BBC CELLPACK

Electrical Products

Technical information

SURGE ARRESTERS IN MEDIUM VOLTAGE NETWORKS

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This brochure was prepared in cooperation with the High Voltage Testing and Engineering Commission based in Zurich, Switzerland (FKH Zurich) between February and April 2020. It contains general information on surge arresters for the medium voltage distribution network and explains general terms as well as the basic selection of surge arresters.
This brochure was prepared to provide general technical information. It is not a guideline for the specific selection of a particular surge arrester, since only the respective customer knows the detailed actual network conditions in each individual case. The respective user in each individual case is therefore solely responsible for selecting a suitable surge arrester, taking into consideration the respective network conditions.

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Surge arresters in medium voltage networks

1 | TASK OF SURGE ARRESTERS MEANING OF THE ARRESTER DATA

Surge arresters protect the internal insulation of high-voltage equipment against short-term overvoltages. They are caused by lightning strikes (atmospheric overvoltages) or by switching operations (switching overvoltages).

It must be taken into consideration that surge arresters cannot be used to limit temporary overvoltages or in particular against an unwanted temporary voltage rise due to earth faults in the distribution network. A surge arrester, with its non-linear characteristics, must be selected so that it does not reach a conductive state in case of temporary overvoltages. It would otherwise be thermally overloaded (see section 2.1). It should, however, reliably limit high dangerous impulse voltages.

The focus is primarily placed on protecting the non-self-healing insulation of the equipment in the medium voltage network. Overhead lines at the medium voltage level with air-insulated sections are generally not protected by surge arresters. Flashovers on the self-healing outdoor insulation are tolerated for overhead lines. After a short disconnection to extinguish any arcs between the phase wires or to earth, operation can be continued immediately.

Above all, the distribution transformers and the switching cells, as well as the cables and their accessories are protected against overvoltages. The surge arresters must therefore be installed directly next to the equipment that requires protection. (See section 3)

1.1 | TOUCH-PROOF COUPLING PLUG SURGE ARRESTER CTKSA

The CTKSA coupling surge arresters are exclusively used with shielded, threaded BBC Cellpack cable connections at the input of the switching cells. They are touch-proof surge arresters in a shielded housing according to DIN EN IEC 60099-5 (VDE 0675-5): 2019-02 [2], section 5.2.2.5. Despite their touch-proof safety features during operation, the field must be de-energised and earthed when the surge arresters are disassembled and removed. In order to disassemble a surge arrester from a coupling system, the remaining system must be subsequently terminated with insulated screw inserts to ensure voltage resistance.

Important applications for CTKSA surge arresters include the following:

- at cable entry points in mixed networks with overhead line and cable components
- on cable outgoing feeder panels for protection against switching overvoltages, especially for longer cable routes
- on transformers with separable connectors with longer cable entry points

Since surge arresters must comply with a separate test standard, it is not possible to apply standards for cable accessories. It is important to pay attention to the variations in terminology, especially in the voltage terms used.

1.2 | DEFINITION OF THE MOST IMPORTANT ELECTRICAL PARAMETERS TO CHARACTERISE A SURGE ARRESTER

U_s Maximum permissible continuous operating voltage ("system voltage") in the distribution network (interlinked voltage, RMS value), frequently designated U in the fittings sector.

U_c Maximum permissible continuous operating voltage (RMS value of the AC operating frequency) across the arrester terminals for which the thermal stability of the arrester has been verified according to the specified working test.

U_{res} Measured peak value of the residual voltage of a surge arrester during a standard current impulse. Residual voltages measured at individual MO (metal-oxide) resistors can be added to the total residual voltage of an overall arrester.

U_{pl} Maximum residual voltage of a surge arrester for a lightning discharge current impulse ("lightning impulse protection level")

U_{ps} Maximum residual voltage of a surge arrester for a switching leakage current surge ("switching surge protection level").

U_r Rated arrester voltage, highest permissible RMS value of a temporary overvoltage applied for 10 seconds (according to test specifications).

U_{ref} Reference voltage of an arrester: peak value of the operating frequency voltage divided by √2 across the arrester terminals at which the reference current i_{ref} flows. U_{ref} and i_{ref} are characteristic values which define an operating point which is located in a range of the current voltage characteristic curve where the ohmic leakage current becomes dominant compared to the capacitive current. Voltages higher than U_{ref} cause a thermal overload of the arrester.

Q_{rs} Maximum repeated charge transfer rating during the working test.

Q_{th} Maximum thermal charge transfer rating. Charge that can be discharged by the arrester within 3 minutes during the thermal recovery test without any thermal runaway during the recovery test.

