for ventilation and air conditioning technology, recooling towers, PV systems and much more. With conventional external lightning protection systems, it is often difficult to maintain the prescribed separation distances. One solution to this problem is to install an isolated or HVI lightning protection system.

Isolated lightning protection

With isolated lightning protection, the building is comprehensively protected against direct lightning strikes by the use of self-supporting air-termination rods, air-termination masts or cable-covered masts. The concept of isolated lightning protection has proven itself in practice and is particularly recommended for new buildings. This procedure prevents uncontrolled flashovers between the air-termination systems and earthed, electrically conductive elements and other installations. An alternative method is to attach air-termination and down-conductor systems to the object to be protected using electrically insulating materials such as GRP (glass-fibre reinforced plastic).

HVI Lightning Protection

HVI Lightning Protection comprises high-voltage-resistant, insulated down conductors and matching system components, such as supporting tubes, brackets and connection elements. The special feature is the sheathing of the conductor carrying the lightning current. This conductor, which is coated with a semi-conductive insulating material, replaces the physical separation distance to be maintained, allowing the HVI Conductor to be laid directly on or underneath the parts of the building, electrical cables or pipework to be protected.

Wind load: Correctly dimensioning a lightning protection system

- ➔ Basis for the design of concrete bases, fixings and air-termination systems
- ➔ Eurocode: observe country-specific regulations

When planning and installing air-termination systems as part of a lightning protection system, the wind load plays a fundamental role in preventing damage and accidents (e.g. the air-termination rod tipping over or breaking). Wind load calculations are the basis for the correct dimensioning and selection of air-termination systems.

Wind load is one of the climatically induced effects on structures or components. It results from the pressure distribution around a structure that is exposed to a wind flow. The wind load acts as a surface load perpendicular to the contact surface and is primarily made up of pressure and suction effects.

Good to know: throughout Europe, the Eurocode forms the basis for structural dimensioning and design. Country-specific normative adjustments must be taken into account. The special part of the Eurocode EN 1991-1-4 deals with wind loads and, due to technical building regulations, is often a component for required structural analyses.



Influencing factors

Local and technical factors are included in the calculation of the actual wind load to be expected:

Local parameters:

- Wind zone: Defines the basic wind speed / dynamic pressure in a specific area
- Terrain type: Defines the surroundings of a structure; e.g. open area, suburb, urban area
- Height above ground level: Defines the height of a building above ground level

Technical parameters of the air-termination system:

- Air-termination system dimensions (height, diameter)
- Materials
- Type of fixing
- Use of HVI Conductors
- Spanning cables

Influencing factors to be considered separately:

- Ridges or summits
- Ice build-up
- Building heights over 300 m
- Terrain heights over 800 m (above sea level)

The combination of the different local parameters results in a so-called **gust wind speed**. In conjunction with the technical parameters, this forms the basis for the design of the lightning protection system and the corresponding product selection.

Attention: when determining the wind load, please take into account any **special country-specific characteristics**. Individual specifications, terrain types and tables can be found on the Web.

5 steps for wind load calculation

Step 1: determining the wind zone

This is based on the location of the project. Please take a look at the country-specific requirements. Here you will find the respective wind zone by postcode or location-dependent considerations.

Step 2: determining the terrain type

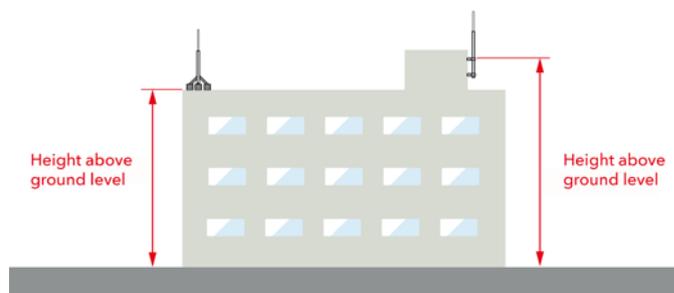
Terrain-specific loads also influence the wind load. For this reason, it must be determined in which of the following terrain types the structure is located:

- **Terrain type I:** open sea; lakes with at least 5 km open area in wind direction; smooth, flat land without obstacles
- **Terrain type II:** terrain with hedges, individual farmsteads, houses or trees, e.g. agricultural area
- **Terrain type III:** suburbs, industrial or commercial areas, forests
- **Terrain type IV:** urban areas in which at least 15% of the area is built up with buildings whose average height is > 15 m

Step 3: determining object heights above ground

This height specification includes the height above ground level. The height point to be determined (height above ground) depends on the type of installation of the air-termination system:

- For self-supporting air-termination systems/stands: Height above ground level = stand erection level
- For air-termination systems attached to a wall / the object: height above ground level = highest clamping point on the object



Step 4: determining the gust wind speed

Using the parameters defined in steps 1 to 3, the respective gust wind speed can be taken from the tables (see country-specific information).

Step 5: considering individual technical parameters

In a final step, the determined gust wind speed is compared with the specifications of the planned lightning protection components (information in the installation instructions).

Services and support

DEHN is ready to assist you. And offers you planning tools and services for calculating the wind load and selecting suitable products.

Planning tools:

- DEHNplan
- DEHNsupport Toolbox:

Our technical support team can help with specific questions relating to wind load calculations and product selection.

Services and planning support

<http://de.hn/bLPU5>



Separation distance is key

- Separation distance: the basis for planning the lightning protection system
- Challenges: spatial and architectural requirements
- The solution: HVI Lightning Protection

Maintaining the separation distance prevents dangerous flashovers from occurring between earthed parts of the building structure (e.g. steel girders, reinforcements, lift rails, etc.) or electrical installations and the lightning

current-carrying components of the lightning protection system (air-termination systems, down conductors, etc.). Failure to do so may result in sparks, which can cause personal injury, property damage or fire.

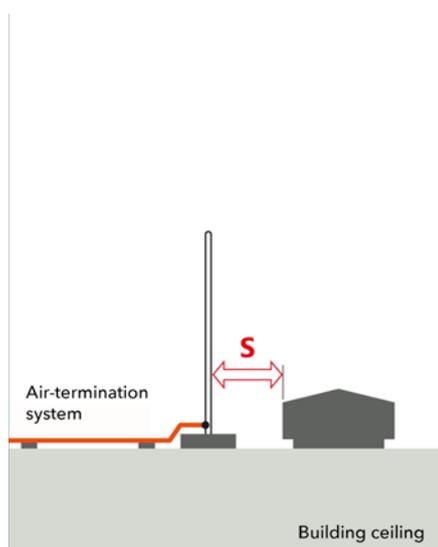
Separation distance - the basis of a lightning protection concept

The lightning current is fed into the down conductors by means of an air-termination system and channelled into the ground in a controlled manner. The design of an isolated and insulated lightning protection system is based on the separation distance. The calculation is carried out

in accordance with the DIN EN 62305-3 standard, which defines the necessary parameters and factors. The minimum distance that must be maintained between the air-termination system or down conductor and the electrical or metallic conductive parts of the building structure is determined. Examples include:

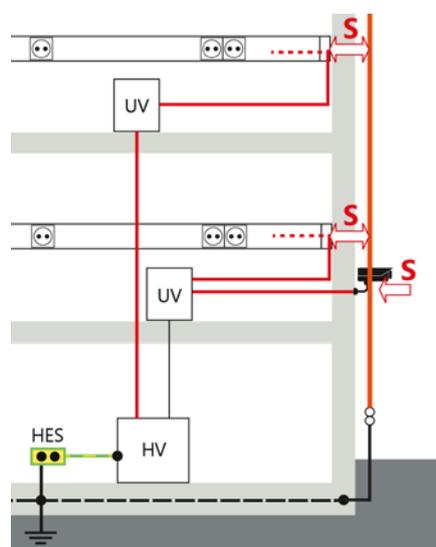
Roof-mounted structures

Such as roofing, roof-mounted fans



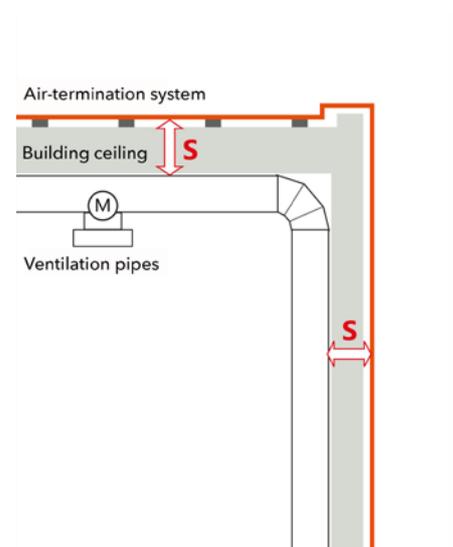
Electrical cables

Such as cable trunking systems, outdoor cameras



Conductive parts of a building

Such as installation tubes, ventilation pipes





Calculating the separation distance

According to IEC 62305-3 (VDE 0185-305-3), the required separation distance is calculated as follows:

$$s = \frac{k_i \cdot k_c}{k_m} \cdot l$$

s	Separation distance
k_i	Dependent on the selected protection class of the lightning protection system
k_c	Dependent on the current sharing in the down-conductor system
k_m	Dependent on the material of the electrical insulation
l	The length along the air-termination system or down conductor in metres from the point where the separation distance is supposed to be determined to the next equipotential bonding or earthing point

Detailed information on calculating the separation distance is provided by the Lightning Protection Guide in the section "Electrical insulation of external lightning protection - separation distance".

