



# **Lightning and surge protection for biogas plants**

In modern biogas plants, biodegradable organic substrates such as manure, dung, grass, straw, green waste, residues of the sugar, wine and beer production, leftovers and grease are fermented in an air-tight container (fermenter). In this oxygen-free atmosphere, bacteria produce biogas from the fermentable, organic biomass components. This biogas is used to generate heat and electricity.

**Figure 9.3.1** shows the basic principle of a biogas plant. Biogas plants frequently consist of feed-in systems for solids and/or liquid substrates, one or more heated fermenters, a storage tank, a post-fermenter, if any, a gas tank and a gas treatment unit, if any. The gas engine with heat exchanger and a generator connected to it is referred to as combined heat and power station (CHP). Depending on the energy content of biogas, a combined heat and power station generates electricity with an efficiency of about 30 % and heat with an efficiency of about 60 %. While the electricity is fed into the public power grid, some of the heat is used for heating the fermenter and the waste heat is used, for example, for heating residential and agricultural buildings.

### Necessity of a lightning protection system

Different hazards and risks for persons, the environment and system technology can occur during the generation, storage and energy recovery of biogas. To be able to take adequate

precautions and protection measures, potential risk sources which may cause failure or a dangerous event are considered in a risk analysis according to the German Federal Immission Control Act (BImSchG)/Ordinance on Industrial Safety and Health (BetrSichV).

The German Safety Regulations for Agricultural Biogas Plants published by the German Agricultural Professional Association as well as the German BGR 104 specify that measures which prevent the ignition of dangerous explosive atmospheres must be taken in potentially explosive atmospheres to avoid ignition sources.

According to sub-clause 5.3.1 of the EN 1127-1 standard, there are thirteen different ignition sources. In sub-clause 5.3.8 of the EN 1127-1 standard and in the German BGR 104, lightning is defined as a possible ignition source: "If lightning strikes in an explosive atmosphere, ignition will always occur. Moreover, there is also a possibility of ignition due to the high temperature reached by lightning conductors. Large currents flow from where the lightning strikes and these currents can produce sparks in the vicinity of the point of impact. Even in the absence of lightning strikes, thunderstorms can cause high induced voltages in equipment, protective systems and components".

A risk analysis according to the calculation method specified in IEC 62305-2 (EN 62305-2) must be performed to define the