W_{th} Maximum nominal thermal energy absorption capacity in kJ/kV of U_r, which can be introduced into the arrester within 3 minutes without inducing thermal runaway, proven by the so-called working test.

I_n Leakage lightning surge currents, for which the residual voltage of the arrester is specified.

T_1 Surge time: 1.25 times the time in which a current impulse increases from 10% to 90% of the peak value.

T_2 Time to half-value: Time between the start of the surge until it falls to half of its peak value.

1.3 | ATMOSPHERIC OVERVOLTAGES

Atmospheric overvoltages in medium voltage installations may only be expected in networks with overhead lines or outdoor installations. Overvoltages not only occur during lightning strikes direct into the conductor wires, but also during lightning strikes in the immediate vicinity of medium voltage overhead lines. The voltages induced by the electromagnetic field, which are generated by the lightning current, may cause flashovers across the insulators. This is why surge arresters, which are used at the ends of medium voltage overhead lines, are not used to protect the overhead lines themselves, but the equipment connected to them.

Surge arresters are not essential in pure cable networks. Dangerous overvoltages due to lightning strikes can be ruled out to a large extent. The protective effect of surge arresters against atmospheric overvoltages is defined by the residual voltages to which the arrester limits the voltage during lightning current impulse.

To characterise the arresters, the residual voltages are used for standard impulses with different amplitudes and shapes (table 1).

Designation	Rise time	Time to half-value	Peak value according to classification			
Lightning impulse	8 µs	20 µs	2.5 kA,	5 kA	10 kA	20 kA
High current impulse	4 µs	10 µs	25 kA,	65kA	100 kA	
Steep impulse	0.9 … 1.1 µs	<20 µs	2.5 kA,	5 kA	10 kA	20 kA
Switching surge	30 … 100 µs	60 … 200 µs	250 A, 500 A, 1000 A, 2000 A			
Thermal charge transfer rating, medium voltage: Qth				0.45 … 10 C		

Table 1 | Test loads of medium voltage arresters: standardised current surge shapes to simulate lightning strikes and switching transients as well as value range for the charge transfer rating

1.4 | SWITCHING OVERVOLTAGES

In special cases, surge arresters are also used to protect against switching overvoltages. To characterise the residual voltages of surge arresters in this area, there are also standardised longer switching current impulses with a correspondingly lower amplitude (table 1). An important case of a switching overvoltage is when the voltage doubles on a connected cable or overhead line due to reflection at the open end on the opposite side.

1.5 | ELECTRICAL CHARACTERISTICS OF SURGE ARRESTERS DEFINITION OF VOLTAGE LEVELS

The highly non-linear dependence of the arrester current on the applied voltage is represented in figure 1 over the entire relevant functional range of an arrester. The characteristic curve sections are shown in a qualitative manner and are not considered as specifications. The most important voltage and current characteristics are indicated in the diagram (see also definitions in the section 1.2).

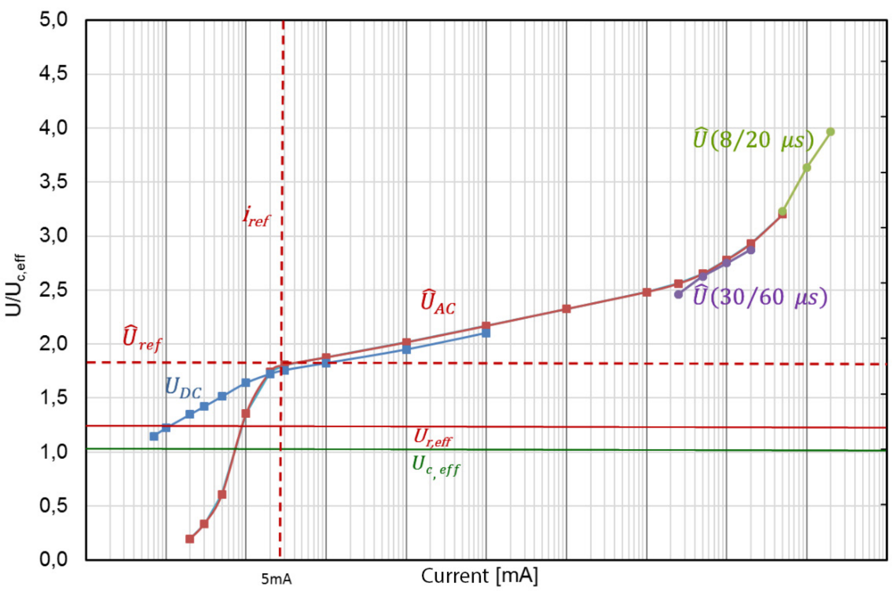


Figure 1

Qualitative current-voltage characteristics of a surge arrester for DC voltage, AC voltage, switching and lightning current impulses. The peak value is indicated for alternating voltage. The most important values for the voltage characteristic are entered (see definitions).

