WWTP / DWTP PROTECTION

Lightning and surge protection in waste water purification plants (WWTPs and DWTPs)

Cirprotec Technical Article No. 5

1. Introduction

Installations at Wastewater Treatment Plants (WWTP) and Drinking Water Treatment Plants (DWTP) are highly sensitive to the effects of overvoltages and surges.

There are two main reasons. The first is that these installations require a large land area, resulting in a high probability of lightning strikes, as well as very long cable lengths (for connecting field equipment), which facilitates the induction of surges in the actual cables.

Secondly, the equipment in this sort of installation is itself highly sensitive to this type of problem. Unless they are properly protected, both control and monitoring equipment such as robots and field equipment such as PH-meters, reach end of life because of a voltage surge, necessitating a service interruption to replace it. The cost of plant shutdown and repair or replacement of equipment associated with these incidents is very high.

The Spanish Low Voltage Electrotechnical Regulation of 2002 (REBT) and ITC-BT-23 state: *Surge protection*, both legally mandatory, reflect the sensitivity of electrical equipment, and require the installation of these protections in cases of overhead feeds, or if continuity of supply is important.

In addition, some equipment in these installations is affected by electromagnetic interference from the network (noise), which requires the installation of filters to absorb these harmful influences.

In this article Cirprotec explains what they are and how to protect each type of overvoltage, and how the proposed solution offers the highest performance in protecting all equipment and service continuity.

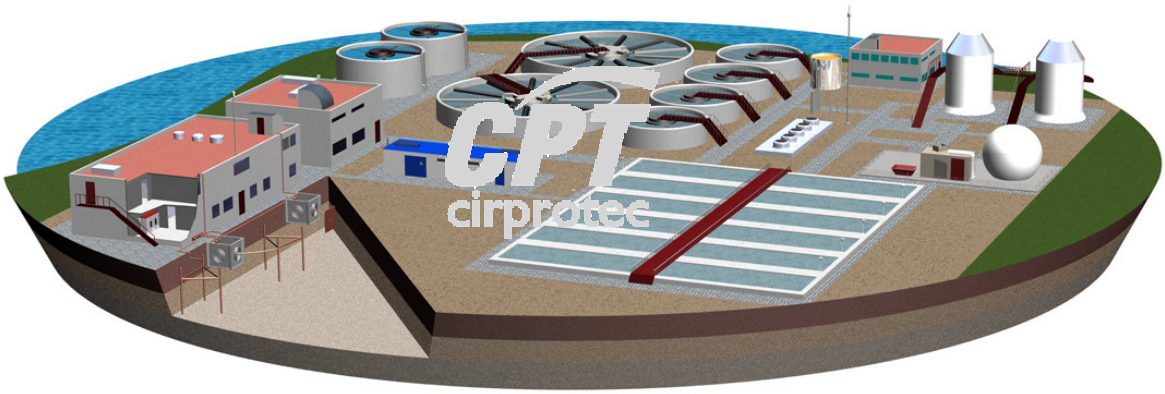

Fig 1. Installation layout at a wastewater treatment plant

2. What are overvoltages?

When analysing the phenomenon of overvoltages, a distinction is always made between **transient overvoltages (surges) and permanent overvoltages (TOV).** Although they both represent an increase in voltage above the allowable limit, their causes, magnitude, duration and method of protection are different.

Transient overvoltages are surges that can reach tens of kilovolts with a duration of the order of microseconds. Despite their short duration, the high energy content can cause serious problems to equipment connected to the line, from premature aging to destruction, causing disruptions to service and financial loss.

This type of overvoltage can have various different causes, including atmospheric lightning directly striking the external protection (lightning rods) on a building or transmission line or the associated induction of electromagnetic fields in metallic conductors. Outdoor and very long lines are the most susceptible to these fields, often receiving large induction currents. It is also common for non-weather phenomena, such as transformer centre switching or switching off motors or other inductive loads to cause voltage spikes in adjacent lines.

