Retrofitting sewage plants with lightning and surge protection measures
A more efficient use of drinking water is growing in significance, especially against a backdrop of increasingly scarce drinking water resources. Therefore, sewage plants are a key element of the drinking water cycle. The necessary high efficiency of sewage plants (Figure 9.4.1) requires that the operating procedure be optimised and the operating costs be reduced at the same time. For this purpose, high investments were made in electronic measuring equipment and distributed electronic control and automation systems over the last years. However, these new electronic systems only provide a low resistance to transients compared to conventional technology. The structural conditions of the widespread outdoor wastewater treatment systems with measuring equipment and control units extending over large areas additionally increase the risk of interference caused by lightning discharges or surges. Thus, it is most likely that the complete process control system or parts thereof fail if no protection measures are taken. The consequences of such a failure can be serious ranging from costs for re-establishing the availability of the sewage plant to the unknown costs for eliminating ground water contamination. Consequently, external and internal lightning protection measures must be taken to efficiently eliminate this threat and to increase the availability of the systems.

**Assessment of the risk for the operations building**
The example described in the following was calculated based on the IEC 62305-2 (EN 62305-2) standard. We expressively point out that the procedure shown is only an example. This solution is not binding in any way and can be substituted by other equivalent solutions. In the following, only the essential characteristics of the example will be shown. At first, a questionnaire with important questions on the structure and its use was discussed and filled in together with the operator. This procedure allows to prepare a lightning protection concept that is comprehensible for all parties involved. The concept includes the minimum requirements which, however, can be technically improved at any time.

**Plant description**
The complete process control system of the sewage plant is centrally located in the operations building. In case of a lightning strike, substantial partial lightning currents and surges are injected into the switch rooms via the extended cables leading to measuring stations and substations. In the past, this caused destruction and failure of the plant over and over again. The same applies to the power supply and telephone line. The operations building itself must be protected against damage resulting from fire (caused by a direct lightning strike) and the electrical and electronic systems (control and automation system, telecontrol system) from the effects of the lightning electromagnetic pulse (LEMP).

**Additional conditions:**
- **Protection measures against lightning effects** have already been taken (external lightning protection system accord-
Figure 9.4.2 Division of the operations building into lightning protection zones; example: selection of surge protective devices for the oxygen measurement device

<table>
<thead>
<tr>
<th>Protection for…</th>
<th>Type</th>
<th>Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply system</td>
<td>TN system</td>
<td>DEHNguard DG M TN 275</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DEHNguard DG M TN 275 FM</td>
</tr>
<tr>
<td></td>
<td>TT system</td>
<td>DEHNguard DG M TT 2P 275</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DEHNguard DG M TT 2P 275 FM</td>
</tr>
<tr>
<td>Oxygen measurement device</td>
<td>e.g. 4 to 20 mA</td>
<td>BLITZDUCTOR BXT ML4 BE S 24 + BXT BAS base part</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BLITZDUCTOR BXT ML2 BE 24 + BXT BAS base part</td>
</tr>
</tbody>
</table>

According to the previous IEC 62305-1 (EN 62305-1) standard, VGA 280/4 surge protective devices (SPDs) installed at the entrance point of the 230/400 V power supply line into the building, VM 280 SPDs of requirement class C installed in the switchgear cabinets of the measuring and control equipment.

The following types of loss are relevant: L2: Loss of service to the public (water supply and wastewater disposal) and L4: Loss of economic value (structures and their contents). Type of damage L1: Loss of human life was excluded since the plant will be fully automated at a later date.

An assessment of the actual state shows that the calculated risk $R$ for the types of damage L2 and L4 is still considerably higher than the tolerable risk $R_T$.

Possible protection measures are taken to ensure $R < R_T$ for both types of damage:

- Installation of a lightning protection system with class of LPS III according to IEC 62305-3 (EN 62305-3) (this complies with the recommendations in the German VdS publication 2010).

- Installation of type 1 SPDs according to IEC 61643-11 (EN 61643-11) (power supply) and SPDs of category D1 according to IEC 61643-21 (EN 61643-21) for the information technology lines (measuring and control lines as well as telecommunication lines) at the zone transitions from LPZ 0A to 1.

- Type 2 SPDs according to IEC 61643-11 (EN 61643-11) (power supply) and surge protective devices of category C2 according to IEC 61643-21 (EN 61643-21) for the information technology lines (measuring and control lines as well as telecommunication lines) at the zone transitions from LPZ 0B to 1 and 1 to 2.

**Lightning protection zone concept**
To ensure maximum technical and economic protection, the operations building is subdivided into lightning protection zones (LPZs). Subsequently, a risk analysis is carried out for each LPZ and the relevant types of damage. The mutual dependencies of the LPZs are then examined and the required
protection measures are defined to reach the necessary protection goal in all lightning protection zones. The following areas were subdivided into lightning protection zone 1 (LPZ 1) and lightning protection zone 2 (LPZ 2):

- Evaluation unit in the control room (LPZ 2)
- Oxygen measurement device in the aeration tank (LPZ 1)
- Interior of the control room (LPZ 1)

According to the lightning protection zone concept described in IEC 62305-4 (EN 62305-4), all lines at the boundaries of lightning protection zones must be protected by suitable surge protection measures.

**Figure 9.4.2** exemplarily shows suitable surge protection measures for the oxygen measurement device in the aeration tank. The field cables are located in LPZ 0B throughout their entire course. Therefore, type 2 SPDs can be used for protecting the oxygen measurement device and the control systems since (partial) lightning currents are not to be expected in LPZ 0B.