The challenge:

maintaining separation distances in practice

For aesthetic reasons, modern architecture can make it difficult to install down conductors with GRP spacers on a building. In addition, difficulties arise with extensions, renovations and changes of use of existing installations, as conventional lightning protection systems may not be able to fulfil the separation distance requirements. In addition, the roof is often the last available installation area for various applications. Nevertheless, lightning protection systems are usually prescribed specifically for public, commercial or industrial buildings, and it is essential to observe the necessary separation distances.

The solution: HVI Lightning Protection

The required separation distances often cannot be realised with conventional lightning protection systems. Not so with the HVI lightning protection system. With its unique design and special sheath, HVI Lightning Protection enables the separation distance to be maintained - and in the simplest possible way.

HVI Lightning Protection

Safety and flexibility of the highest level

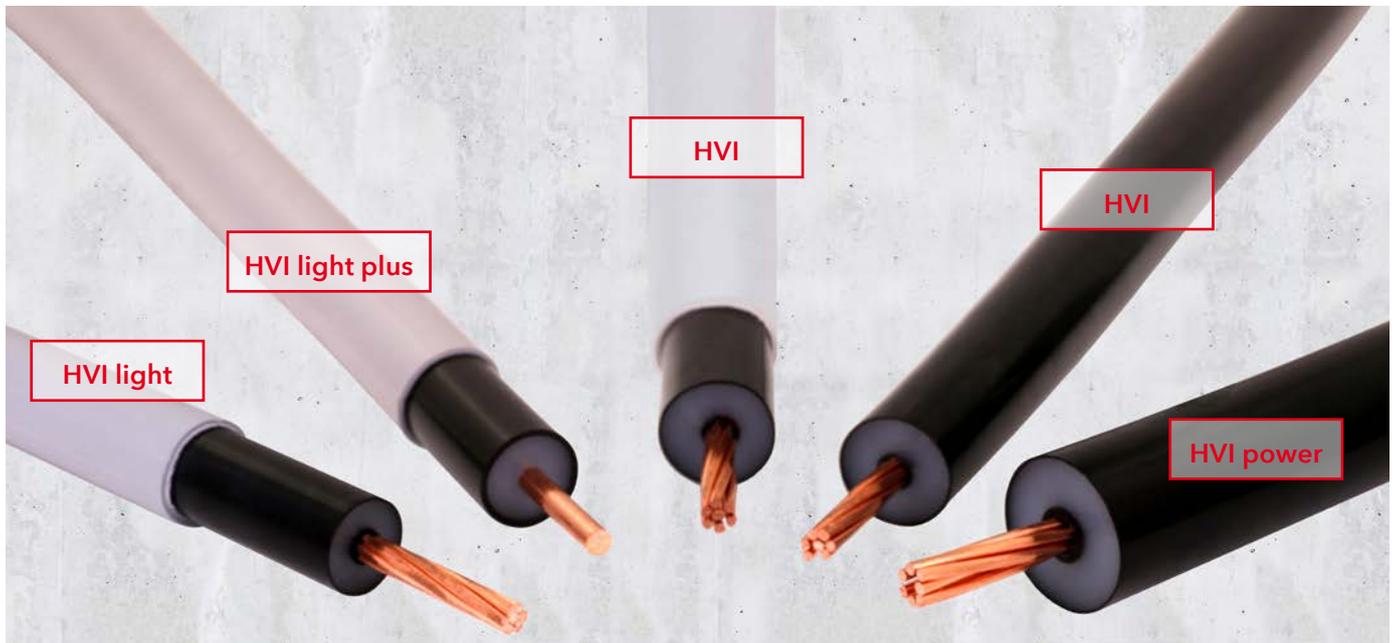
HVI Lightning Protection – what makes it special: the lightning current is conducted safely and creepage discharges and flashovers are avoided. This makes it easy to maintain the required separation distances.

HVI Lightning Protection offers maximum protection and maximum flexibility during installation. The HVI Conductor is a high-voltage-resistant, insulated down conductor from DEHN. The conductor carrying the lightning current is encased in high-voltage-resistant insulation and a semi-conductive sheath in such a way that uncontrolled disruptive discharges and creeping flashovers are prevented and lightning currents are safely dissipated. In contrast to insulated conductors with a metallic, braided shield, there is therefore no risk of high-energy induction currents with the HVI Conductor. The lightning-current-carrying connection of metallic, earthed building installations is not required. Additional equipotential bonding measures can therefore be easily coordinated and installed.

Another advantage: HVI Conductors meet the need for a modern look and design. The grey conductors can be painted in the same colour as the building and all variants can be installed behind the façade. The system thus enables optimum adaptation to the building architecture and offers a wide variety of design options.

HVI lightning protection system – all the benefits at a glance

- Reliably maintain separation distances: you install directly next to conductive parts of the building or directly next to electrical cables or pipework
- Easy to install: you can install safely, easily and quickly with modular components and special tools
- Integration within the building architecture: all HVI Conductors with a grey sheath can be colour-matched
- Easy to retrofit: HVI Lightning Protection takes up little space and leaves room for the future installation of roof structures such as PV or air-conditioning technology.
- Suitable for use in hazardous areas:
 - For Ex zone 2 and 22: all HVI variants
 - For Ex zone 1 and 21: HVI light plus, HVI and HVI power



HVI product family

The large number of installations and intensive development activities have given us a head start in terms of experience, which is reflected in the HVI Conductor types. These correspond to the different installation requirements for lightning protection systems.

The possible uses of HVI Conductors are extremely diverse and suitable for every application. Only DEHN offers such a wide range - and over 20 years of experience in insulated lightning protection.

The range includes the conductor types:

- HVI light
- HVI light plus
- HVI
- HVI power

HVI lightning protection: Which conductor do you need and when?

The separation distance is a decisive factor when selecting the right conductor:

	HVI light	HVI light plus	HVI	HVI power
Separation distance in air	≤ 45 cm	≤ 60 cm	≤ 75 cm	≤ 90 cm
Version	Squirrel grey	Signal grey	Light grey / black	Black
Lightning current carrying capability	150 kA	150 kA	150 kA	200 kA
Class of LPS	II - IV	II - IV	II - IV	I - IV
Protection against electric shock	✗	✓	✓ / ✗	✗
Approval for use in hazardous areas	✗	✓	✓	✓
Paintable	✓	✓	✓ / ✗	✗
Without additional equipotential bonding	✓	✓	✗	✗
Solid inner conductor	solid / stranded	✓	✗	✗

HVI Lightning Protection

<http://de.hn/c6yS2>



HVI light

- Separation distance $s \leq 45$ cm (in air)
- Suitable for installing on flat and gable roofs
- Simple installation due to solid inner conductor

The roof surfaces of buildings often form the uppermost installation level. Despite the risk of possible lightning strikes, pipelines, electrical and information technology systems as well as PV systems are installed there. These systems have conductive connections, through which lightning currents can enter the interior of the building.

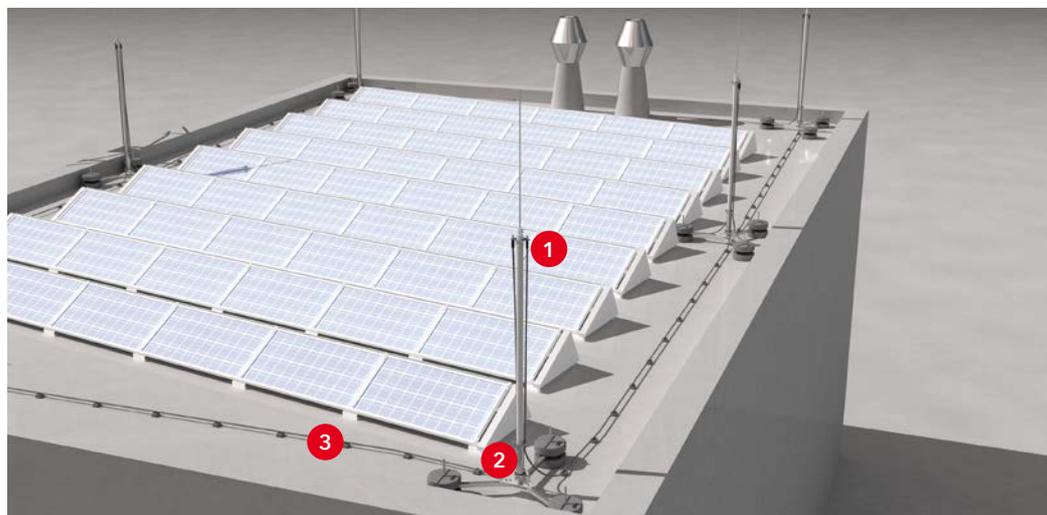
A major advantage of the HVI light Conductor is its quick and easy installation without the need for a conventional cable sealing end. Instead, the cable is connected to the supporting tube in the tripod with an adjustment range. This does not have to be connected to the functional equipotential bonding.

Technical features:

- Equivalent separation distance $s \leq 45$ cm (in air), or $s \leq 90$ cm (solid building material)
- Tested with I_{imp} 150 kA ($k_c = 1$; 10/350 μ s)
- Tested to IEC/TS 62561-8
- Aluminium supporting tubes with insulating clearances made of glass-fibre reinforced plastic (GRP), UV-stabilised
- Available in reels (100/500 m) for on-site assembly or as cut-to-length conductors packed in boxes up to 70 m long



HVI light
product range
<http://de.hn/8raW9>



1 Conductor and connection heads



HVI light Conductor (100 m on a reel)

Part No.	819 125
Material	Cu/PE
Diameter	20 mm

HVI light Conductor (cut to length)

Part No.	819 129
Material	Cu/PE
Diameter	20 mm



Connection element for HVI light Conductor

Part No.	819 299
Material	StSt
Connection	Bolt, Ø10 mm, L 50 mm



Fixing kit for HVI light Conductor

Part No.	819 289
Material	Stainless steel/ aluminium
Connection	Square hole, plate support 13 mm

2 Supporting tubes and stands



Air-termination mast 30 for HVI light Conductor SET I 2,300 mm total height

Part No.	819 282
Material	HDG steel, GRP/Al, StSt
Standard	IEC/TS 62561-8

SET components: tripod (HDG steel) r = 320 mm, fixing kit, supporting tube (GRP/Al) D = 30 mm, L = 1,300 mm, air-termination tip (StSt) L = 1,000 mm.