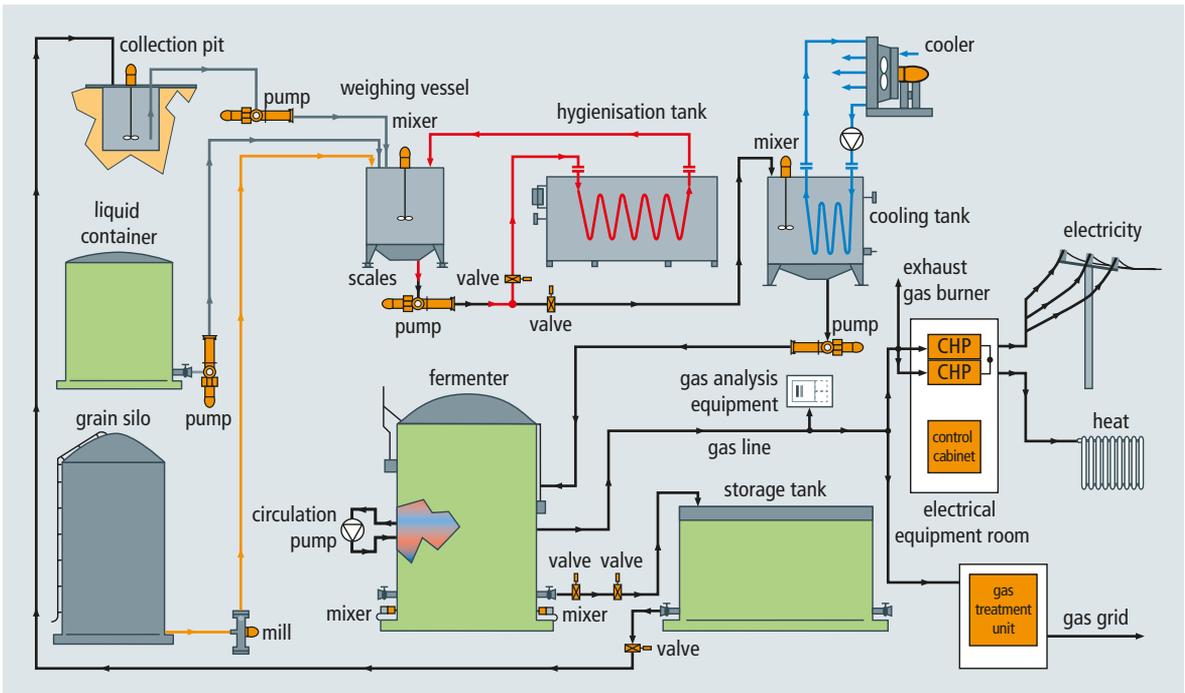


Figure 9.3.1 System overview of a biogas plant

relevant protection measures. The purpose of this risk analysis is to determine the risk resulting from direct and indirect lightning strikes for a structure including the persons and equipment therein. If the risk is higher than the tolerable risk, lightning protection measures must be taken to minimise the risk resulting from a lightning strike so that it is no longer higher than the tolerable risk.

Supplement 2 of the German DIN EN 62305-3 (VDE 0185-305-3) standard includes additional information on special buildings including requirements on lightning protection systems for biogas plants. According to this supplement, biogas plants should be protected by isolated air-termination and down-conductor systems if it cannot be excluded that risks resulting from ignitable sparks occur at contact and connecting points.

### External lightning protection

The fermenter, which is available in different designs, is the core of every biogas plant. Therefore, the required lightning protection system must always be adapted to the structural conditions of the fermenter. There are different solutions for the same protection goals. As mentioned in Supplement 2 of the German DIN EN 62305-3 (VDE 0185-305-3) standard, a lightning protection system with class of LPS II meets the general requirements for systems with a risk of explosion and thus those for biogas plants.

A lightning protection system consists of an external and internal lightning protection system.

The function of an external lightning protection system is to intercept all lightning strikes including side flashes to the structure, to conduct the lightning current from the point of strike to the ground and to disperse it in the ground without causing damage to the structure to be protected resulting from thermal, mechanical or electrical effects.

### Fermenters with foil roof

Fermenters with foil roof are frequently used for biogas plants. If lightning strikes the foil roof of the fermenter, it will be damaged and melting and spraying effects at the point of strike can cause fire and explosion. Lightning protection measures must be taken in such a way that direct lightning strikes to the foil roof of the fermenter are prevented (**Figure 9.3.2**).

The German Safety Regulations for Agricultural Biogas Plants define that e.g. Ex zone 2 is located in a radius of 3 m around the foil roof of the fermenter. In Ex zone 2 potentially explosive atmospheres only occur occasionally or for a short period of time. This means that a potentially explosive atmosphere is only to be expected in case of rare and unpredictable events (failure and maintenance work). Therefore, air-termination systems may be positioned in Ex zone 2 according to IEC 62305-3 (EN 62305-3).

The rolling sphere method is used to determine the height and number of air-termination systems. The sag of the rolling

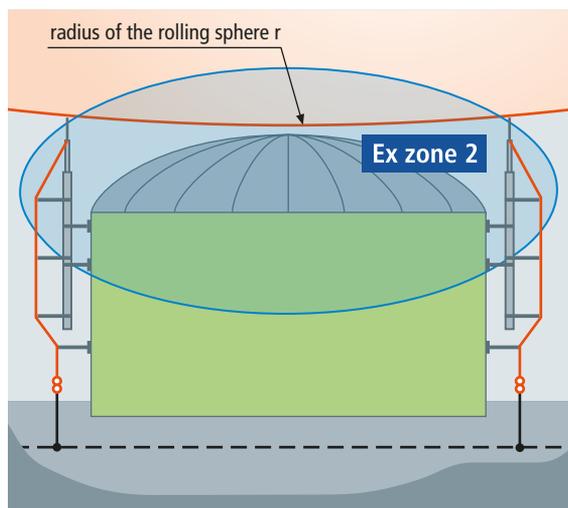


Figure 9.3.2 DEHNiso Combi system used to protect a fermenter with foil roof

Type	Part No.
DEHNiso Combi set, one-piece, total length of 5700 mm	105 455
<b>Consisting of:</b>	
1 StSt air-termination tip, 1000 mm long	105 071
1 GRP/Al supporting tube, 4700 mm long	105 301
3 wall mounting brackets made of StSt (V2A)	105 340
2 GRP/Al spacers, 1030 mm long	106 331

Table 9.3.1 DEHNiso Combi set

sphere, which can be determined according to IEC 62305-3 (EN 62305-3), is decisive for dimensioning the air-termination system. In case of class of LPS II for systems with a risk of explosion, the rolling sphere radius is 30 m (**Figure 9.3.2**). Depending on the gas volume, the inner membranes in the gas storage tank of the fermenter contact the metal inner wall of the fermenter. An insulated down conductor is used to avoid uncontrolled flashover from the down conductor to the metal wall of the fermenter. The lightning protection system is electrically isolated from conductive parts of the fermenter since the down conductor is routed separately by means of spacers made GRP (glass-fibre reinforced plastic). The length of the spacers depends on the separation distance determined according to IEC 62305-3 (EN 62305-3).