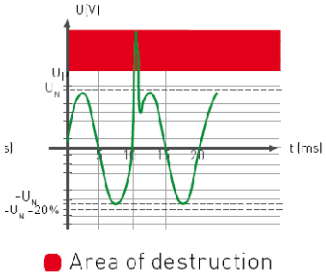

Fig. 2. Transient overvoltage

Transient overvoltages are voltage spikes of tens of kilovolts with a duration of microseconds.

Surge protection is achieved by installing the protector or line discharger on the vulnerable line, connecting it in parallel between the line and earth. This means that in the event of a surge, the protector will discharge excess energy to earth, thus limiting the peak voltage to a value which the electrical equipment connected can withstand.

Besides the phenomenon of transient overvoltages, which may affect any type of conductor, electric transmission lines can transmit a second type of overvoltage, known as **permanent overvoltage (TOV)**. This is considered to be any voltage increase above 10% of the effective nominal value during a period of the order of seconds. Permanent overvoltages are caused by supply problems, or, very often, by bad connections or breakage of the neutral conductor. When the latter occurs, the single-sided voltage received by any system connected between phase and neutral is floating and depends on the imbalance of the charge on the three-phase network, and can supply as much as 400 effective Volts instead of the 230 V expected. An increase in effective voltage may lead to premature aging of receivers, current increases or even their destruction, with the resultant fire risk.

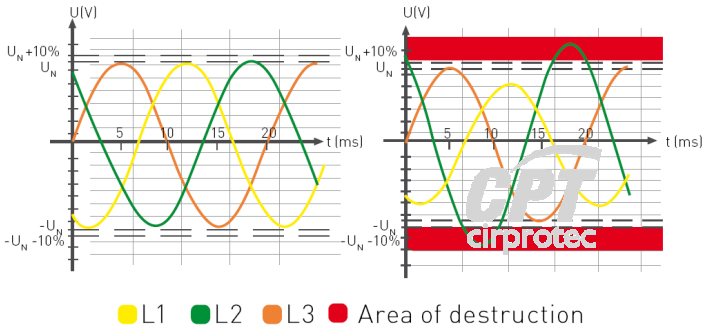

Fig. 3. Permanent Overvoltage (TOV)

The protection method for this type of overvoltage consists of monitoring the voltage between each of the phases and neutral and breaking the circuit if this value rises to over 10% above nominal.

3. Effect of overvoltages and surges on DWTP and WWTP installations.

Transient overvoltages in DWTP and WWTP systems have been known about for a long time. The configuration of the system, outdoors, with long lengths of cable, leads to a high incidence of inductions produced by atmospheric phenomena. For this reason, the Spanish REBT regulation, via Technical Instruction ITC-23, deals this problem and how to solve it.

The first peculiarity of this type of installation is in its physical properties and topology. They are isolated installations covering large areas with abundant quantities of water and metal. All these factors mean the isokeraunic index (lightning strikes per km2 per year) has a very high value, **making it necessary to install lightning rods with an early streamer emission device (ESE).**

Fig. 4. Nimbus ESE Range

Installing lightning rods (1 or 2 per plant is usually sufficient), allows the lightning strike to be discharged to earth, thus preventing it from striking somewhere on the structure or on a person.

Once the lightning strike is controlled, the **overvoltage and surge protection** must de dimensioned. To do this, an analysis of the equipment to be protected is performed, and possible surge paths, since damage will only be avoided if they are all protected. In the case of a WWTP or DWTP, the most sensitive pieces of equipment are: PLCs, variable speed drives, field devices (e.g. probes and flow metres), computers, etc.

All of this equipment will receive the overvoltage via the power supply network and the communication or control lines. So the protection has to be sized to deal with each of these lines.

In the first place, protection against both conducted and induced surges must be applied to the electrical supply cables. This is how the highest surges are usually received, so properly coordinated multi-step protection is needed, because of the different locations of the electrical panels. The use of several protectors makes it possible to discharge to earth all the energy of the surge, limiting voltage in the equipment to harmless values.