Air-termination mast 50 for HVI light Conductor SET III 4,900 mm total height

Part No.	819 390
Material	HDG steel, GRP/Al, Al
Standard	IEC/TS 62561-8

SET components: tripod (HDG steel) r = 560 mm, fixing kit, supporting tube (GRP/Al) D = 50 mm, L = 1,900 mm, air-termination rod (Al) L = 3,000 mm.

3 Conductor holder and fixing components



Roof conductor holder for flat roofs - with conductor supports type FB

Part No.	253 015
Stone material	Concrete (C35/45)
Conductor routing	loose



Adapter for installing the HVI light Conductor (accessories for part no. 253 015)

Part No.	253 026
Material	Plastic
Conductor holder	20 mm



Roof conductor holder for roof with standing seam

Part No.	202 852
Material	StSt
Clamping range	0.7-8 mm



Conductor holder for HVI light Conductor

Part No.	275 220
Material	PA
Female thread	M8

HVI light plus

- ➔ Separation distance $s \leq 60$ cm (in air)
- ➔ Reduced installation and planning costs
- ➔ Visual integration: grey tone that blends into concrete walls

The high-voltage-resistant insulated down conductor provides advantages for installation and planning. The multitude of product properties combined within it make this possible: the integrated protection against electric shock, the non-essential additional equipotential bonding connection, the approval for use in hazardous areas, an inner conductor of just 16 mm² – and much more. These features make HVI light plus suitable for a wide range of lightning protection projects.

The coaxially constructed cable consists of a single-wire inner conductor with a thick-walled high-voltage-resistant insulation and a semi-conductive outer sheath. This design allows the HVI light plus to maintain an equivalent separation distance in air of 60 cm to earthed metal building installations without creepage discharge. This measure prevents uncontrolled flashovers and the lightning current is directed to the earthing system. The lightning current carrying capability of the HVI light plus is 150 kA and it can be used in lightning protection classes II, III and IV at $k_c = 1$.

The adjustment range is established without the need for an additional equipotential bonding connection. This leads to simplified planning and assembly options and, as a result, to considerable time savings.

The HVI light plus has been tested with regard to its lightning current carrying capability and impulse withstand voltage both as a single conductor and as a system in accordance with IEC/TS 62561-8 and offers simplified design possibilities.

Advantages:

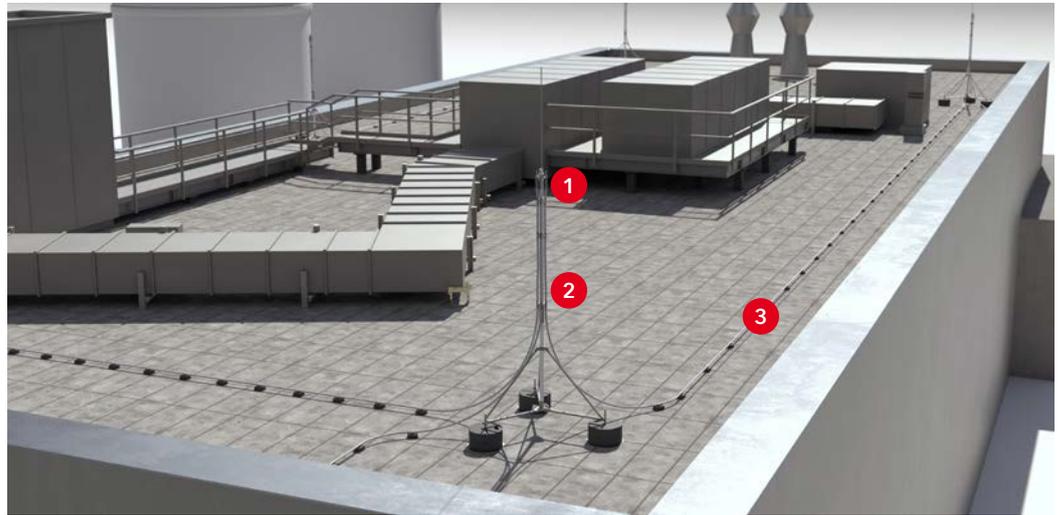
- Reduced installation and planning costs thanks to a solid inner conductor and no need for additional equipotential bonding.
- Cost saving, since existing tools can be used for the HVI range.
- Protection against electric shock with an additional grey sheath
- Visual integration by using a grey tone that blends into concrete walls; it can also be painted over.

Technical parameters:

- Equivalent separation distance $s \leq 60$ cm (in air), or $s \leq 120$ cm (solid building material)
- Lightning current carrying capability 150 kA
- Class of LPS II-IV
- Tested to IEC/TS 62561-8
- Available in reels (100 / 500 m) for on-site assembly, as cut-to-length conductors packed in boxes up to 70 m or pre-assembled conductors for installation inside and outside the tube
- Approval for use in hazardous areas: zones 1/21 and 2/22



HVI light plus
product range
<http://de.hn/Mo8PH>



1 Conductor and connection heads



HVI light plus Conductor (On a 100-m reel)

Part No.	819 600
Material	Cu/PE
Diameter	21 mm

HVI light plus Conductor (cut to length)

Part No.	819 609
Material	Cu/PE
Diameter	21 mm



Connection kit for HVI light plus Conductor for installation inside the tube

Part No.	819 645
Material	StSt
Connection	Bolt, Ø10 mm, L 50 mm



Connection element for HVI light plus Conductor

Part No.	819 640
Workshop	StSt
Diameter	21 mm

2 Supporting tubes and stands



HVI light plus Conductor inside the supporting tube with air-termination tip SET | 2,400 mm total height

Part No.	819 674
Standard:	IEC/TS 62561-8

SET components: supporting tube (GRP/Al) D = 40 mm, L = 2,400 mm, air-termination tip (StSt) length = 500 mm, HVI light plus pre-assembled for installation inside the tube.



Tripod for supporting tubes with side outlet

Part No.	107 390
Material	StSt

Tripod hinged with half shell for tubes D 40/50 mm; radius 680 mm, inclination angle 10°.



Adapter set

Part No.	107 399
Material	GRP/Al

Used with three and four-legged stands for reduction from D 50 mm to D 40 mm.

3 Conductor holder and fixing components



HVI light plus Ex W55 holder

Part No.	275 460
Material	StSt
Conductor routing	Fixed



Roof conductor holder with base plate und concrete block SET

Part No.	253 229
Material	StSt
Rd holder	20-23 mm



Air-termination mast fixing kit Ø40

Part No.	819 642
Material	Stainless steel/ aluminium/ plastic
Conductor holder	4x



Fixing kit for Ø40/50 supporting tubes

Part No.	819 296/819 297
Material	Plastic
Conductor holder	4x in GRP area

HVI

- ➔ Separation distance $s \leq 75$ cm (in air)
- ➔ Available in black or grey finish

The HVI Conductor has a wide range of applications. It protects larger roof-mounted structures, antennas or masts with information technology equipment from direct lightning strikes - even in potentially explosive atmospheres. It is used for a separation distance $s \leq 75$ cm in air and $s \leq 150$ cm for solid building materials.

It also offers the option of installing conductors directly up to the earthing system. If this is not required, it can be connected to existing conventional lightning protection systems (elevated / isolated ring conductor).

The HVI Conductor can be installed inside the supporting tube and therefore offers no additional wind attack surface. If the current needs to be split between several conductors in order to reduce the separation distance, or if longer cable lengths are required, up to four additional conductors can be installed on the outside of the supporting tube using a special fixing kit.

Benefits

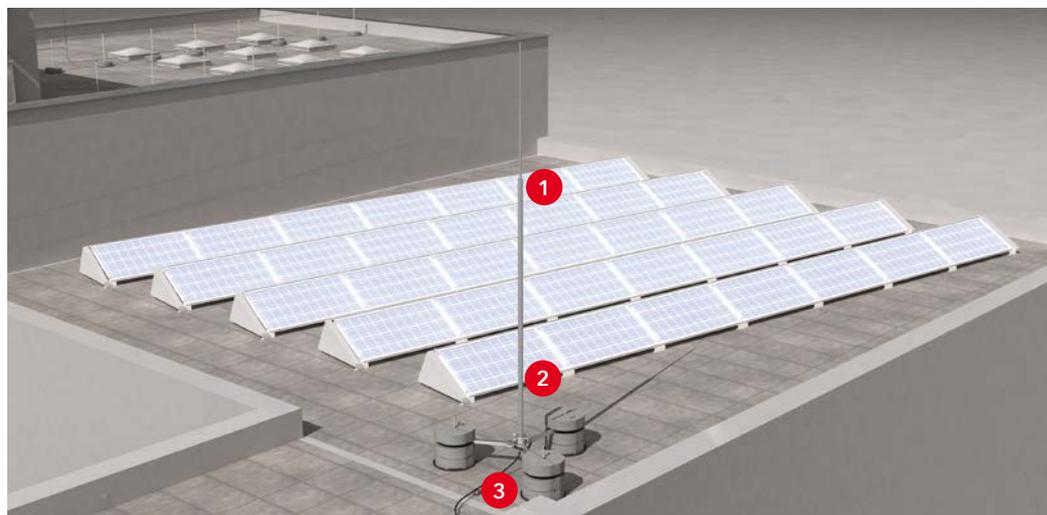
- Ideal solution for a wide range of uses.
- Ideal for harsher environments thanks to additional GRP/StSt supporting tubes
- Safe and TÜV-certified solution for the non-sparking discharge of lightning currents in Ex zones 1 and 21

