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Kurtatsch, Italy, February 10, 2017

Manual for overvoltage protection for LED luminaires – rev 1

Through the introduction of LED luminaires, substantial improvements have been achieved with respect to conventional technologies: considerable savings in energy and improved precision and evenness of the distribution of the light, to the advantage of both the operator and the user of the facilities. On the other hand, LED luminaires are equipped with highly advanced electronic components and for that reason react with greater sensitivity to overvoltages in the devices in comparison to conventional technologies.

With unprotected luminaires, overvoltages can damage the lamp control gear, the LED circuit, and even the LED itself and can result in a partial or complete failure of the luminaire.

Overvoltages can be subdivided into two types, depending upon the electrical systems:

- Overvoltages in common mode: these are overvoltages that occur between active conductors and the ground.
- Overvoltages in differential mode: these are overvoltages that occur between a phase and the neutral wire.

The main causes of overvoltages are:

- Direct lightning strike through the wires: lightning strikes the power line and arrives via the active conductor to the installation and the luminaire. Electrical and electronic devices that are connected to the power grid sustain considerable damage, and there is a great risk of fire.

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- Indirect lightning strikes through direct coupling: the lightning strikes grounded metal parts (metal masts, antennas, lightning rods), leading to an increase in voltage at the ground conductor and to overvoltages in common mode. According to the hyperbolic law, the amplitude of the overvoltage is reduced the further away the strike point of the lightning is. Damage can occur to electrical and electronic devices up to a distance of 100 m from the strike point.

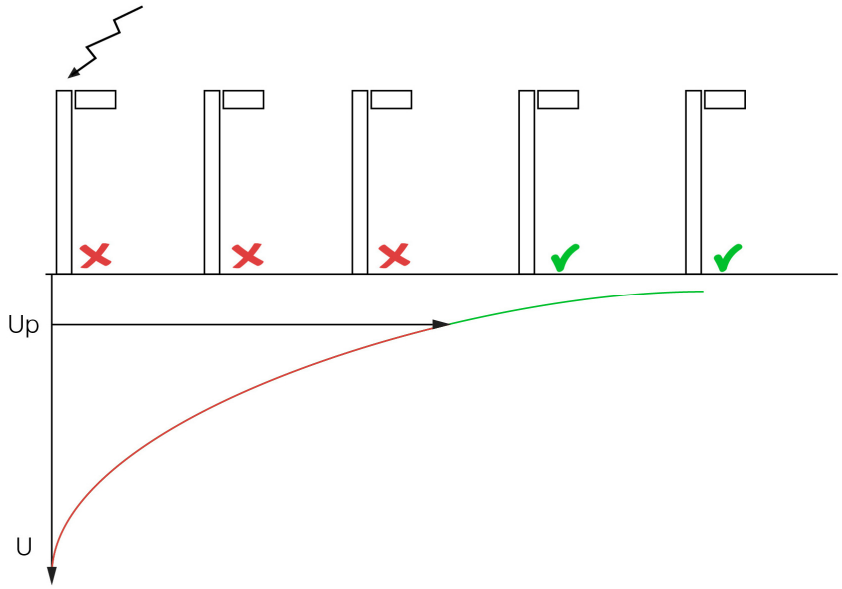

Fig. 1: Distance-dependent voltage curve at the ground conductor with an indirect lightning strike

- Indirect lightning strikes through inductive coupling: changes in the electromagnetic field through atmospheric discharges can induce overvoltages in wires within a radius of several hundred meters. The damage that is caused by this is less severe and affects primarily electronic devices.
- Activating of loads in the network through switching operations on transformers, electric motors, or the ignition unit of conventional lighting installations. These are overvoltages in differential mode. In comparison to overvoltages through atmospheric discharges, they have a lower amplitude, but they occur very frequently and lead to premature damage of electronic devices.

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- Overvoltages through electrostatic charges. These are overvoltages that occur between the active conductors and the insulated housings which are electrostatically charged through the effect of the wind with dry air.

Indicative parameters for amplitude by the type of overvoltage:

- Lightning strikes: 10-100 kV.
- Overvoltages through electrostatic discharges: up to 30 kV.
- Overvoltages in differential mode through switching operations: 1-5 kV.