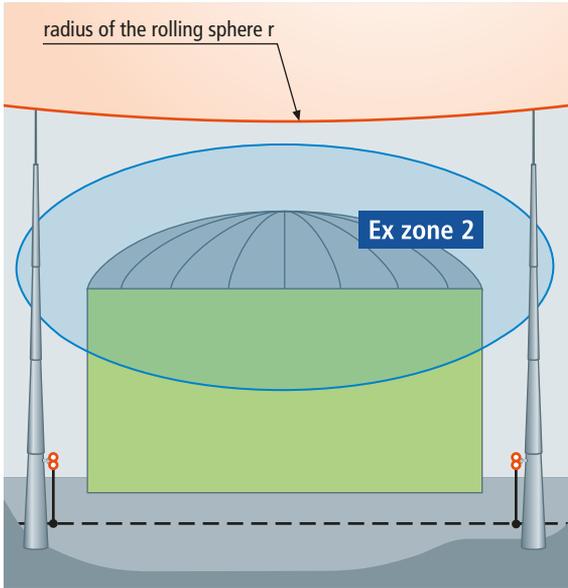


Figure 9.3.3 Protection of a fermenter with a foil roof by means of telescopic lightning protection masts

The DEHNiso Combi set according to **Table 9.3.1** is used for the application illustrated in **Figure 9.3.2**.

Another possibility to avoid direct lightning strikes to fermenters with foil roof is to use steel telescopic lightning protection masts (**Figure 9.3.3**). These masts are installed in natural soil or in the ground foundation. Free heights above ground level up to 25 m or in case of customised versions even higher can be achieved. The standard lengths of the steel telescopic lightning protection masts are supplied in partial lengths of 3.5 m, offering enormous transportation benefits. More detailed information on the use of steel telescopic lightning protection masts can be found in installation instructions No. 1729.

A third possibility to protect fermenters with foil roof from direct lightning strikes is to use a HVI Conductor. HVI Conductors are high-voltage-resistant, insulated conductors with a special outer sheath. In the field of lightning protection, they are typically used as insulated down conductors for keeping the separation distance according to IEC 62305-3 (EN 62305-3). To this end, the separation distance must be calculated according to IEC 62305-3 (EN 62305-3). Then it must be checked whether this calculated separation distance can be achieved by means of the equivalent separation distance of the HVI Conductor. There are two possible solutions:

➔ **Solution 1:** Air-termination masts with **one** HVI Conductor (**Figure 9.3.4**). The maximum total length of the air-

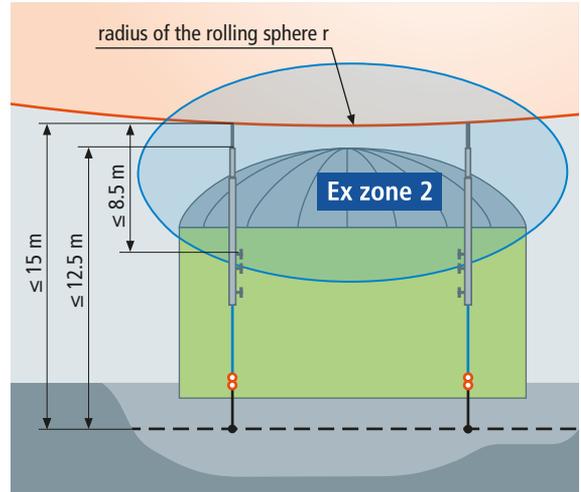


Figure 9.3.4 Protection of a fermenter by means of air-termination masts, isolated by means of a HVI Conductor (Part No. 819 720)