**Lightning protection system**

The existing lightning protection system of the operations building was tested according to the requirements of class of LPS III. The indirect connection of the roof-mounted structures (air-conditioning systems) via isolating spark gaps was removed. Air-termination rods with the required separation distances and protective angles were used to protect the sewage plant from a direct lightning strike (Figure 9.4.3). Consequently, in case of a direct lightning strike to the control room, partial lightning currents can no longer flow into the structure and cause damage. Due to the dimensions of the control room (15 m x 12 m), the number of down conductors (4) did not have to be changed. The local earth-termination system of the operations building was tested at all measuring points and the values were documented. Retrofitting was not required.

**Lightning equipotential bonding for all conductive systems entering the sewage plant**

In principle, all conductive systems entering the sewage plant must be integrated in the lightning equipotential bonding (Figure 9.4.4). This is achieved by directly connecting all metal systems and indirectly connecting all live systems via surge protective devices. Type 1 SPDs (power supply systems) and category D1 SPDs (information technology systems) must have a discharge capacity of 10/350 μs test waveform. Lightning equipotential bonding should be established as close as possible to the entrance point into the structure to prevent lightning currents from entering the building.

**Equipotential bonding**

Consistent equipotential bonding according to IEC 60364-4-41 (HD 60364-4-41), IEC 60364-5-54 (HD 60364-5-54) and IEC 62305-3 (EN 62305-3) is established in the entire operations building. The existing equipotential bonding system is tested to avoid potential differences between different extraneous conductive parts. Supporting and structural parts of the building, pipes, containers, etc. are integrated in the equipotential bonding system so that voltage differences do not have to be expected, even in case of failure. If surge protective devices are used, the cross-section of the copper earthing conductor for equipotential bonding must be at least 16 mm² in case of SPDs for power supply systems and at least 6 mm² in case of SPDs for information technology systems (e.g. BLITZDUCTOR) or the cross section specified in the installation instructions must be used. Moreover, in areas with potentially explosive atmospheres the connections of the equipotential bonding conductors e.g. at equipotential bonding bars must be secured against self-loosening (e.g. by means of spring washers).

**Surge protection for the low-voltage power supply system**

In the described application, the VGA 280/4 surge protective device installed at the entrance point into the building is replaced by a DEHNventil M TNS 255 FM type 1 combined arrester (Figure 9.4.5) since the “old” SPD no longer fulfils the requirements for lightning protection systems according to IEC 62305-3 (EN 62305-3). The VM 280 type 2 SPDs were tested by means of a PM 10 arrester test unit. Since the test values were still within the tolerances, the SPDs did not have to be removed. If further SPDs are installed for protecting terminal equipment, they must be coordinated with each other and with the terminal equipment to be protected. The relevant installation instructions must be observed.

In other respects, the use of surge protective devices in the low-voltage consumer’s installation does not differ from other
### Lightning Equipotential Bonding

Figure 9.4.4 Lightning equipotential bonding according to DIN EN 62305-3 (VDE 0185-305-3), Supplement 1

<table>
<thead>
<tr>
<th>No. in Fig.</th>
<th>Protection for</th>
<th>Surge protective device</th>
<th>Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power supply systems</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 1 | TN-C system | DEHNventil DV M TNC 255  
DEHNventil DV M TNC 255 FM*  
DEHNventil DV ZP TNC 255 | 951 300  
951 305  
900 390 |
| 1 | TN-S/TT system | DEHNventil DV M TT 255  
DEHNventil DV M TT 255 FM*  
DEHNventil DV ZP TT 255 | 951 310  
951 315  
900 391 |
| **Information technology systems** | | | |
| 2 | Telecontrol, telecommunication | BLITZDUCTOR BXT ML2 BD 180 or  
BLITZDUCTOR BXT ML4 BD 180  
+ BXT BAS base part | 920 247  
920 347  
+ 920 300 |
| **Measuring and control equipment** | | | |
| 3 | Intrinsically safe measuring circuits  
+ systems | BLITZDUCTOR BXT ML2 BD S EX 24 or  
BLITZDUCTOR BXT ML4 BD EX 24  
+ BXT BAS base part | 920 280  
920 381  
+ 920 301 |
| **Bus systems** | | | |
| 4 | e.g. Profibus DP | BLITZDUCTOR BXT ML2 BD HFS 5  
+ BXT BAS base part | 920 271  
+ 920 300 |

*floating remote signalling contact*
applications (for more detailed information, please also see brochure DS 649 E “Red/Line Selection Guide”).

**Surge protection for information technology systems**

The entrance point into the building serves as a transfer point between all information technology lines and the sewage plant. At this point, lightning current carrying SPDs (category D1), e.g. of type DRL 10 B 180 FSD, are installed. The lines are directly routed from this transfer point to the switchgear cabinets and are connected there. According to the risk analysis, the incoming lines for the 20 mA signals and the telecontrol system must be protected by adequate arresters from the DEHNconnect or BLITZDUCTOR series. These SPDs can be installed in conformity with the lightning protection zone concept (category C2) and are compatible with the system (Figures 9.4.6 and 9.4.7).

This ensures a consistent surge protection concept for the information technology lines.

Additional applications for protecting sewage plants can be found in brochure DS 107 E which can be downloaded at www.dehn-international.com.