Technical features:

- Equivalent separation distance $s \leq 75$ cm (in air), or $s \leq 150$ cm (solid building material)
- Tested with I_{imp} 150 kA ($k_c = 1$; 10/350 μ s)
- Tested to IEC/TS 62561-8
- Supporting tube in aluminium or stainless steel version
- Easy installation of the internally routed conductor thanks to side outlet on the supporting tube
- Outer diameter: 23 mm black; 20 mm grey
- Available in reels (100 / 400 m light grey / 500 m black) for on-site assembly, as cut-to-length conductors packed in boxes up to 70 m or pre-assembled conductors for installation inside and outside the tube



HVI product range
<http://de.hn/aQazX>



1 Conductor and connection heads



HVI Conductor (on a 100-m reel)

Part No.	819 135 / 819 136
Colour	Black / light grey
Diameter	20 mm / 23 mm

HVI Conductor (cut to length)

Part No.	819 131 / 819 132
Colour	Black / light grey
Diameter	20 mm / 23 mm



Connection kit for HVI Conductor Ø23 mm for installation inside the supporting tube

Part No.	819 147
Material	StSt
Connection	Bolt Ø 10 mm, length 50 mm



Connection kit for HVI Conductor Ø 23 mm for installation outside the supporting tube

Part No.	819 148
Material	StSt
Connection	Bolt Ø10 mm, length 50 mm

2 Supporting tubes and stands



Supporting tube with air-termination rod and side outlet

Part No.	105 326
Material	GRP/Al

SET components: supporting tube (GRP/Al) D = 50 mm, L = 3,200 mm, air-termination rod (Al) length = 2,500 mm



Height-adjustable and hinged tripod for Ø50 supporting tubes

Part No.	105 351
Material	HDG steel
Radius	620 mm



Hinged four-legged stand with half shell for Ø40/Ø50 tubes

Part No.	107 490
Material	StSt
Radius	680 mm

3 Conductor holder and fixing components



Wall mounting bracket with range of adjustment from 150-200 mm

Part No.	105 344
Material	StSt
Supporting tube/air-termination rod clamping range	40-50 mm



Conductor holder with tensioning strap

Part No.	275 320
Material	StSt
Rd holder	20-23 mm



Roof conductor holder for round standing seam roofs

Part No.	202 850
Material	StSt
Rd holder	20-23 mm



Conductor holder for the HVI Conductor

Part No.	275 239
Material	StSt
Rd holder	23 mm

HVI power

- ➔ Separation distance $s \leq 90$ cm (in air)
- ➔ Lightning current carrying capability of 200 kA ($k_c = 1$)
- ➔ Used in hazardous areas

The HVI power Conductor represents the most powerful version of high-voltage-resistant insulated conductors. It is used in various environments such as industrial plants, hospitals, data centres and silos. Large separation distances are required in particular for buildings with considerable dimensions or increased protection class and safety-related requirements.

In many industrial sectors, there is a risk of explosive atmospheres forming during technical operations. When planning and installing lightning protection systems, it is therefore essential to be sensitive to the potential lightning-related ignition sources. This is possible by electrically insulating the lightning protection system from conductive parts of the building structure and installation. A safe and tested solution for the discharge of lightning currents is provided by the special type of conductor installation of the HVI power Conductor from DEHN.

Benefits

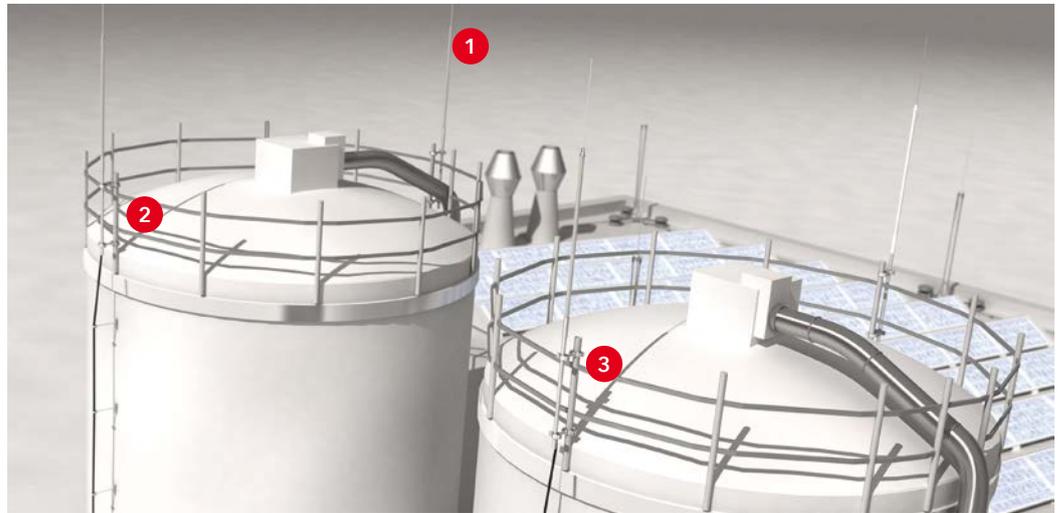
- Suitable for all classes of LPS (when $k_c = 1$)
- Safe and TÜV-certified solution for the non-sparking discharge of lightning currents in Ex zones 1 and 21

Technical features:

- Equivalent separation distance $s \leq 90$ cm (in air), or $s \leq 180$ cm (solid building material)
- Tested with I_{imp} 200 kA ($k_c = 1$; 10/350 μ s)
- Tested to IEC/TS 62561-8
- Supporting tube in aluminium or stainless steel version
- Outer diameter of 27 mm
- Available in reels (100 m) for on-site assembly, as cut-to-length conductors packed in boxes up to 80 m or pre-assembled cable for installation inside and outside the tube
- Stainless steel mounting material for use in corrosive environments



HVI power
product range
<http://de.hn/2HiBd>



1 Conductor and connection heads



**HVI power long Conductor
(on a 100-m reel)**

Part No.	819 137
Colour	black
Diameter	27 mm

**HVI power Conductor
(cut to length)**

Part No.	819 163
Colour	black
Diameter	27 mm



**Connection kit for HVI power
Conductor Ø27 mm for installation
inside the supporting tube**

Part No.	819 142
Material	StSt
Connection	Bolt Ø10 mm length 50 mm



**Connection kit for HVI power
Conductor Ø27 mm for installation
outside the supporting tube**

Part No.	819 149
Material	StSt
Connection	Bolt Ø10 mm length 50 mm

2 Supporting tubes



**Supporting tube with air-termina-
tion rod without side outlet**

Part No.	105 563
SET components: supporting tube (GRP/Al) D = 50 mm, L = 3,500 mm, air-termination tip (Al) length = 1,000 mm.	



Railing clamp D48 - 60 mm

Part No.	105 354
Material	StSt
Supporting tube/ air-termination rod clamping range	48-60 mm



**Wall mounting bracket with range
of adjustment from 150-200 mm**

Part No.	105 344
Material	StSt
Supporting tube/ air-termination rod clamping range	40-50 mm

3 Conductor holder and fixing components



**Conductor holder with
tensioning strap**

Part No.	275 249
Material	StSt
Rd holder	27 mm



**Roof conductor holder with base
plate und concrete block SET**

Part No.	253 333
Material	StSt
Rd holder	27 mm



HVI power Ex P240 holder

Part No.	275 455
Material	StSt
Rd holder	27 mm



**Conductor holder for
HVI power Conductor**

Part No.	275 339
Material	StSt
Clamping range	50-300 mm

Practical example: Retrofitting a HVAC system

Planning steps for adapting the external lightning protection system

Retrofitting

The adaptation of roof systems and the retrofitting of ventilation systems often associated with it are necessary for various reasons. In many buildings, the existing ventilation systems are outdated and no longer meet current requirements. These outdated systems can no longer fulfil their functions efficiently. At the same time, installed heating and cooling generators often reach their performance limits and are unable to cope with additional tasks.

Another aspect is the increasing importance of reducing CO₂ emissions and lowering energy consumption. In this context, the need to implement more environmentally friendly and energy-efficient solutions is becoming increasingly important. Customised approaches that integrate highly efficient heat and cold recovery play a key role here. These targeted improvements can increase the

performance of ventilation systems and reduce operating costs in the long term. These new solutions are often found as retrofitted installations on roof surfaces.