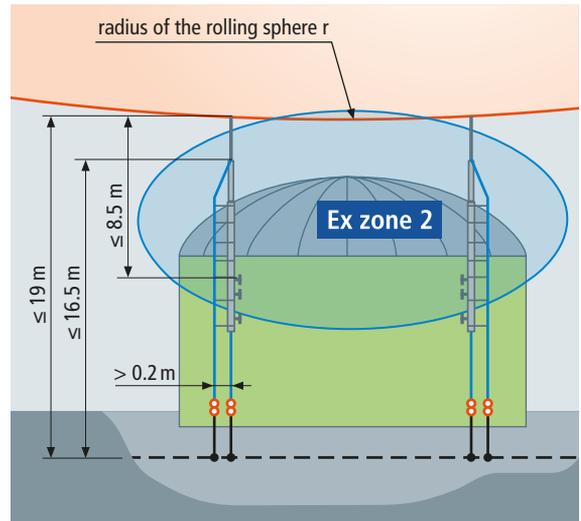


Figure 9.3.5 Protection of a fermenter by means of air-termination masts, isolated by means of two HVI Conductors (Part No. 819 750)

termination system from the equipotential bonding level (earth-termination system) to the air-termination tip is 15 m (in case of class of LPS II). The maximum free length above the top edge of the fermenter must not exceed 8.5 m (for mechanical reasons).

➔ **Solution 2:** Air-termination masts with **two** HVI Conductors (**Figure 9.3.5**). The maximum total length of the air-



Figure 9.3.6 Fermenter made of bolted metal sheets



Figure 9.3.7 Protection of a fermenter made of metal sheets by means of an isolated air-termination system (source: Büro für Technik, Hösbach)

termination system from the equipotential bonding level (earth-termination system) to the air-termination tip is 19 m (in case of class of LPS II). The maximum free length above the top edge of the fermenter is also 8.5 m.

**Note:** The two HVI Conductors must be installed in parallel at intervals of more than 20 cm.

More detailed information on HVI Conductors and the relevant installation instructions can be found at [www.dehn-international.com](http://www.dehn-international.com).

### Design service

Isolated air-termination systems are complex and comprehensive systems. DEHN will be pleased to assist you in designing isolated air-termination systems based on HVI Conductors, the DEHNiso Combi system or steel telescopic lightning protection masts. This design service is available for a fee and comprises:

- ➔ Drawings of the lightning protection system (general layout drawings)
- ➔ Detailed drawings for the isolated air-termination system (in some cases in the form of exploded views)
- ➔ Comprehensive parts list of the components required for the isolated air-termination system
- ➔ Quotation based on this parts list.

If you are interested in our design service, please contact your local sales representative or our head office in Neumarkt, Germany at [www.dehn-international.com](http://www.dehn-international.com).

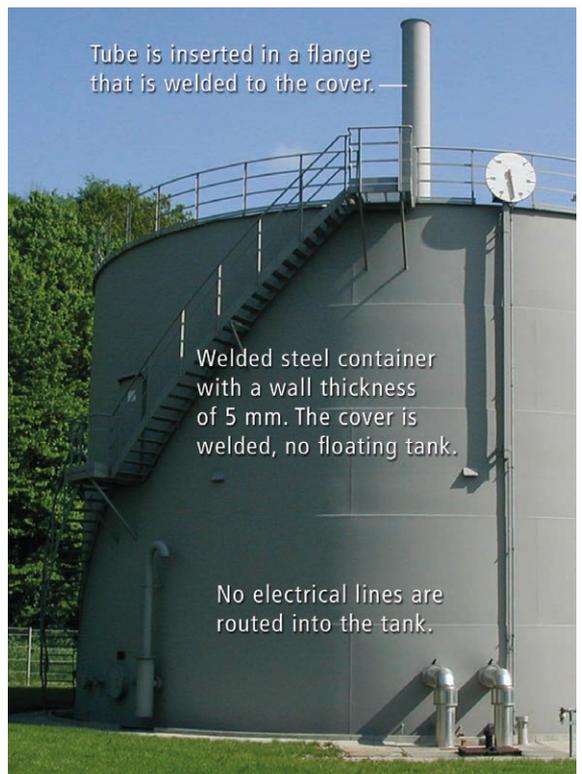


Figure 9.3.8 Welded steel container (source: Eisenbau Heilbronn GmbH)

### Fermenters made of metal sheets

Fermenters made of metal sheets typically have a thickness between 0.7 mm and 1.2 mm. The individual metal sheets are screwed together (Figure 9.3.6).

If metal sheets are to be used as natural air-termination system, the metal sheets must have the relevant thickness listed in Table 3 of IEC 62305-3 (EN 62305-3). If the thickness of the metal sheets does not comply with Table 3 of IEC 62305-3 (EN 62305-3), a lightning strike may cause melting or impermissible heating at the point of strike resulting in a risk of fire and explosion. In this case, these fermenters must be protected

by additional air-termination systems to avoid melting at the point of strike. For this purpose, an isolated lightning protection system is installed. The rolling sphere method is used to determine the arrangement of the air-termination system. The down conductor is routed along the metal sheets by means of spacers according to the calculated separation distance (Figure 9.3.7).