2 | SELECTING THE SURGE ARRESTER

2.1 | SELECTION BASED ON THE MAXIMUM PERMISSIBLE CONTINUOUS OPERATING VOLTAGE U_c

The maximum permissible continuous operating voltage U_c, which may be continuously applied across an arrester, is one of the most important dimensioning parameters of an arrester. It must not be exceeded for a considerable period of time during operation to prevent thermal overload of the arrester. The voltage may be exceeded by transient overvoltages and by temporally limited slighter higher voltages lasting a few seconds, which is specified by a characteristic curve (figure 5). For example, the surge arrester may be loaded with the specified voltage U_r for 10 seconds.

The correct dimensioning of the permissible continuous operating voltage U_c takes first priority even before selecting the lowest possible level of protection. If the U_c is dimensioned too low and does not take into consideration, for example, the highest temporary overvoltages that may occur, the arrester may fail in corresponding operating situations with corresponding consequential damage. The temporary overvoltages (earth fault/earth short circuit) primarily depend on the neutral point treatment.

It should be noted that a large number of special cases are possible for the neutral point treatment. It is therefore not necessary at this point to offer a conclusive description of the respective neutral point treatments and the influence on the selection of surge arresters at this point, especially since the localisation of the surge arrester (use between phase and earth or neutral point and earth) also plays a significant role.

For this reason, only the cases of "isolated neutral point" and "low-resistance earthed neutral point" are described below in a simplified form for the case of installing the arrester between phase and earth.

Simplified representation for low-resistance earthed neutral point

The most important issue is how the distribution network behaves in the event of an earth fault. The neutral point treatment determines the phase voltages which occur in case of an earth fault. The decisive factor here is the earth fault factor m, which defines the ratio of the maximum phase voltages on the unaffected phases to the phase voltage during normal operation in the event of an earth fault.

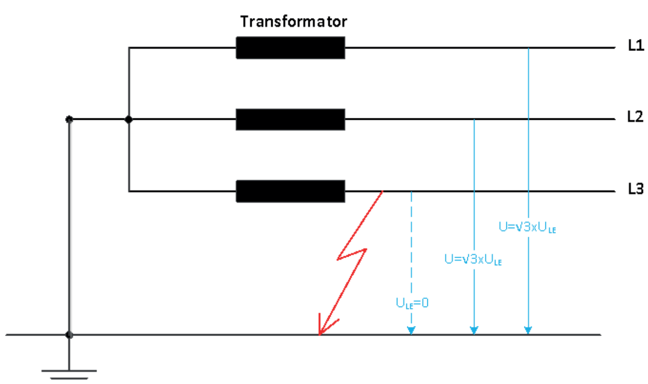


Figure 2 | Faulty low-resistance earthed neutral point

The earth fault factor is m = 1 for a network with directly earthed transformer neutral points (an exception in medium voltage networks). This means that the phase voltages of the unaffected phases essentially remain unchanged in the event of an earth fault, because a rapid disconnection usually occurs in less than one second (a so-called earth short circuit with corresponding tripping current for an overcurrent protection device).

In this case, the arrester must be required to have a maximum continuous voltage U_c that is greater than the system voltage during operation.

$$U_c > U_s / \sqrt{3}$$

A security factor of 5% is usually chosen:

$$U_c = 1.05 \cdot U_s / \sqrt{3}$$

Simplified representation for isolated neutral point or earth fault compensation
The phase-to-earth voltage on the unaffected phases continuously rises to the value of the interlinked voltage (system voltage) in the network with isolated transformer neutral points or in the suppressed or inductively compensated network. This voltage rise can occur over several hours or days (the so-called "earth fault"). The following therefore applies to the earth fault factor: m=√3.