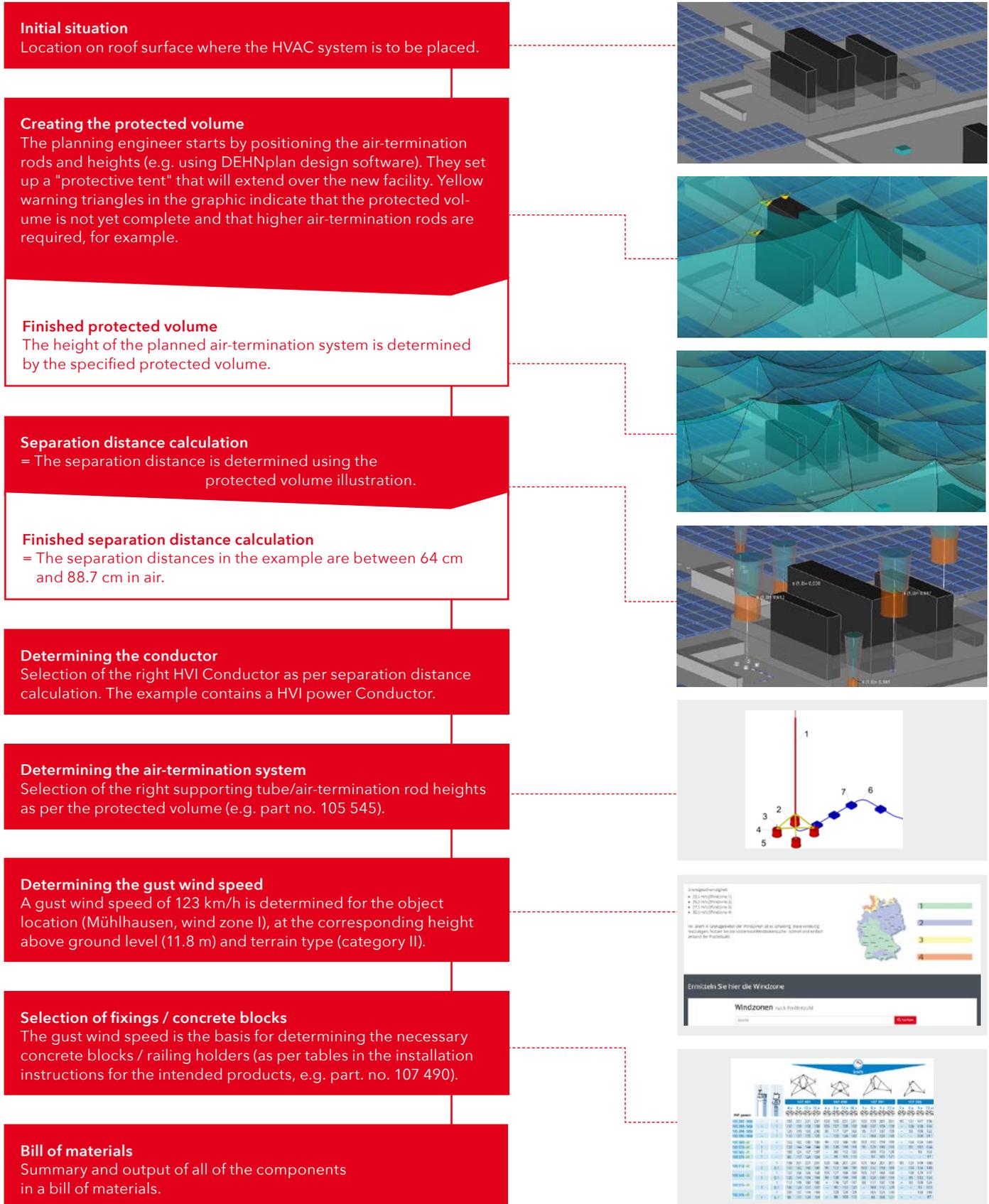
The challenge

If there are already lightning protection systems in situ, the subsequent integration of technical systems, such as air conditioning split units, chillers, cooling towers, recooling units, air-conditioning systems, flue gas systems or PV installations, requires special attention. And the lack of space usually poses a further challenge. Free roof space on today's industrial, functional or commercial buildings is often very limited due to the wide range of technical building requirements. This is a challenge for planning and professional integration into the lightning protection system.



Planning – step by step

Using the example of a retrofitted heating, air conditioning and ventilation system, the following flow chart provides an insight into the necessary planning steps.



HVI Check

- ➔ Dielectric withstand test length of the HVI Conductor
- ➔ 1-kV and 15-kV measuring methods
- ➔ Test involves low installation effort

HVI check is DEHN's measuring system for determining the function and condition of HVI Conductors. Both measuring methods can be used to reliably detect both mechanical and electrical damage (e.g. holes or electrical breakdown as a result of overloads) to HVI Conductors.

HVI check includes the two measuring methods 1 kV and 15 kV, testable / insulated connection elements, insulating caps, tools and clamps. The test is to be carried out with a commercially available insulation measuring device.

Benefits

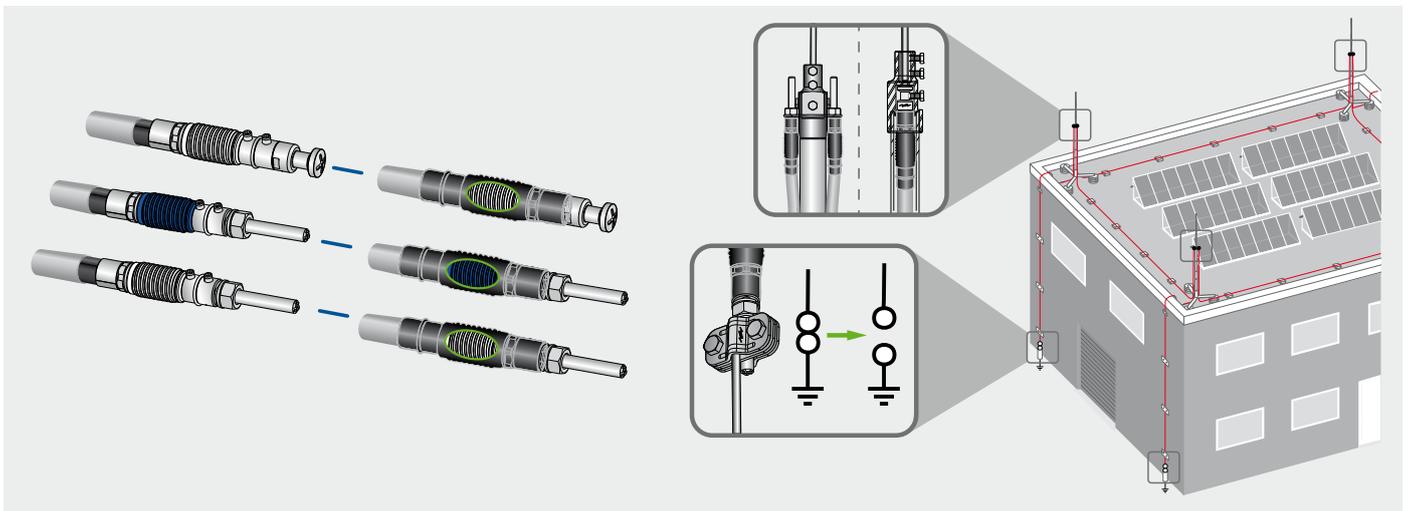
- **Freedom of choice and flexibility.** A method can be selected depending on the lightning protection system and individual requirements: 1 kV for locating various types of damage/impairment and 15 kV for rapid detection of holes.
- **Safety.** Electrical and mechanical damage can be found quickly by means of a HVI check.
- **Cost saving and familiar handling.** The test can be carried out with a commercially available insulation measuring device that you may already own.
- **Saving time and effort.** Performing the test involves little installation work.

Measuring method

The following types of defect can be identified depending on the method:

Type of defect	Measuring method 1 kV	Measuring method 15 kV
HVI Conductor screwed through the centre - connection of inner conductor with earthed metal façade	✓	✓
HVI Conductor screwed through the centre - Connection of inner conductor with semi-conductive sheath	✓	✓
HVI Conductor severed	✗	✓
HVI Conductor with electrical breakdown after overload - in Ex zone 1 and 21 (without an explosive atmosphere)	✗	✓
HVI Conductor with hole - in Ex zone 1 and 21 (without an explosive atmosphere)	✗	✓

Note: it is assumed that the HVI Conductors have been installed with insulated connection elements throughout.



Testable, insulated connection elements and simplified measurement principle

Testable connection elements



Insulated connection element, earth-side

Part No. 819 646

Material StSt

1-kV and 15-kV measuring method, bolt connection 10x50 mm; conductor type HVI light plus; PU 5 pieces.



Insulated connection element, installation inside the tube

Part No. 819 647

Material StSt

1-kV and 15-kV measuring method, special mushroom head connection; conductor type HVI light plus; PU 5 pieces.



Insulated connection element, installation outside the tube

Part No. 819 648

Material StSt

1-kV and 15-kV measuring method, M12 thread with square connection; conductor type HVI light plus; PU 5 pieces.

Clamp



Measuring point clamp

Part No. 819 649

Material StSt

1-kV and 15-kV measuring method; Ø18x20-mm clamping range; conductor type HVI light plus and HVI; PU 5 pieces.

Insulating caps



Insulating cap HVI set

Part No. 597 817

Material StSt

1-kV and 15-kV measuring method; bolt connection 10x50 mm; conductor type HVI light plus; PU 5 pieces.

Tool



HVI head stripping tool

Part No. 597 125

Material Aluminium

Cutting head, 1-kV and 15-kV measuring method; conductor type HVI light plus; PU 1 piece.

Safety components



Discharge bar

Part No. 785 022

Material Glass-fibre reinforced polyester tube

Connection Cable lug with Ø8.4-mm hole



Chain post set Secur

Part No. 700 110

Colour Red / white

Material Posts: plastic
Base: cement



Warning sign

Part No. 700 059

Material Free foam, weather-resistant

Dimensions 200x280 mm

More information to HVI check

<http://de.hn/4cYPo>



General accessories



Lateral air-termination tips for Ø50 supporting tubes

Part No.	819 183
Material	Al
Length	530 mm

Lateral air-termination tips for Ø50 supporting tubes

Part No.	819 185
Material	Al
Length	1030 mm



Lateral air-termination tips for Ø50 supporting tubes

Part No.	819 184
Material	StSt
Length	530 mm

Lateral air-termination tips for Ø50 supporting tubes

Part No.	819 186
Material	StSt
Length	1030 mm



HVI cutter

Part No.	597 032
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Cable shears for easily cutting all HVI Conductor types down to length.