### Steel container

Figure 9.3.8 shows a biogas tank enclosed by fully welded steel sheets. According to Table 3 of IEC 62305-3

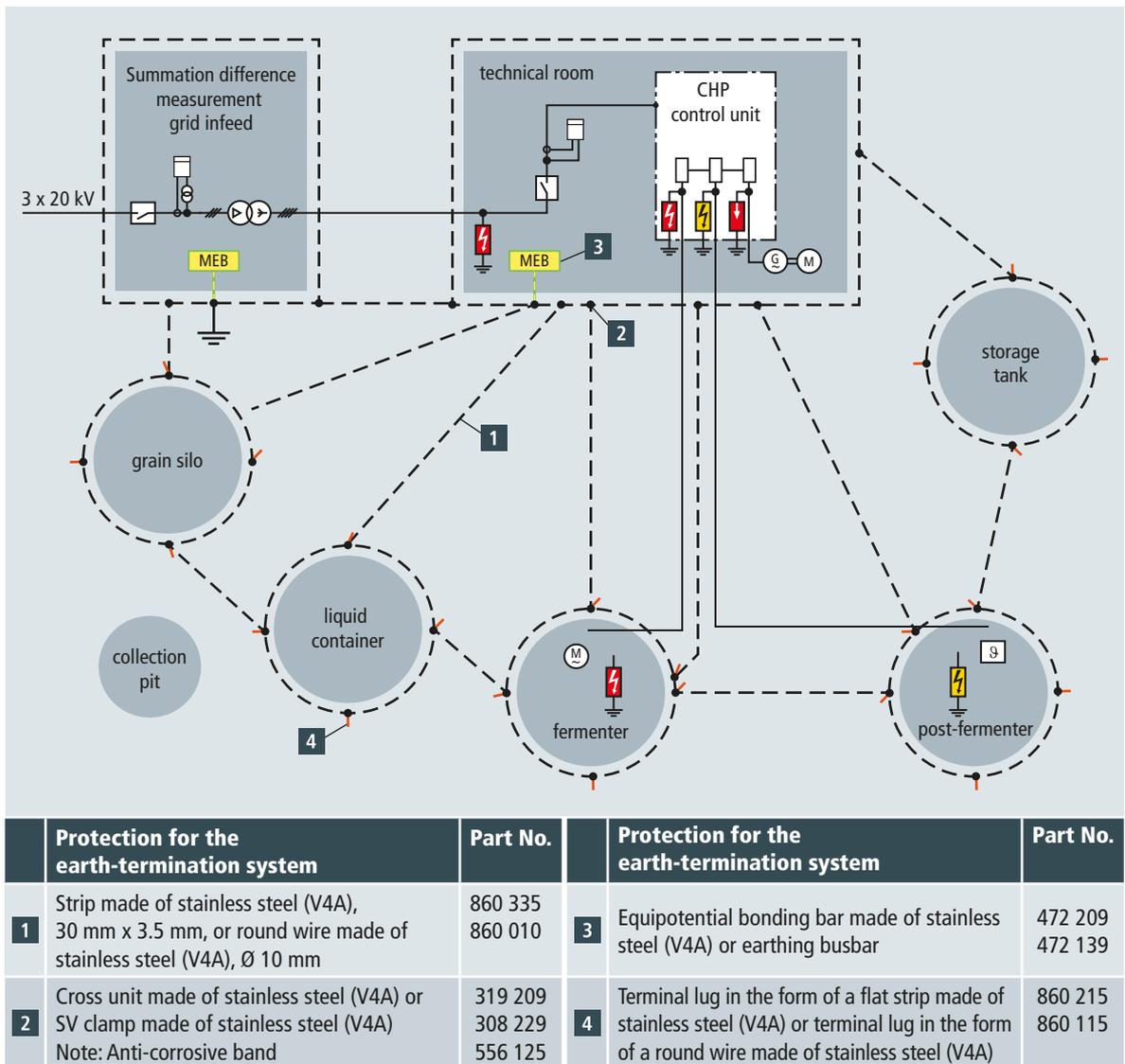


Figure 9.3.9 Intermeshed earth-termination system for a biogas plant

(EN 62305-3), a minimum wall thickness of the enclosure of 4 mm is required for steel. The lightning protection system must meet the requirement according to Annex D of IEC 62305-3 (EN 62305-3) "Additional information for LPS in the case of structures with a risk of explosion". If the Ex zones of exhaust openings are located in the protected volume of lightning current carrying metal parts of the enclosure, no additional air-termination systems are required. If this is not the case, additional air-termination systems must be installed to protect the exhaust openings from direct lightning strikes.