The following then applies to U_c:

$$U_c > U_s$$

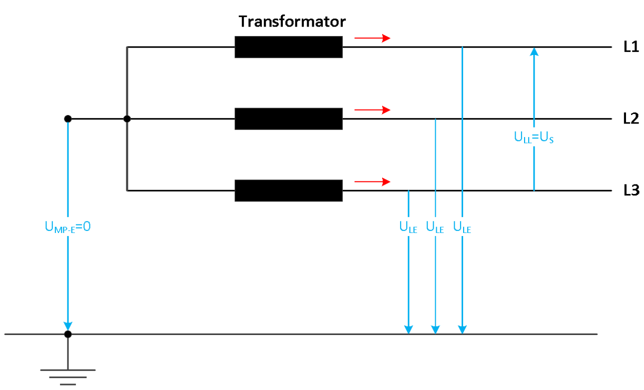


Abbildung 3 | Isolated neutral point without fault

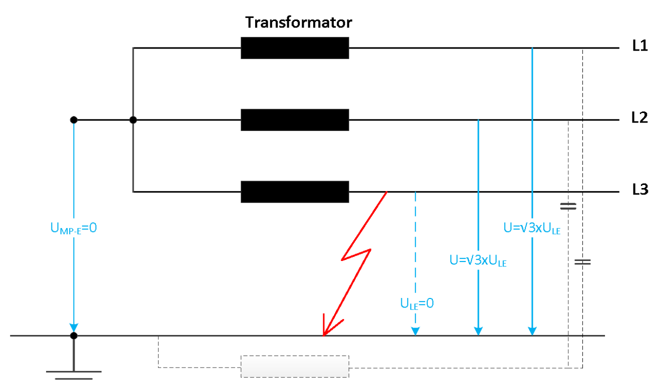


Abbildung 4 | Isolated neutral point with a fault

It must be taken into consideration that voltages higher than U_c, so-called temporary overvoltages, can overload the arrester. This would be the case, for example, if the terminal voltage would ultimately be above the selected voltage U_c after the voltage was increased by a factor of √3.

For the design of U_c, in addition to the above conditions, a small reserve must be provided which takes into consideration the highest possible operating voltage, the presence of harmonics as well as voltage transients in case of repetitive earth faults.

This is why the manufacturer specifies a voltage-time curve which indicates the maximum duration for exceeding the continuous operating voltage U_c. This curve is still permissible without overloading the arrester (figure 5).

Two different curves are specified for the overload time curve:
1. in case the arrester has been pre-loaded by a preceding transient overvoltage and a corresponding preheating process was carried out (lower blue line)
2. for the non-preloaded case (upper red straight line).

The lower straight line applies to standardised preloading, which corresponds to the nominal thermal charge transfer rating Q_{th} and is specified for each type of arrester. To verify the specified load capacity with temporary overvoltages, the arrester is subjected to two lightning current impulses within 1 minute, the net charge of which must correspond to Q_{th}. The arrester must then withstand any overvoltage with the corresponding duration according to the red curve without sustaining any damage. This is selectively checked with an alternating voltage load directly following the impulses with U_r for 10 seconds and then with U_c for 30 minutes (see also section 2.4).

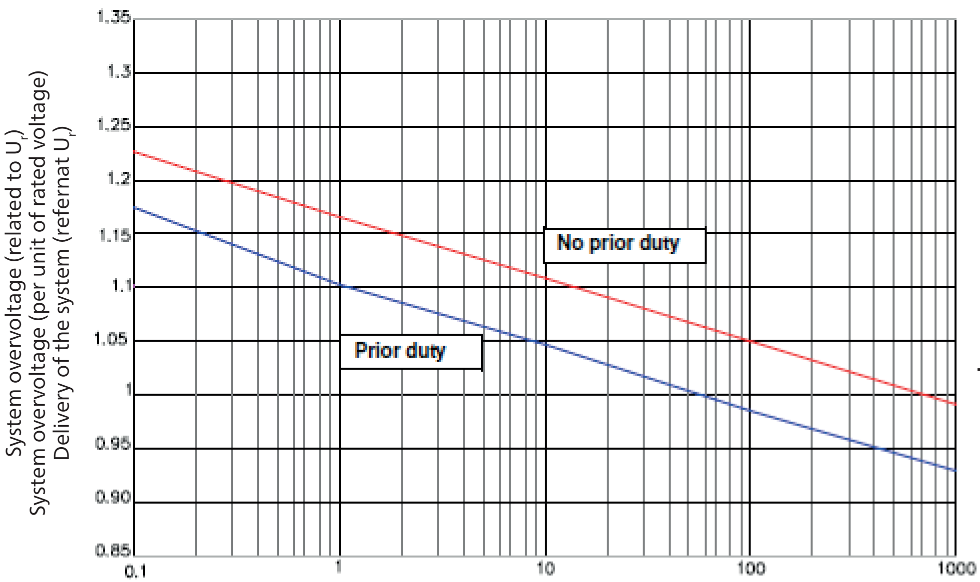


Figure 5

Voltage-time diagram for the permissible temporary overvoltages (Temporary Overvoltage TOV) according to (IEC 60099-4 [1] section 6.10) at 60°C ambient temperature. Top red: without pre-loading, bottom blue: after loading with the maximum thermal charge transfer rating Q_{th}

After determining the minimum permissible continuous voltage at the arrester U_c, the next higher stage value is usually selected from the manufacturer's table.