Stripping tool for HVI / HVI light plus Conductor

Part No.	597 220
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For stripping Ø20-mm Conductors.



Stripping tool for HVI power Conductor

Part No.	597 227
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For stripping Ø27-mm Conductors.



DEHN helix

Part No.	597 230
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Stripping tool for HVI Conductors.



Spare blades

Part No.	597 130
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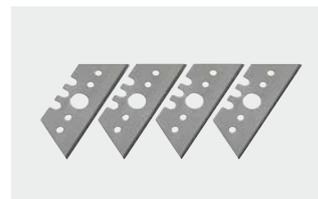
For DEHNhelix.



Spare blades for HVI head 20

Part No.	597 101
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4x spare blades for HVI head 20.



Spare blades for HVI head 27

Part No.	597 102
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4x spare blades for HVI head 27.



Information sign DE, EN/FR, IT

Part No.	480 598/480 597
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"ATTENTION! Separated Lightning Protection with HVI conductor system".

Types of HVI Conductors: technical information

	HVI light	HVI light plus	HVI		HVI power
Equivalent separation distance (in air)	≤ 45 cm	≤ 60 cm	≤ 75 cm		≤ 90 cm
Structure	Solid / stranded	Solid	Solid / stranded		Stranded
Cross-sections	19 mm ²	16 mm ²	19 mm ²		25 mm ²
Colour	Squirrel grey	Signal grey	Black	Light grey	Black
Protection against electric shock	-	Yes	-	Yes	-
Inner conductor material	Copper	Copper	Copper		Copper
Outer diameter	20 mm	21 mm	20 mm	23 mm	27 mm
Equivalent separation distance (solids)	≤ 90 cm	≤ 120 cm	≤ 150 cm		≤ 180 cm
Minimum bending radius (10x outer diameter)	200 mm	210 mm	200 mm	230 mm	270 mm
Operating temperature	-30°C to +70°C	-30°C to +70°C	-30°C to +70°C		-30°C to +70°C
Temperature for installation	-5°C to +40°C	-5°C to +40°C	-5°C to +40°C		-5°C to +40°C
Tensile load capacity	950 N	800 N	950 N		1200 N
UV/weather-resistance	Yes	Yes	Yes		Yes
Tested with I_{imp} (10/350 μ s)	150 kA ¹⁾	150 kA ¹⁾	150 kA ¹⁾		200 kA
Use in class of LPS (when $k_c = 1$)	II, III, IV	II, III, IV	II, III, IV		I, II, III, IV
Max. permitted cable length LPL I (when $k_c = 1$)	-	-	-		11.25 m
Max. permitted cable length LPL II (when $k_c = 1$)	7.5 m	10.0 m	12.5 m		15 m
Max. permitted cable length LPL III/IV (when $k_c = 1$)	11.25 m	15.0 m	18.75 m		22.5 m
Installation in Ex zones 1 and 21	Not permitted	Permitted	Permitted		Permitted
Cable weight / 100 m	~ 40 kg	~ 45 kg	~ 48 kg	~ 63 kg	~ 73 kg

¹⁾ Based on IEC/EN 62561-1



Outlook for future lightning protection standard IEC 62305-3,
Edition 3

Attached, isolated and electrically insulated lightning protection

The current version of the IEC 62305-3 lightning protection standard is currently being revised. This involves discussing and redefining existing terminology in relation to lightning protection systems.

Up till now there has been no standardised international definition of the terms "isolated lightning protection", "insulated lightning protection" and "conventional lightning protection". In practice, this offers scope for different interpretations and designs of lightning protection systems. In order to avoid this in future, the current revision will lay out terminology unambiguously.

In this context, the future IEC 62305-3 Edition 3 lightning protection standard is expected to differentiate between the following types of external lightning protection systems (LPSs):

- Attached lightning protection system
- Isolated lightning protection system
- Electrically insulated lightning protection system

What will these terms mean exactly in the future? The following list provides an overview of the normative designations and examples of suitable practical implementation. A combination of the designs shown is also possible.

On the following pages, you will also find further information on the designs and lightning protection components:

- DEHNiso Combi
- DEHNiso spacers
- Self-supporting air-termination rods
- Telescopic lightning protection masts

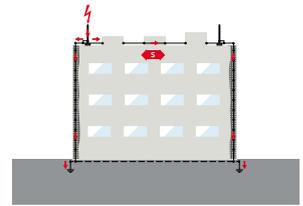
Attached lightning protection system

The lightning current (path) can come into contact with the structure to be protected.

The separation distance is not maintained.

External lightning protection system not isolated from the structure to be protected.

The systems and building structure are integrated into the lightning protection system.



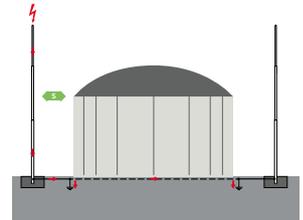
Isolated lightning protection system

The lightning current (path) has no electrical contact with the structure to be protected, except via the earthing system in the ground.

The separation distance is maintained.

External lightning protection system isolated from the structure to be protected.

The lightning protection system is **electrically und spatially isolated** from the system; z. B. in the form of telescopic lightning protection masts.



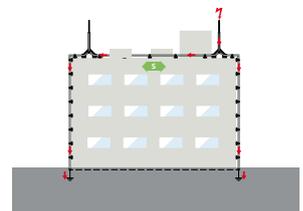
Electrically insulated lightning protection system

The lightning current (path) has no electrical contact with the structure to be protected, except via the earthing system in the ground.

Separation distance is maintained.

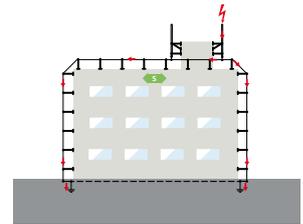
Version with electrically insulated HVI system
External lightning protection system not spatially isolated yet electrically insulated from the structure to be protected.

This includes a complete lightning protection system (with air-termination system and down conductors) of electrically insulating down conductors; e.g. using HVI Lightning Protection.



Version with electrically insulated DEHNiso system
External lightning protection system not spatially isolated yet electrically insulated from the structure to be protected.

This includes a complete lightning protection system (with air-termination system and down conductors) of electrical insulators.

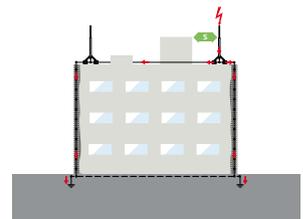


Partially isolated lightning protection system

Isolated external lightning protection system for a part of the structure to be protected.

The rest of the building structure is designed as a non-isolated lightning protection system; e.g. by integrating the building structure / reinforcement.

Separation distance is maintained for part of the structure; e.g. on the roof by means of self-supporting air-termination rods.

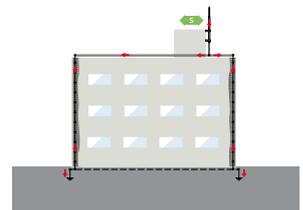


Partially electrically insulated lightning protection system

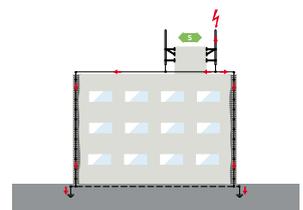
Lightning protection system electrically insulated for a part of the structure to be protected.

The rest of the building structure is designed as an attached lightning protection system; e.g. by integrating the building structure / reinforcement.

Version with electrically insulated HVI system
The separation distance is maintained for part of the structure; e.g. at roof level, by means of **electrically insulating HVI down conductors**.



Version with electrically insulated DEHNiso system
The separation distance is maintained for part of the structure; e.g. at roof level, by means of **electrical insulators (DEHNiso)**.



 Blitzstrom I [kA]	 LPS Ausführung mit isolierter Leitung nach DIN 62561-8 HVI-Blitzschutz aus hochspannungsfester isolierter Leitung (z.B. HVI power Leitung)	 Isolator nach DIN 62561-8 DEHNiso-Distanzhalter aus glasfaserverstärktem Kunststoff (GFK)
 Blitz-Teilströme	 Erdungssystem	 Trennungsabstand „s“ eingehalten
 LPS Ausführung mit Rundleiter nach DIN EN 62561-2 z.B. DEHNalu-Draht		 Trennungsabstand „s“ nicht eingehalten

DEHN iso-Combi

- Erect isolated air-termination systems easily
- Suitable for large-scale protected volumes

DEHNiso Combi is a practical, modular and flexible component range that meets the mechanical and design requirements at your site. With DEHNiso Combi, isolated air-termination systems are also possible for complicated contours of the volume to be protected. The electrical and metal installations protruding above the roof level are protected against lightning strikes, and the coupling of parts of the lightning current into the structure is prevented.

The separation distance is maintained by an insulating joint in the supporting tube and a spacer bar made of glass-fibre reinforced plastic. DEHNiso Combi makes it very easy to set up isolated air-termination systems.