### Earthing concept

To avoid high potential differences between the individual earth-termination systems, they are interconnected to an overall earth-termination system (Figure 9.3.9). This is achieved by intermeshing the individual earth-termination systems of the buildings and systems. Mesh sizes from 20 m x 20 m to 40 m x 40 m have proven to be economically and technically feasible. By intermeshing all earth-termination systems, potential differences between the parts of the installation are considerably reduced. Moreover, the voltage stress on the electrical connecting cables between the buildings in case of lightning effects is reduced.

### Feeding electricity into the grid

The biogas produced is typically used in gas or pilot injection engines to generate electricity and heat. In this context, such engines are referred to as combined heat and power plants (CHP). These CHPs are located in a separate operations building. The electrical equipment, switchgear cabinets and control cabinets are housed in the same room or in a separate room of this operations building. The electricity generated by the CHPs is fed into the public grid (Figure 9.3.10).

Lightning equipotential bonding, which must be established for all conductive systems entering the building, is an integral part of a lightning protection system. Lightning equipotential bonding requires that all metal systems be incorporated in the equipotential bonding so as to cause as little impedance as possible and that all live systems are indirectly integrated in the equipotential bonding via type 1 surge protective devices. Lightning equipotential bonding should be established as close as possible to the entrance point into the structure to prevent partial lightning currents from entering the building. The incoming 230/400 a.c. lines of the main low-voltage distribution board of the consumer installation (Figure 9.3.10) are protected by type 1 surge protective devices (SPDs). DEHNbloc, for example, is a type 1 surge protective device with RADAX Flow spark gaps for power supply systems. This lightning current arrester has a discharge capacity up to 50 kA (10/350  $\mu$ s) per pole. The patent-protected RADAX Flow principle limits and extinguishes short-circuit

currents (follow currents) up to 100 kA<sub>rms</sub>. Undesired supply disruption resulting from tripping main fuses is thus prevented. Type 2 DEHNguard M TNS 275 FM surge arresters are installed in the downstream sub-distribution boards.

A modular multipole DEHNventil combined arrester with high follow current limitation is installed in the distribution board of the CHP (Figure 9.3.10). This prewired spark-gap-based combined arrester comprises a base part and plug-in protection modules. DEHNventil ensures maximum availability of the installation, disconnection selectivity with respect to 20 A gL/gG fuses as well as limitation and extinction of mains follow currents up to short-circuit currents of 100 kA<sub>rms</sub>.

If DEHNventil is installed close to the loads ( $\leq 5$  m), protection of terminal equipment is also ensured.