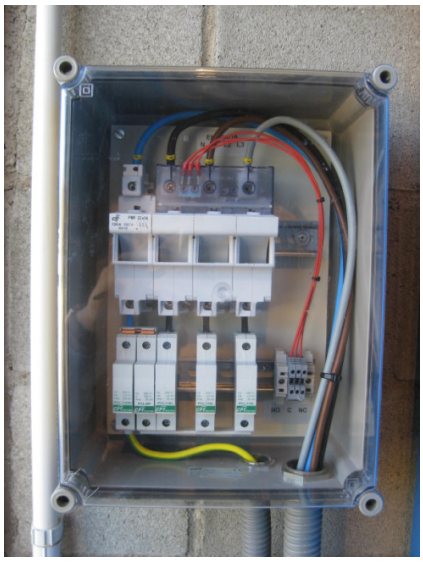

Fig. 4. Type 1 electrical supply protectors, PCL range

Based on these indications, protectors will be fitted in all the electrical panels: incoming power supply panel, motor control panels, control building panel (offices), etc. As shown in the diagram on the next page, the main incomer protectors are Type 1 which, according to the IEC 61643 classification, are capable of discharging a large amount of energy to earth (direct lightning strike). Protection of all panels will be Type 2 which, according to the IEC 61643 standard, limit the overvoltage to values small enough to ensure the protection of the equipment. This stepped protection ensures proper protection of equipment connected to the main supply network.

Additionally, variable speed drives need protection in the output. If the distance between these and the motors is greater than 10 meters, the cables may receive induced power, causing a surge that might damage the drive. If the cable path is outdoors, the level of

induction will be much higher, causing surges several kilovolts higher. Even without these distances, output protection is always recommended due to overvoltages coming from the earth itself.

It should be pointed out that the protection of the electrical feed cables to the PLC or power supplies must be achieved with a surge protector which includes an EMI filter, as this sort of equipment is highly sensitive to disturbances on the network.

Secondly, more protectors must be installed to **protect equipment from surges induced on control, data or communication lines**. These are the inputs and outputs of the PLC, communication bus, telephone lines or any antennae the building may have. It is important to emphasize that when an atmospheric phenomenon causes a surge, it will be present in conduction or induction mode in all metallic cables: electrical supply, communications, telephone, etc. These protectors are in DIN rail format too, and are installed as close as possible to the equipment to be protected. Similarly, if the equipment is connected to an antenna via a coaxial cable, it may receive surges via this path, making protection obligatory.

Fig. 5. PLC input, output and communication lines, highly sensitive to surges

Field devices such as probes, flow meters, pH meters etc., also require protection from surges, on both electrical supply and data lines It is very important to minimise the distance between the protectors and the equipment to be protected. Based on this recommendation, a small box will be fitted next to the equipment, with both surge protectors. **The electrical supply surge protector must have a built-in EMI filter.**

Fig. 6. Field device solution, comprised of data network protection and electrical supply surge protection with EMI filter

Finally, **permanent overvoltage (TOV)** protection must be sized. Given the characteristics of this installation, protection is sized to disconnect the equipment which is most sensitive to this overvoltage, including the PLC. When disconnecting the PLC, a lot of other equipment is disconnected and thus protected until the TOV ceases.

4. Cirprotec solution

Based on the above comments, complete protection will correspond to the detailed list below, and the various models and their field location can be seen on the next page.

- **Lightning protection using lightning rods with an early streamer emission device (ESE)**

  The installation of one or two Nimbus range ESE lightning rods will be sufficient in most installations.

- **Surge protectors in electrical panels for electrical power feed cables.**

  As discussed in the previous point, the following will be installed:
  - A first step upstream of the main switchboard, PCL range.
  - A second step in the main switchboard and secondary panels, CS or PSC range
  - The second step in variable drive outputs or motor starters as well.
  - A third step in the most sensitive equipment (PLCs), DM range.

- **Surge protectors in electrical panels for communication and data cables, etc.**

  Protection of signal card inputs and outputs (analogue or digital): BNV or DIN24V range
  PLC communications protection: DB9 Sub-D range

- **Permanent overvoltage protection (TOV) for control circuits.**

  Protection using Overcheck range.