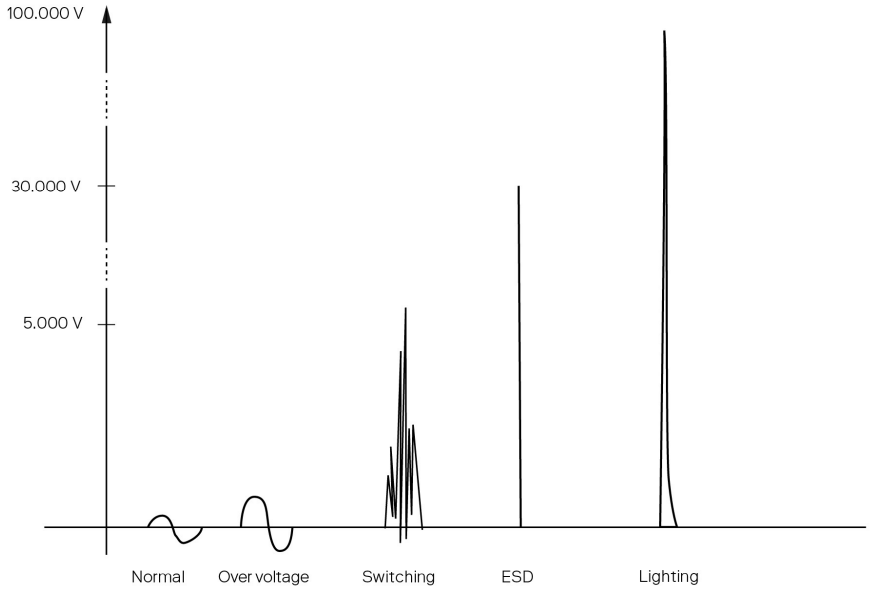

Fig. 2: Amplitude and typical form of overvoltages

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Features of the Basic Protection of ewo Luminaires

Reference standard EN 61547 requires a test level of ±1 kV in differential mode and ±2 kV in common mode. In many cases, this test level turns out to be insufficient to guarantee the protection of the electronic components in LED exterior lighting.

The electronics of ewo luminaires are equipped with additional surge protection devices (SPD) that go beyond the test level that is required by the standard which guarantee a higher degree of overvoltage protection. What that means in detail is:

- Luminaires in Protection Class I offer:
  - Protection against overvoltages in common mode (active conductor – ground) and against electrostatic discharges up to a test level of 8 kV*/** (10 impulses) and, with some models, up to 10 kV*/** (1 impulse).
  - Protection against overvoltages in differential mode (phase – neutral) through a voltage dependent resistor (VDR) up to a test level of 6 kV*/**.
- Luminaires in Protection Class II offer:
  - Protection against overvoltages in common mode (active conductor – ground) and against electrostatic discharges up to a test level of 8 kV*/** (10 impulses) and, with some models, up to 10 kV*/** (1 impulse). The common mode protection is realized through potential equalization without VDR or a similar device according to the provisions of the EN 60598:2014 standard.
  - Protection against overvoltages in differential mode (phase – neutral) through a voltage dependent resistor (VDR) up to a test level of 6 kV*/**.

** According to tests carried out under the IEC 6100-4-5 standard.*

*** General indicative parameters. The relevant product-specific values are provided in the corresponding datasheet or offer.*

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Protection of Luminaires of Protection Class I

In order to ensure the correct manner of functioning of the protective devices, ewo luminaires of Protection class I should be built into an installation that is connected to a protective ground wire in accordance with specifications. The installation which is realized in this way offers:

- Protection against discharges in differential mode through varistors that are integrated in the driver.
- Protection against overvoltages in common mode, integrated in the driver.
- Protection against electrostatic discharges through potential equalization.

This installation makes it possible to achieve basic protection against the most common causes of malfunction. The configuration of the installation corresponds to the representation in the figure below.