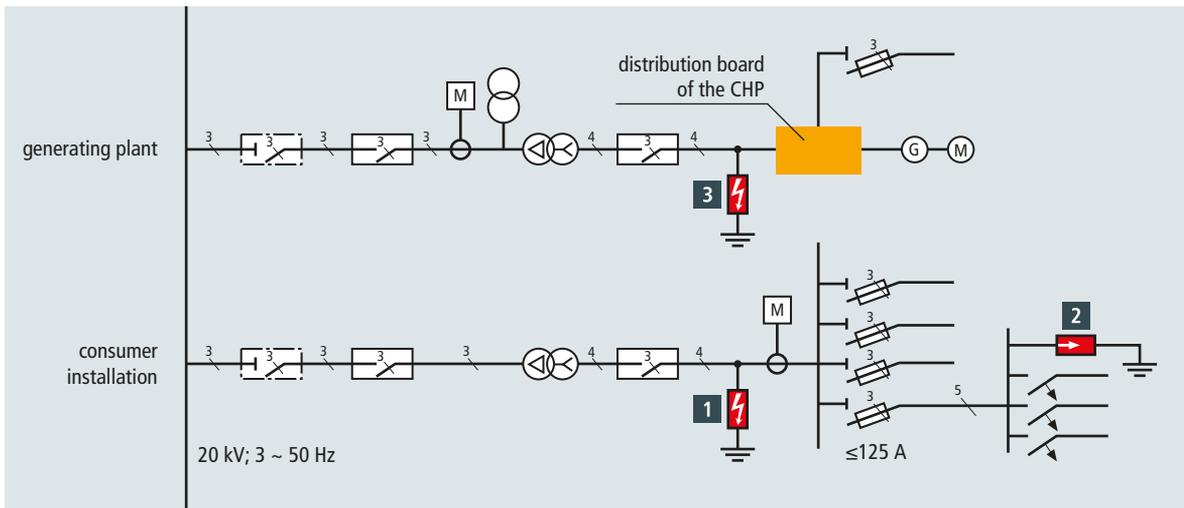
### Remote monitoring

The remote monitoring system ensures that the performance data of the biogas plant are permanently available. The installation-specific measured values can be directly read off the acquisition unit. This unit features interfaces such as Ethernet or RS 485 which are connected to a PC and/or modems for remote enquiry and maintenance. Remote monitoring, for example via modem, allows service staff to log on to existing systems and to provide immediate support to the operator in case of failure. The modem is connected to the network termination unit (NTBA) of a basic ISDN connection. It must also be ensured that the measured data are forwarded by means of the telecommunication network via ISDN modem to provide permanent monitoring and to optimise the installation's performance. For this purpose, the U<sub>k0</sub> interface upstream of the NTBA which is connected to the ISDN modem is protected by a BLITZDUCTOR XT combined arrester (Figure 9.3.11). It is advisable to use a DEHNprotector surge arrester to protect the power and data side of telecommunications terminal equipment and telephone systems with RJ connection. Figure 9.3.11 shows an example of how to protect a CCTV camera by means of these arresters. A shielded UKGF BNC surge arrester is provided for the coaxial cable (video transmission system). More detailed information on the protection of CCTV systems can be found in chapter 9.7 "Surge protection for CCTV systems".

### Process control

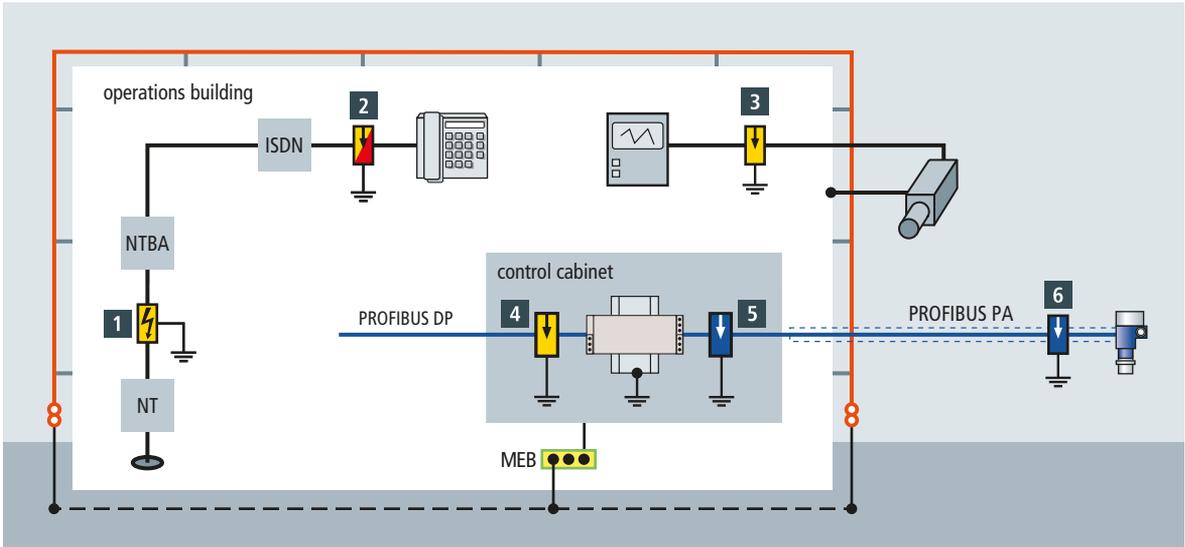
The control unit is a key element of a biogas plant. Its function is to centrally actuate all pumps and mixers, record process data such as the gas volume and gas quality, monitor the temperature, acquire all input materials as well as visualise and document all data.

If the process control fails as a result of surges, processes for biogas production are interfered with and interrupted. Since these processes are extremely complex, unscheduled downtime can lead to further problems so that the standstill period may be extended to several weeks.