The considerations regarding insulation co-ordination and the selection of the characteristics of the surge arrester are summarised in figure 6 (see also figure 7).

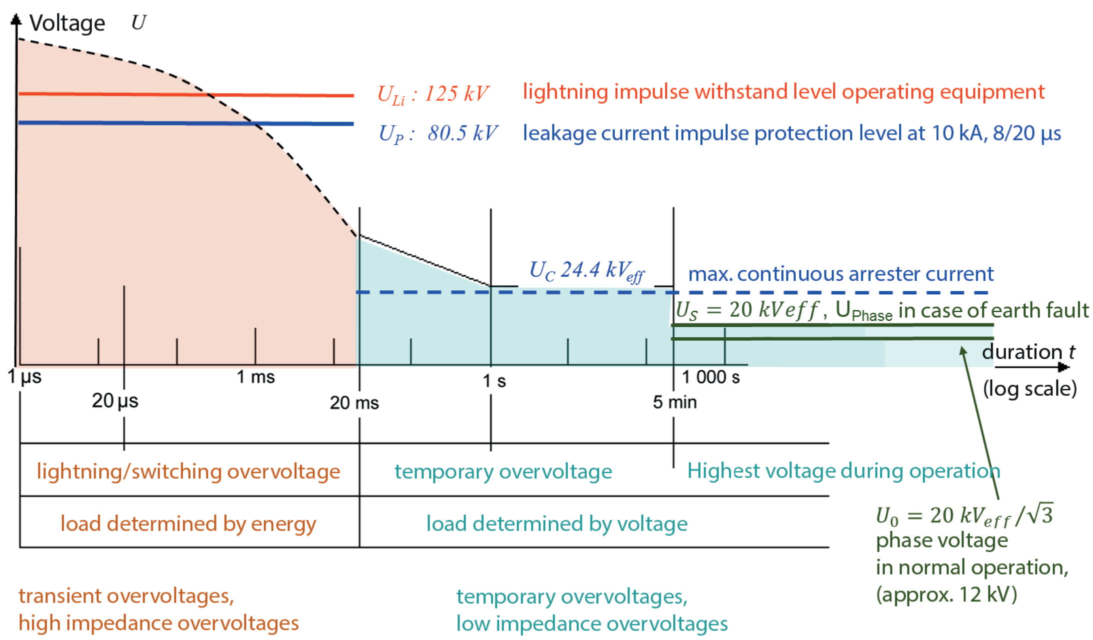


Figure 6

Voltage levels according to IEC 60071-1 [3] for planning the insulation co-ordination in a medium voltage network using an example of an arrester with U_c: 24.4 kV (Ur: 30 kV) with $U_{residual}$ 8/20µs/10kA = 80.5kV:
red: Equipment insulation level
blue: Voltage level of the surge arrester
dark green: operational voltage values

2.2 | TESTING THE PROTECTION LEVEL

For each type of arrester, the protection levels for the impulse voltage forms, which are tabulated in the brochure, are obtained by selecting U_c, table 2. If the highest network voltage during operation is 20.8 kV (fault operation), the type CTKSA 24kV would have to be selected.

Figure 7 provides an example of the voltage curve on one phase during the limitation of a lightning impulse voltage by a surge arrester to the corresponding residual voltage at a lightning impulse of 8/20µs 10kA.

Technical data	CTKSA 8kV	CTKSA 12kV	CTKSA 17kV	CTKSA 19,5kV	CTKSA 22kV	CTKSA 24kV	CTKSA 34kV
Rated voltage (U_r)	10 kV	15 kV	21 kV	24 kV	27 kV	**30 kV**	42 kV
Maximum continuous operating voltage (U_c)	8,0 kV	12,7 kV	17,0 kV	19,5 kV	22,0 kV	**24,4 kV**	34,0 kV
Residual voltage (IEC 60099-4) with:							
Steep current impulse (1/T, T< 20 µs)	28,3 kV	42,5 kV	59,5 kV	68,0 kV	76,5 kV	**85,0 kV**	119,0 kV
Lightning impulse 8/20 µs:							
5 kA	24,8 kV	37,2 kV	52,1 kV	59,6 kV	67,0 kV	**74,4 kV**	104,0 kV
10 kA	26,9 kV	40,3 kV	56,4 kV	64,4 kV	72,5 kV	**80,5 kV**	112,8 kV
20 kA	29,3 kV	44,0 kV	61,6 kV	70,4 kV	79,2 kV	**88,0 kV**	123,2 kV