Benefits

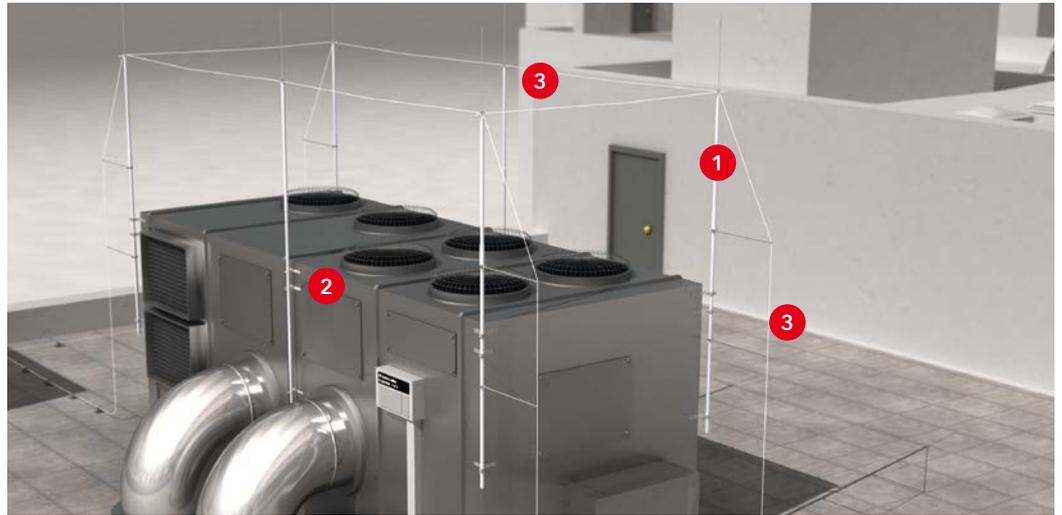
- Creation of large-scale protected volumes thanks to intelligent positioning of the air-termination rods
- Comprehensive fixing system: attached (tube, profile system, wall) or self-supported on stands
- Retrospectively installed superstructures

Technical features

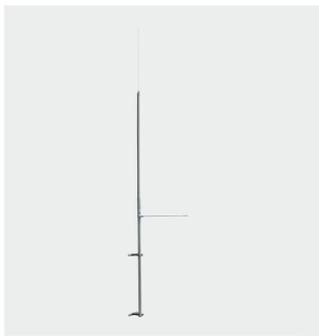
- Tested to IEC/TS 62561-8
- Dimensioned and proven taking account of possible wind loads (Eurocode)
- Tested and proven material factor $k_m = 0.7$ for calculating the separation distance



DEHN iso-Combi
product range
<http://de.hn/nb95B>



1 Air-termination systems



DEHNiso Combi height 4,200 mm | SET

Part No. 105 440

Normative references IEC/TS 62561-8

SET components: supporting tube (GRP/Al) D = 50 mm, L = 3,200 mm, air-termination tip (StSt) L = 1,000 mm, including wall mounting bracket (StSt) and spacer (GRP/Al) L = 1,030 mm.



Alternatively: supporting tube Ø50

Part No. 105 300

Material GRP/Al

Length 3,200 mm

2 Fixing components and stands



Wall mounting bracket, horizontal, flat

Part No. 105 340

Material StSt

Distance from wall 80 mm

Air-termination rod clamping range 50 mm



Wall mounting bracket, vertical with saddle clamp

Part No. 105 342

Material StSt

Distance from wall 46 mm

Air-termination rod clamping range 40-50 mm



Fixing clamp Ø50

Part No. 105 361

Material StSt

Clamping range, tube Ø 50-300 mm

Length of spacer 30 mm



Hinged tripod for DEHNiso Combi

Part No. 105 201

Material HDG steel

Radius 1,435 mm

Supporting tube length 4.7-6.2 m

3 Conductor holder and accessories



Aluminium cable

Part No. 840 050

Material Aluminium

50-mm² aluminium cable as per EN 62561-2 for use in lightning protection systems as a down conductor or as a spanning cable for air-termination systems.



MV clamp for fixing the bracing cables

Part No. 105 079

Material StSt

Rd holder 8-10 mm



Air-termination tip for screwing into the head of the supporting tube

Part No. 105 071

Material StSt

Air-termination tip (L x Ø) 1,000 x 10 mm



3x brace for DEHNiso Combi

Part No. 105 601

Material StSt

Brace length 2,910 mm

DEHNiso spacers

- Components for maintaining the separation distance
- Product range available for nearly all applications
- Available pre-assembled or as an individual assembly kit

The DEHNiso spacer system is a practical, versatile component range for maintaining separation distances. The modular system offers a simple and economical solution for almost all applications. It can be used as a static

support for self-supporting air-termination rods. It is also possible to support ring conductors while observing the separation distance.

Benefits

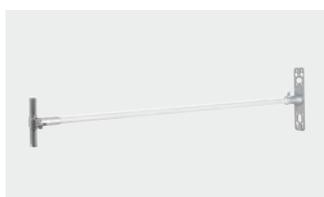
- Pre-assembled spacer bars suitable for the respective installation location (tube, wall, profile)
- Can be configured on site: all system components are available individually (GRP bar, conductor holder, pipe clamps)
- Technical features
- Tested to IEC/TS 62561-8
- Dimensioned and proven taking account of possible wind loads (Eurocode)
- Tested and proven material factor $k_m = 0.7$ for calculating the separation distance
- High-quality GRP insulation material



DEHNiso spacers
product range
<http://de.hn/5bcHb>



1 Spacers



Spacer with rod holder and fixing plate

Part No.	106 115
Material	StSt
Length	530 mm



Spacer with rod holder and pipe clamp

Part No.	106 245
Material	StSt
Length	530 mm



Spacer with conductor holder

Part No.	106 165
Material	StSt
Length	515 mm



Spacer for supporting tube Ø50

Part No.	106 331
Material	GRP/StSt
Length	1,030 mm

2 Roof conductor holder



Base plate

Part No.	253 300
Material	Plastic
Diameter	300 mm



Concrete block

Part No.	253 301
Material	Concrete (C35/45)
Weight	4.6 kg



Profile bar Ø10

Part No.	253 310
Material	GRP
Length	3,000 mm



Conductor holder with lock bush

Part No.	253 302
Material	Plastic
Rd holder	8 mm

3 Air-termination rods and accessories



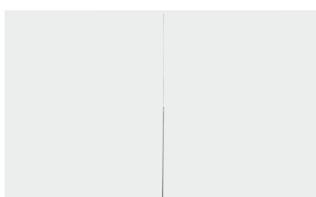
Concrete base with fixing wedge and plastic base plate

Part No.	102 340
Material	Concrete (C45/55)
Weight	17 kg



DEHNalu round wire

Part No.	840 018
Material	AlMgSi
Length	148 m



Air-termination rod L2000

Part No.	106 210
Material	Al
GRP insulating clearance	975 mm



MV clamp for DEHNiso

Part No.	393 069
Material	StSt
Clamping range Rd	16/16 mm

Self-supporting air-termination systems

- For use in large areas (e.g. flat roofs)
- Space-saving versions available
- Solutions that can be used flexibly

With self-supporting air-termination rods, large areas can be integrated into the protected volume. There is no need for additional mechanical contacting of roof superstructures, air-conditioning units or fans. Self-supporting air-termination rods are erected using N-legged stands in combination with concrete bases. The number of concrete bases depends on the maximum gust wind speed. Correctly designing for stability and dimensioning the air-termination rod appropriately will provide the planning engineer, installer or property owner with a high-quality air-termination system.

Benefits

- Comprehensive product range: air-termination rod heights from 1.0 m to 14.0 m
- Weight-optimised, easy transport and assembly
- Highly stable and low spatial requirements
- Flexible and for universal use

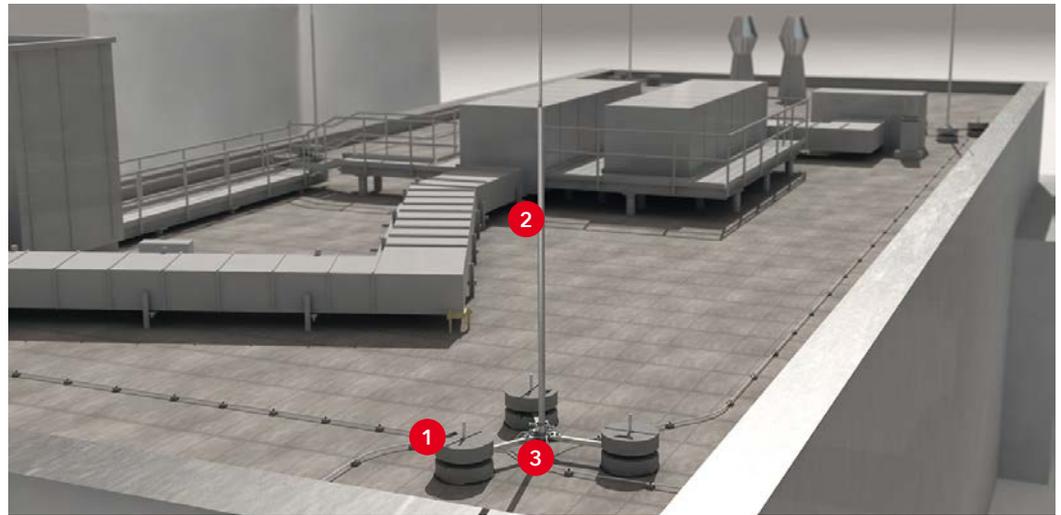
Technical features

- Adjustment of the air-termination rod for roof or building inclination up to an inclination angle of 5–10°
- System solution tested to EN 62561-1
- Dimensioned and proven taking account of possible wind loads (Eurocode)