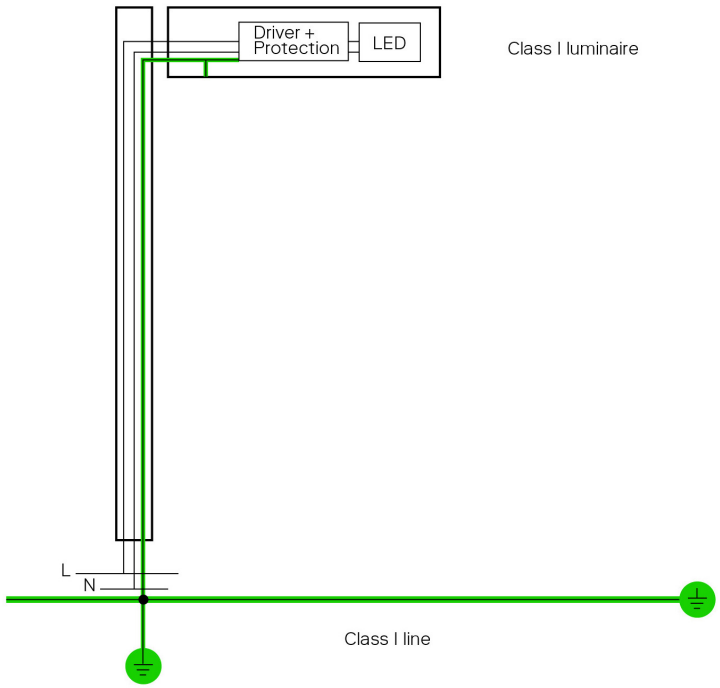

Fig. 3: Basic protection for luminaires in Protection Class I that are built into installations of Protection Class I****

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With indirect lightning strikes, the overvoltage amplitude may possibly exceed the test level close to the location of the strike for which the integrated protection systems were designed. The higher the test level of the protection system, the lower the distance from the location of the lightning strike against which the luminaire is effectively protected. By building in additional protection devices, the annual number of luminaires that are damaged by events that possibly lead to overvoltages can be statistically reduced.

If the designer considers it to be reasonable to increase the degree of protection, the following measures are recommended:

- Building in a type T3 / T2 *** SPD with phase, neutral wire, and ground connections to every mast base for the improvement of common mode protection with a significant increase in the discharge capacity. Recommended test level: 10 kV-5 kA or higher.
- Building in a type T2 / T1 *** SPD in the junction box for the improvement of protection against events of higher intensity.

**** In accordance with IEC 61643-11*

In this case, the installation is configured as in the following figure.

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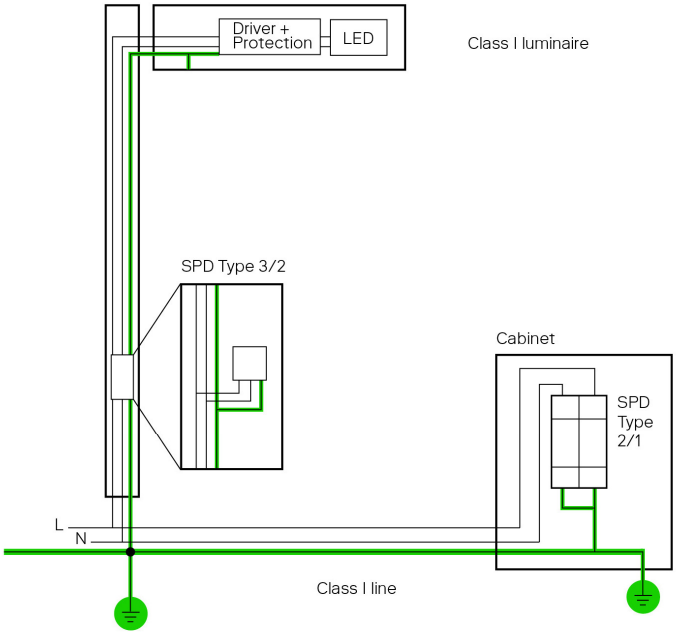

Fig. 4: Improved protection for luminaires in Protection Class I that are built into installations of Protection Class I****

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Protection of Luminaires of Protection Class II

The luminaires that are built into Protection Class II installations that are designed and conform to the specifications of Protection Class II have the following basic protection available:

- Protection against discharges in differential mode through varistors that are integrated in the driver.
- Protection against electrostatic discharges through potential equalization (electrical circuit in accordance with the Y1 standard for capacitors and resistances).

For protection against discharges in common mode, the standard that is in force prohibits for safety reasons the building in of active surge protection devices (SPD) between active conductors and grounds in installations of Protection Class II.

That means that luminaires in Protection Class II which are built into installations of Protection Cass II may not be effectively protected against overvoltages in common mode (primarily lightning strikes).

In order to guarantee optimal protection, ewo strongly advises against using installations that are realized in Protection Class II.

The protection of luminaires of Protection Class II can be improved if they are built into installations of Protection Class I with protective grounding according to specifications.

In this case, it is possible to increase the protection of the luminaire through the following measures:

- Building in a type T3 / T2 *** SPD with phase, neutral wire, and ground connections to every mast base for the improvement of common mode protection with a significant increase in the discharge capacity. Recommended test level: 10 kV-5 kA or higher.
- Building in a type T2 / T1 *** SPD in the junction box for the improvement of protection against events of higher intensity.

**** In accordance with IEC 61643-11.*

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In this case, the installation is configured as in the following figure.