Table 2 | Manufacturer specification of the arrester data

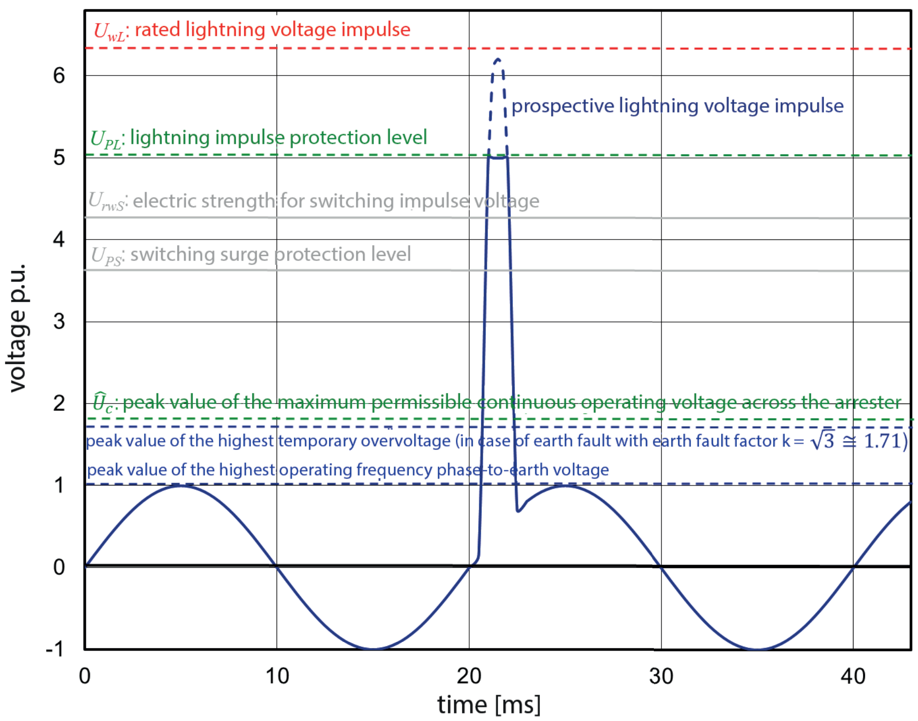


Abbildung 7

Example of a voltage curve of a network phase when a lightning overvoltage occurs, which is limited ("cut off") by a surge arrester.
Comments: Note that, unlike in figure 1, the unit of voltage (1 p.u.) is not the RMS value but the peak value.
For the withstand voltage at switching impulse voltage, the factor from [4] item 5.2 was used U_{rw} ("required withstand voltage").

2.3 | SELECTING THE NOMINAL DISCHARGE CURRENT I_n

The nominal discharge current should correspond to the current impulse at the maximum expected lightning overvoltage at the input of a switching station. The arrester is designed to meet the requirements arising from a distant lightning strike into the overhead line. As a rule, dimensioning for a rare lightning strike with a high lightning impulse > 100 kA directly at the connection point of a transformer station is not cost-effective.

In the event of a strike into an overhead line, the maximum current amplitude I_{max}, which the arrester must conduct to earth, is calculated from the flashover voltage U_{fo} of the overhead line insulators, the lightning protection level U_{pl} of the arresters and the characteristic impedance Z of the overhead line.

$$I_{max} = \frac{2 \cdot U_{f0} - U_{pl}}{Z_s} \qquad (1)$$

U_{fo} Flashover voltage of the overhead line insulation
U_{pl} Protection level during a lightning impulse
Z Wave impedance of the line

The following numerical values can be calculated for a network with U_s = 20 kV (12/20 (24) kV):

$$Z=300\ \Omega,\quad U_{f0}=320\ \text{kV},\quad U_{pl}=80.5\ \text{kV},\ \Rightarrow I_{max}=1.865\ \text{kA}$$

In this case, an arrester for 10 kA nominal discharge current with a reserve could be sufficient. However, for strikes close to the station, the leakage current increases up to the value of the lightning impulse, depending on the distance of the strike, and may exceed the determined value.

2.4 | CRITERIA FOR SELECTING THE ARRESTER CLASS (PERFORMANCE CHARACTERISTICS OF THE CLASSES)

In contrast to the voltage design of surge arresters, the design according to energy absorption capacity is less clear, and the effect on network availability is also complex. As a result, the class selection must be based either on extensive studies or on experience-based rules of the network operator.

The design of the arrester class depends on the maximum expected energy with which the surge arrester can be loaded during operation.