Self-supporting air-termination systems product range

<http://de.hn/5jMUj>



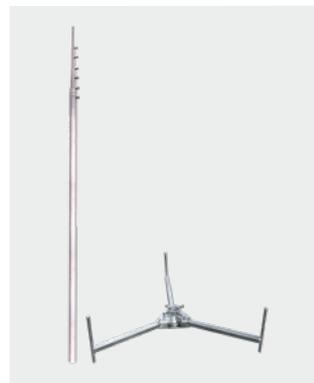
1 Air-termination systems



Air-termination rod Ø40 /16/10 4,000 mm with tripod | SET

Part No.	105 400
Material	Air-termination rod: Al Tripod: HDG steel

SET components: self-supporting air-termination rod, height 4,000 mm, hinged tripod, radius 560 mm



Alternatively: self-supporting, telescopic air-termination rods 5,200 mm | SET

Part No.	105 711
Material	Air-termination mast: Al Tripod: HDG steel
Standard	DIN EN 62561-(1+2)

Transport length 1,650 mm

SET components: self-supporting air-termination rod, 5,200 mm, hinged tripod, 560 mm

2 Fixing components and stands



Wall fixing with saddle clamp for tubes Ø40

Part No.	105 140
Material	StSt
Distance from wall	80 mm
Air-termination rod clamping range	40 mm



Railing clamp with spacer for tubes Ø40

Part No.	105 162
Material	StSt
Clamping range Tube	45-65 mm
Air-termination rod	40-50 mm



Wall fixing for tubes Ø40-50

Part No.	105 347
Material	HDG steel
Distance from wall	230-400 mm
Air-termination rod clamping range	40-50 mm



Hinged four-legged stand with half shell for tubes Ø40-50

Part No.	107 490
Material	StSt
Holding fixture	50 and 40 mm
Radius	680 mm

3 Conductor holder and accessories



DEHNhold conductor holder with female thread

Part No.	274 160
Material	StSt
Rd holder	8-10 mm



DEHNQUICK conductor holder saddle clamp

Part No.	390 121
Material	HDG steel
Rd holder	6-10 mm



Concrete base C45/55 and plastic base plate

Part No.	102 010/102 050
Material	Concrete/EVA
Weight	17 kg, with fixing wedge



Conductor holder type FB2 for flat roofs

Part No.	253 050
Material Stone	Concrete
Conductor holder	Plastic
Conductor routing	Loose

Telescopic lightning protection masts

- For installations on open areas
- For forming large protected volumes
- Bucket/screw-in foundation und foundation baskets available

Our extensive range of telescopic lightning protection masts protects installations in open spaces from direct lightning strikes. Depending on the height of the air-termination system, the masts can be erected using screw-in or bucket foundations. No excavation or foundation work is required for telescopic lightning protection masts with screw-in foundations. The screw-in foundation is simply screwed into the natural soil and also fixed with earth rods without any preparation. For telescopic lightning protection masts with a bucket or concrete foundation, a foundation is constructed onto which the telescopic lightning protection masts are mounted using a flange plate.

Benefits

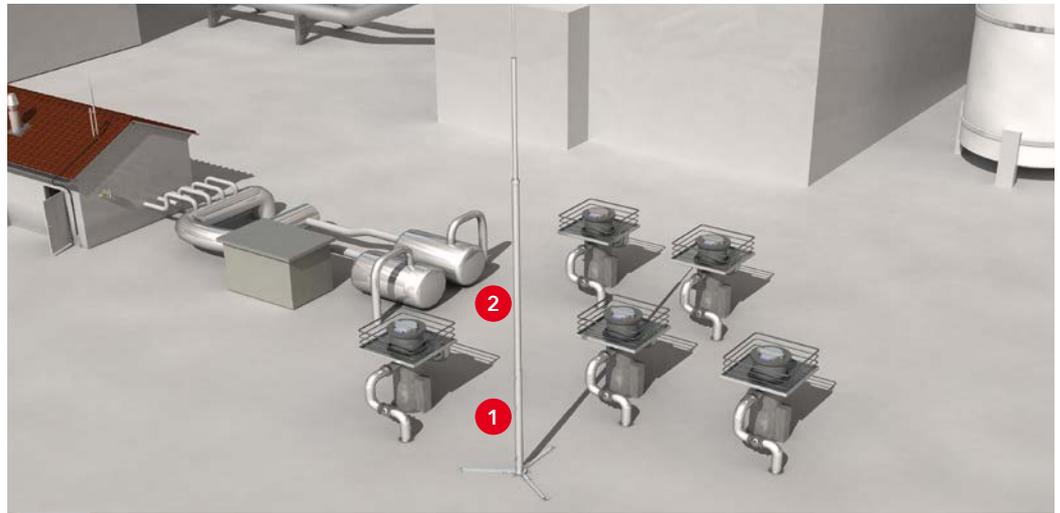
- Comprehensive product range: air-termination rods heights of 6.0 to 24.85 m (above ground)
- Large protected volumes can be formed
- Low spatial requirements

Technical features

- Maximum transport length of 6.0 m
- System solution tested to EN 62561-1
- Dimensioned and proven taking account of possible wind loads (Eurocode)



Telescopic lightning protection masts product range
<http://de.hn/9u5yV>



1 Sets: telescopic lightning protection masts with screw-in foundation up to 11 metres in height above ground



SET: telescopic lightning protection mast 6 m above ground with screw-in foundation

Part No.	103 121
Standard	DIN EN 62561-(1+2)

SET components: air-termination mast (HDG steel), air-termination rod (stainless steel), screw-in foundation (HDG steel).



SET: telescopic lightning protection mast 11 m above ground with screw-in foundation

Part No.	103 126
Standard	DIN EN 62561-(1+2)

SET components: air-termination mast (HDG steel), air-termination rod (stainless steel), screw-in foundation (HDG steel).

2 Telescopic lightning protection mast for bucket or concrete foundation of 13.38 to 24.88 m above ground



Telescopic lightning protection mast 13.38 m above ground with screw-in foundation

Part No.	103 013
Material	HDG steel

Design with height 13.38 m above ground. Telescopic lightning protection mast/air-termination mast for protecting installations against direct lightning strikes. The mast is erected in a bucket foundation (prefabricated part) or an on-site concrete foundation with foundation basket.



Telescopic lightning protection mast 24.88 m above ground with screw-in foundation

Part No.	103 025
Material	HDG steel

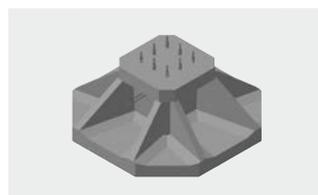
Design with height 24.88 m above ground. Telescopic lightning protection mast/air-termination mast for protecting installations against direct lightning strikes.



Bucket foundation - type K6FU I

Part No.	103 030
Material	Concrete (C50/60)

As prefabricated part for easy erection of telescopic lightning protection masts. For masts with a height of 13.35 to 19.3 m above ground. Flange plate 400 x 400 mm.



Bucket foundation - type K6FU II

Part No.	103 031
Material	Concrete (C50/60)

As prefabricated part for easy erection of telescopic lightning protection masts. For masts with a height of 22.35 to 24.8 m above ground. Flange plate 565 x 565 mm.



Foundation basket for in-situ concrete - small

Part No.	103 040
Material	Steel

For setting in concrete with threaded bolts, suitable for the flange plate of the telescopic lightning protection masts. For masts with a height of 13.35 to 19.35 m above ground. Flange plate 400 x 400 mm.



Foundation basket for in-situ concrete - large

Part No.	103 041
Material	Steel

For setting in concrete with threaded bolts, suitable for the flange plate of the telescopic lightning protection masts. For masts with a height of 22.35 m to 24.85 m above ground (part no. 103 022 or 103 025). Flange plate 565 x 565 mm.

DEHN Services Always at your side

DEHNconcept – planning service

Planning support with protection concepts and calculations for external and internal lightning protection. Hand over the entire planning of the lightning protection system and earthing system to the DEHNconcept team. This will save you time on potentially laborious planning and fine-tuning and gives you certainty. You obtain the plan as a finished module in an open format (dxf/dwg) and a 3D model (nwd format). This way you can integrate this easily into your documentation.

DEHNconcept
takes on your lightning
protection planning:
<http://de.hn/45aV5>



DEHNplan – design software

With DEHNplan, you can easily plan standard-compliant external lightning protection for your project. The BIM-enabled software facilitates your planning with a visual representation of the protected volume and separation distances. Very helpful in practice: the programme automatically creates a bill of materials.

DEHNplan – Fast and
standard-compliant exter-
nal lightning protection:
<http://de.hn/2Dpa4>



DEHNsupport Toolbox – design software

Use the DEHNsupport Toolbox software to calculate individual aspects of your lightning protection concept. Four different calculation modules are available here. Risk analysis, calculation of air-termination rod and earth electrode lengths, and calculation of the separation distance. For your project, you obtain an overview plan with the right protective devices.

DEHNsupport Toolbox
Plan lightning protec-
tion systems digitally:
<http://de.hn/6vvro>



Whether support with planning or specific help with a query – take advantage of DEHN's range of services to the extent that suits you best. We support you at every phase of your project: with complete planning, appropriate software, selection guides and the right products.

DEHNacademy seminar programme

We are happy to pass on our DEHN practical know-how to you. Use the DEHNacademy to keep you and your team up to date as well! The seminar programme for external lightning protection – with practical examples of professional planning, application and installation.

Technical Support

Get yourself some advice. The experts at DEHN's technical support team will be happy to answer your questions on specific products, planning services and software. Get support here. Competent and free of charge – by phone or email.

Personal consultation at
Tel. +49 9181 906 1750
technik.support@dehn.de

HVI Lightning Pro- tection – on the Web

The latest information, an overview of the products and relevant documents for direct download – on our website you will find all the key information about the HVI lightning protection product range.

DEHNacademy
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Surge Protection
Lightning Protection / Earthing
Safety Equipment

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