- **Surge protectors in field device supply and communications lines.**

  DM protection range (power supply network)
  DIN protection range (communications)

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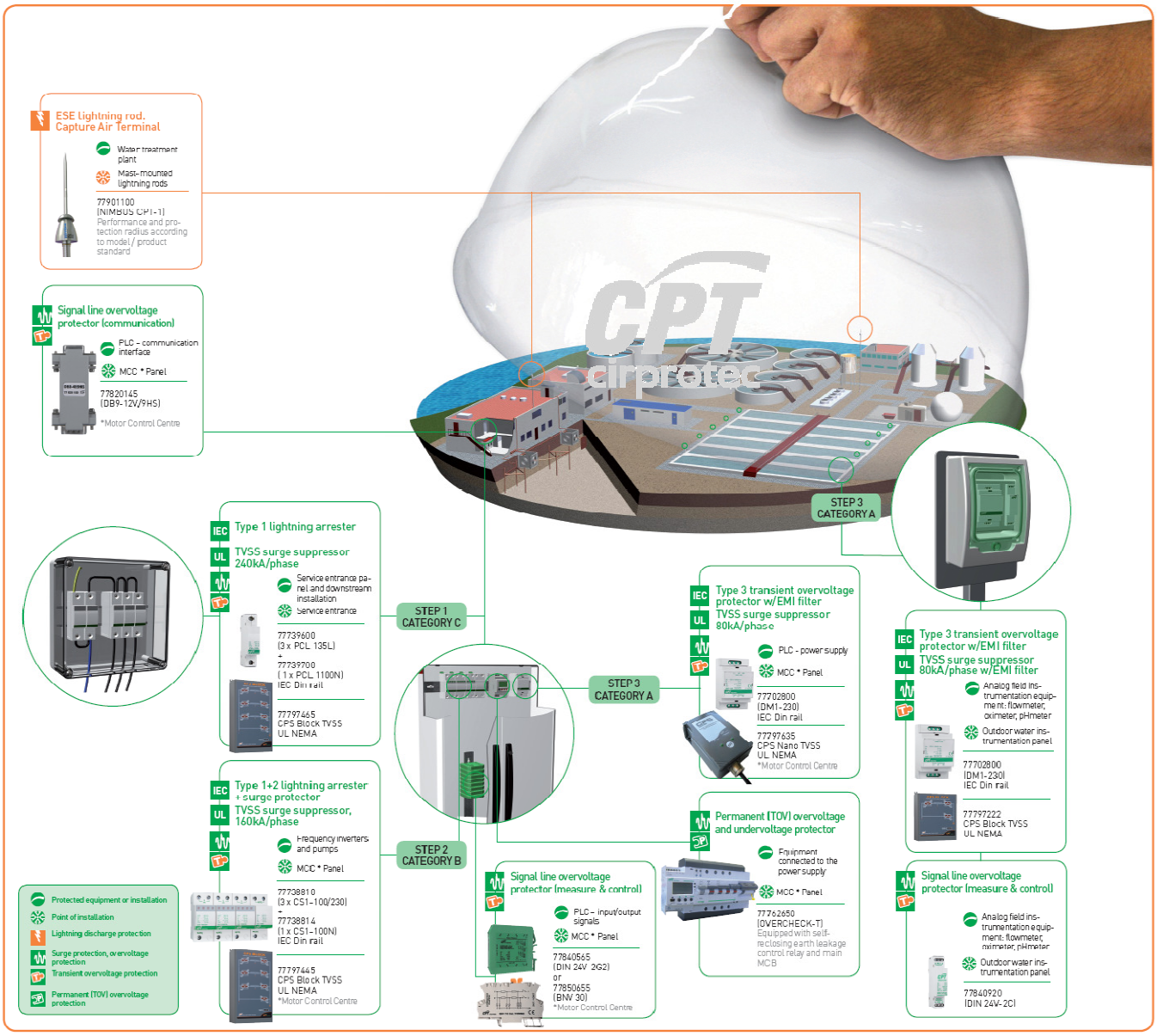

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8.- Power frequency overvoltage. EN50550 standard “Power Frequency Overvoltage Protectors (POP)”