Even arresters of lower classes can generally withstand the load caused by atmospheric overvoltages or their lightning impulses at the end of overhead lines without any damage. The design with respect to atmospheric loads is always a matter of statistics and always refers to the design of the discharge capacity for a specific percentile of the lightning charges, which only put full load on the arrester in the event of close lightning strikes into the line. As a rule, it must be assumed that in the event of rare nearby lightning strikes with a high current amplitude, surge arresters may be overloaded, fail and trigger an earth fault (for statistics on lightning parameters, see lightning protection standard IEC 62305-1 [8]).

The arresters, however, should be able to repeatedly discharge overvoltages due to the relatively frequent switching operations in the network without any damage.

A typical overvoltage that must be dissipated is, for example, a voltage that doubles when an open circuit cable is switched on.

The thermal switching energy of the arrester depends on the following parameters:

- Overvoltage level and waveform
- Network configuration and line impedance
- Protective properties of the arrester
- Frequency of switching operations within a short period of time.

The energy absorption capacity of the selected surge arrester must ultimately be greater than the energy accumulated during the most unfavourable switching operation. Determining the required energy absorption capacity is made more difficult by the complex shapes of the switching transients and by the non-linear characteristics of the surge arrester.

Up until the edition of IEC 60099-4 (2009) [1] was published, energy absorption capacity was defined in the form of line discharge classes 1 to 5. Class 1 was intended for arresters in the distribution network and classes 2 to 5 for station arresters and applications with repetitive loads.

Since the 2014 edition, the station arresters have been designated S (station) and the arresters in the distribution network D (distribution). For both application types, a distinction is made between three application classes (H: high, M: medium, L: low).

The thermal load capacity of surge arresters is specified by the three parameters described below. Tests must be carried out to verify compliance with these parameters. The tests are designed to ensure the quality and reliability of the arresters according to their class. The definitions of these parameters according to IEC 60099-4 [1] are indicated in Table 3 for the standardised surge arrester classes (see also definitions in section 1.2).

Q_{rs}

The repeated nominal charge transfer rating is demonstrated with twenty impulses in groups of two. The arrester is allowed to cool down to ambient temperature between the groups of two. The test simulates unfavourable multiple operational loads. The value is about four times lower than the thermal charge transfer rating.

Q_{th} und W_{th}

The two parameters thermal charge transfer rating and specific thermal energy absorption capacity quantify the unique ability to absorb an energy input without sustaining any damage. This can be expressed in the form of a warming rate that is still tolerable. The aforementioned parameters are equivalent to each other and both feature the charge unit "Coulomb". The thermal energy absorption capacity Wth is specified in relation to the voltage U_r ([kJ/kV] ≙ [C]). The verification in the type test is provided after preheating to 60°C by applying Q_{th} or W_{th}. The arrester must withstand a subsequent alternating voltage load with U_r for 10 seconds and then with U_c for 30 minutes.

During all these tests, the arrester must not become thermally unstable. In addition, it must not exhibit any mechanical damage or a significant change in its electrical characteristics.

Arrester class	Station			Distribution		
Designation	**SH**	**SM**	**SL**	**DH**	**DM**	**DL**
Nominal discharge current [kA]	20	10	10	10	5	2.5
Switching current impulse [kA]	2	1	0.5	-	-	-
Q_{rs} [C]	≥ 2.4	≥ 1.6	≥ 1.0	≥ 0.4	≥ 0.2	≥ 0.1
W_{th} [kJ/kV]	≥ 10	≥ 7	≥ 4	-	-	-
Q_{th} [C]	-	-	-	≥ 1.1	≥ 0.7	≥ 0.45
Corresponding previous line discharge class according to IEC 60099-4: (2009)	4/5	3	2	1	-	-

Table 3 Classification of surge arresters according to their energy and charge absorption capacity in accordance with IEC 60099-5.
Comment: The last line with the previously used line discharge classes is derived from table L.3 in IEC 60099-5:2018 [2].

Within this context, DIN EN IEC 60099-5 (VDE 0675-5):2019-02 [2] stipulates the following :

"Arresters with the designation SL, SM or SH are generally used for surge arresters which protect equipment in high-voltage switchgear. Arresters with the designation DL, DM or DH are primarily used in medium voltage networks."

Arresters of the Distribution High classification (high energy absorption capacity) are primarily used in medium voltage distribution networks to protect transformers, medium voltage switchgear and circuit breakers. Other applications include the protection of generators, motors, smelting furnaces, dry transformers as well as airfield lighting and converters for electrical drives. Applications involving one-sided earthing also include protecting cable sheaths (induction phenomena due to overvoltages occurring in the conductor).