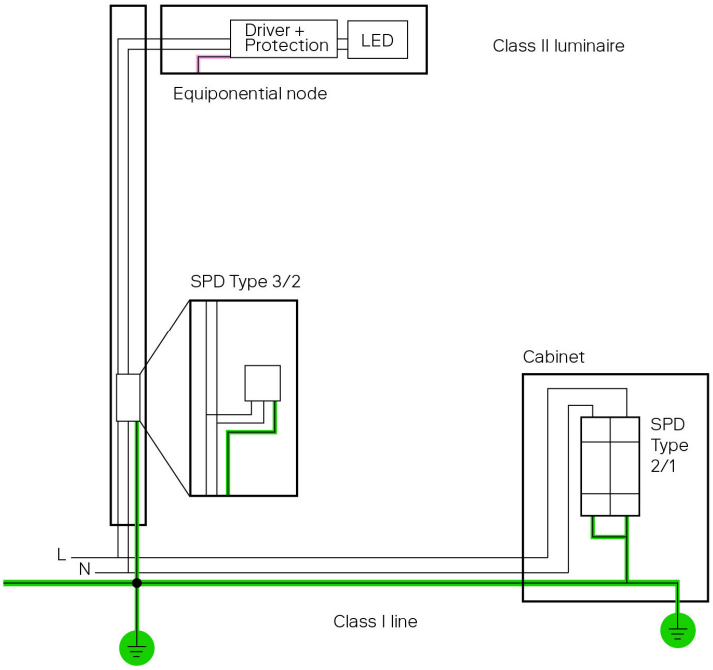

Fig. 5: Improved protection for luminaires in Protection Class II that are built into installations of Protection Class I****

In accordance with DPR. No. 462, installations that are realized according to specifications in Protection Class I are subject to regular inspections of the grounding.

With the realization of installations in Protection Class I, ewo recommends building in luminaires of Protection Class I to the extent that they are available.

***** ewo hereby expressly rejects any liability for the execution of installations that do not correspond to the provisions in force.*

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Protection of Luminaires Built into TN-C Systems (Specific Markets)

In some specific markets, distribution systems of the TN-C type have historically been used up through today. With these systems, the neutral wire is connected directly with the ground, and thus the functions of the two conductors are taken over by a single conductor called the PEN. Today, the TN-C system has not yet been accepted in all countries.****

ewo luminaires that are built into installations with a TN-C system have the following basic protection:

- Protection overvoltages through varistors that are integrated in the driver.
- Protection against electrostatic discharges through potential equalization.

If the designer considers it to be reasonable to increase the degree of protection, the following measures are recommended:

- Building in a type T3 / T2 *** SPD with phase, neutral wire, and ground connections to every mast base for the improvement of common mode protection with a significant increase in the discharge capacity.
  Recommended test level: 10 kV-5 kA or higher.
  In this case, both the ground wire and the neutral wire must be connected to the PEN conductor.
- Building in a type T2 / T1 *** SPD in the junction box for the improvement of protection against events of higher intensity.

ewo recommends the building in of luminaires of Protection Class I into installations with the distribution systems of the TN-C type.

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In this case, the installation is configured as in the following figure.

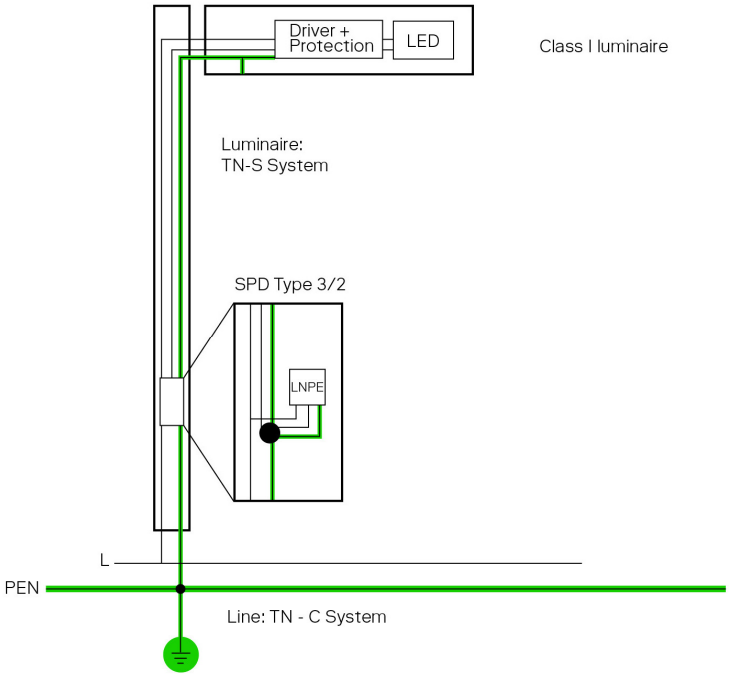

Fig. 6: Improved protection for luminaires that are built into installations with a TN-C system (detailed view of the mast) ****