No.		Surge protective device	Part No.	Notes
<b>Feed-in system / main distribution board</b>				
1	TN-C system	3 x DEHNbloc DB M 1 255 FM	961 125	Single-pole spark-gap-based lightning current arrester with high follow current limitation and remote signalling contact
	TN-S system	4 x DEHNbloc DB M 1 255 FM	961 125	
	TT system	3 x DEHNbloc DB M 1 255 FM + 1 x DEHNgap DGP M 255 FM	961 125 + 961 105	
<b>Alternative</b>				
1	TN-C system	3 x DEHNbloc Maxi DBM 1 255 S	900 220	Coordinated lightning current arrester with integrated arrester backup fuse for industrial busbar systems
	TN-S system	4 x DEHNbloc Maxi DBM 1 255 S	900 220	
	TT system	3 x DEHNbloc Maxi DBM 1 255 S + 1 x DEHNgap Maxi DGPM 1 255 S	900 220 + 900 050	
<b>Alternative</b>				
1	TN-C system	3 x DEHNvenCI DVCI 1 255 FM	961 205	Combined arrester with integrated arrester backup fuse and a voltage protection level ≤ 1.5 kV for terminal equipment
	TN-S system	4 x DEHNvenCI DVCI 1 255 FM	961 205	
	TT system	3 x DEHNvenCI DVCI 1 255 FM 1 x DEHNgap DGP M 255 FM	961 205 961 105	
<b>Sub-distribution board</b>				
2	TN-C system	DEHNguard DG M TNC 275 FM	952 305	Multipole surge arrester with Thermo Dynamic Control and remote signalling contact
	TN-S system	DEHNguard DG M TNS 275 FM	952 405	
	TT system	DEHNguard DG M TT 275 FM	952 315	
<b>Generating plant</b>				
3	TN-C system	DEHNventil DV M TNC 255 FM	951 305	Modular combined arrester with high follow current limitation and a voltage protection level ≤ 1.5 kV
	TN-S system	DEHNventil DV M TNS 255 FM	951 405	
	TT system	DEHNventil DV M TT 255 FM	951 315	

Figure 9.3.10 Excerpt from the block diagram of a biogas plant



No.	Protection for...	Surge protective device	Part No.
<b>Telecommunication / data technology</b>			
1	Fixed line network	BLITZDUCTOR BXT ML2 BD 180 + BXT BAS base part	920 247 + 920 300
2	ISDN devices	DEHNprotector DPRO 23 ISDN	909 320
3	Coaxial cable (video transmission system)	UGKF BNC	929 010
<b>Measuring and control equipment</b>			
4	PROFIBUS DP	BLITZDUCTOR BXT ML4 BD HF 5 + BXT BAS base part	920 371 + 920 300
	Analogue signals (non-hazardous area)	BLITZDUCTOR BXT ML4 BE 24 + BXT BAS base part	920 324 + 920 300
5	PROFIBUS PA Ex (i)	BLITZDUCTOR BXT ML2 BD S EX 24 + BXT BAS EX base part	920 280 + 920 301
	Temperature measurement PT 100, PT 1000, Ni 1000 (non-hazardous area)	BLITZDUCTOR BXT ML4 BC 24 + BXT BAS base part	920 354 + 920 300
<b>Field devices</b>			
6	4–20 mA, PROFIBUS PA, Fieldbus Foundation, Ex (i)	DPI MD EX 24 M 2	929 960
	4–20 mA, PROFIBUS PA, Fieldbus Foundation, non-hazardous area	DPI MD 24 M 2S	929 941

Figure 9.3.11 Surge protection for the installations of information technology systems

The control unit is installed in the control cabinet. In addition to digital inputs and outputs, e.g. PT 100 signals, 4–20 mA signals or the like are evaluated here. To ensure undisturbed and permanent transmission of the measured data to the control unit in the control cabinet at any time, the control and signal lines extending beyond the buildings, for example that of fre-

quency converters and actuators, must be protected by installing BLITZDUCTOR XT lightning current arresters (category D1) as close as possible to the entrance point into the building (Figure 9.3.12). A contactless and fast arrester testing system (LifeCheck) is integrated in these surge protective devices. Surge protective devices for information technology systems



Figure 9.3.12 Combined arrester modules with LifeCheck



Figure 9.3.13 DEHNPipe surge arrester for outdoor use is screwed onto two-conductor field devices

are chosen according to the maximum continuous operating voltage, the nominal current, the type of signal (DC, LF, HF) and the type of signal transmission (balanced, unbalanced).

**Figure 9.3.11** shows examples of surge protective devices for signal and control lines.

It is recommended to install a DEHNPipe surge arrester to protect two-wire field devices such as pressure or level sensors, valves, pressure transmitters or flow meters (**Figure 9.3.13**). This arrester ensures energy-coordinated surge protection for outdoor field devices and takes up little space.