**** In accordance with IEC 61643-11.*

***** ewo hereby expressly rejects any liability for the execution of installations that do not correspond to the provisions in force.*

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Analysis of the Risk of Damage through Overvoltage

In order to determine whether the integrated protection systems are sufficient for the effective protection of the installation, a risk analysis must be carried out. Within that context, the following is to be taken into consideration:

- The danger of lightning strikes in the area in which the installation is built.

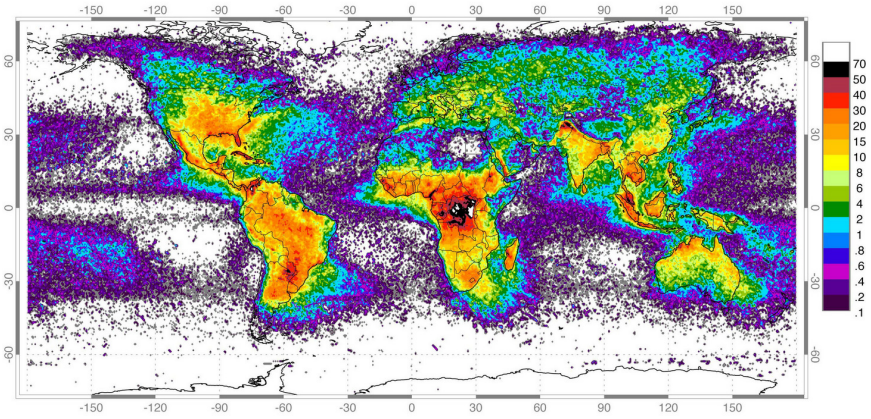

Fig. 7: Map of worldwide annual lightning density (number of lightning strikes per sq. km and per year) in the period 1995-2013 (source: www.nasa.gov)

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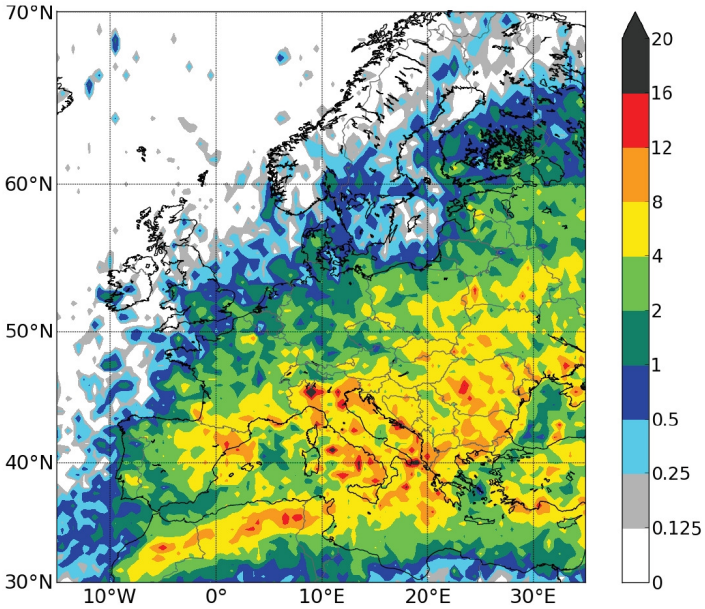

Fig. 8: Map of annual lightning density in Europe (number of lightning strikes per sq. km and per year) (Crown Copyright, source: Met Office)

- Irregularities in the network: high loads close to the installation (electric motors, large electrical installations, lighting systems with high voltage ignition units) or known instabilities in the network.
- Location of the installation: installations in open country and at a greater distance from buildings are more greatly threatened than installations inside or in the immediate vicinity of buildings.
- Close to existing installations at which overvoltage damage has already occurred.
- Safety-related effects from switching off the installation.
- Protection class of the installation.

It is the task of the installation designer to determine whether or not to build in additional protection devices in the system as a result of the risk calculation.

No protection system is capable of guaranteeing absolute protection against damage from direct or indirect lightning strikes. But with the same triggering event, the number of damaged luminaires can be reduced by a more capable protection system.

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