Computer simulations of the switching operations may provide information for precisely determining the energy or charge load of the arrester.

If no such studies are available for the switching conductors, equation (2) offers an approximate conservative estimate of the necessary energy absorption capacity W (see also the definition of the conductor discharge class equation in IEC 60099-4 [1], table 5).

The simplified energy equation (2) is based on the assumption that the entire line is charged to a prospective switching impulse voltage and discharged by the arrester to the value of the protection level within twice the wave travel time of the line.

$$W = U_{ps} \cdot Q_s = U_{PS} \cdot \frac{U_{rp} - U_{ps}}{Z} \cdot \frac{2 \cdot L}{v} \qquad (2)$$

L	Length of the line
v	Propagation speed of the travelling wave
Q_s	Charge discharged by the surge arrester
Z	Wave impedance of the line
U_{ps}	Residual voltage at the lower point of the specified switching impulse amplitude
U_{rp}	Highest switching overvoltage to be expected.

If a surge arrester is still overloaded, e.g. by a high current from a nearby lightning strike with a high amplitude, it will fail and cause an earth fault. When destroyed, it must not explode or result in consequential damage. The earth fault must be rectified by replacing the arrester.

3 | INSTALLATION LOCATION, CONSIDERATIONS CONCERNING THE PROTECTIVE AREA OF AN ARRESTER

When installing an arrester, the distance to the operating equipment requiring protection must be observed. A rough estimate of the protection area can be derived from the following considerations (see figure 8):

After a lightning strike into an overhead line with flashover to earth, a travelling wave U(t), which is limited to the earth flashover voltage, runs at a speed v towards the end of the line with the equipment to be protected. If it is a distribution station equipped with a transformer, it must be considered as high-impedance due to the winding inductance for fast processes. The same applies to an open switch. The voltage of the travelling wave is doubled to 2 U(t) at this "open end" due to reflection. Upon closer examination, the voltage rise does not occur in stages, but with the voltage slope S of the incoming wave.

In any case, twice the running time on the section L must be shorter than the time period for the voltage rise of the travelling wave. The voltage rise is interrupted when the travelling wave, which is reflected at the transformer, has returned to the surge arrester. Equation (3) provides an approximate estimation for the voltage U_e that is still applied to the equipment. On the other hand, the protective distance L for the arrester can be derived from equation (4) from the rated lightning impulse voltage of the LIWV equipment. For this purpose, the length of the arrester with its connection to the earthing system must also be taken into consideration (L=L1+L2). The distance L between the installation location of the arrester and the equipment to be protected is therefore of crucial importance.

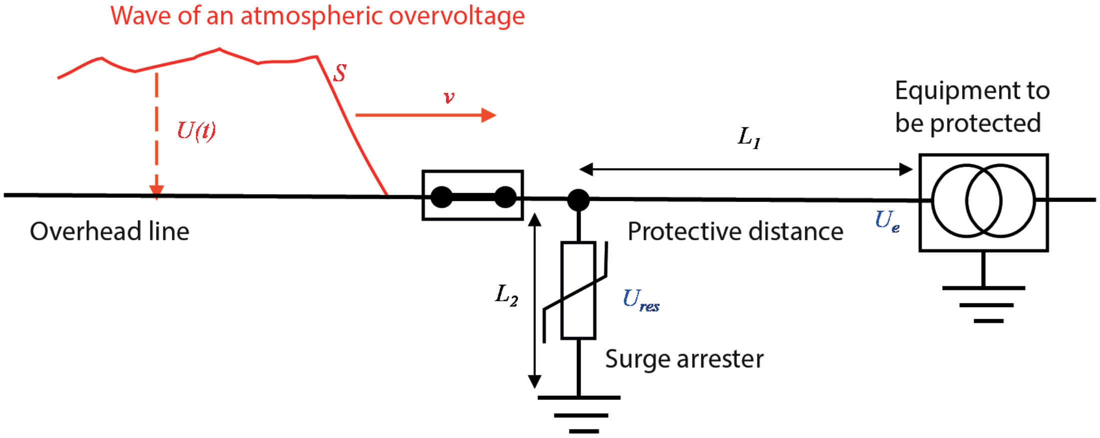


Figure 8

Schematic diagram for the approximate determination of the protective distance for an arrester at a distance

$$\frac{LIWV}{K_s} \geq U_e = U_{res} + \frac{2 \cdot S \cdot L}{v} \qquad (3)$$

$$L \geq \frac{v}{2 \cdot S} \cdot \left(\frac{LIWV}{K_s} - U_{res} \right) \qquad (4)$$

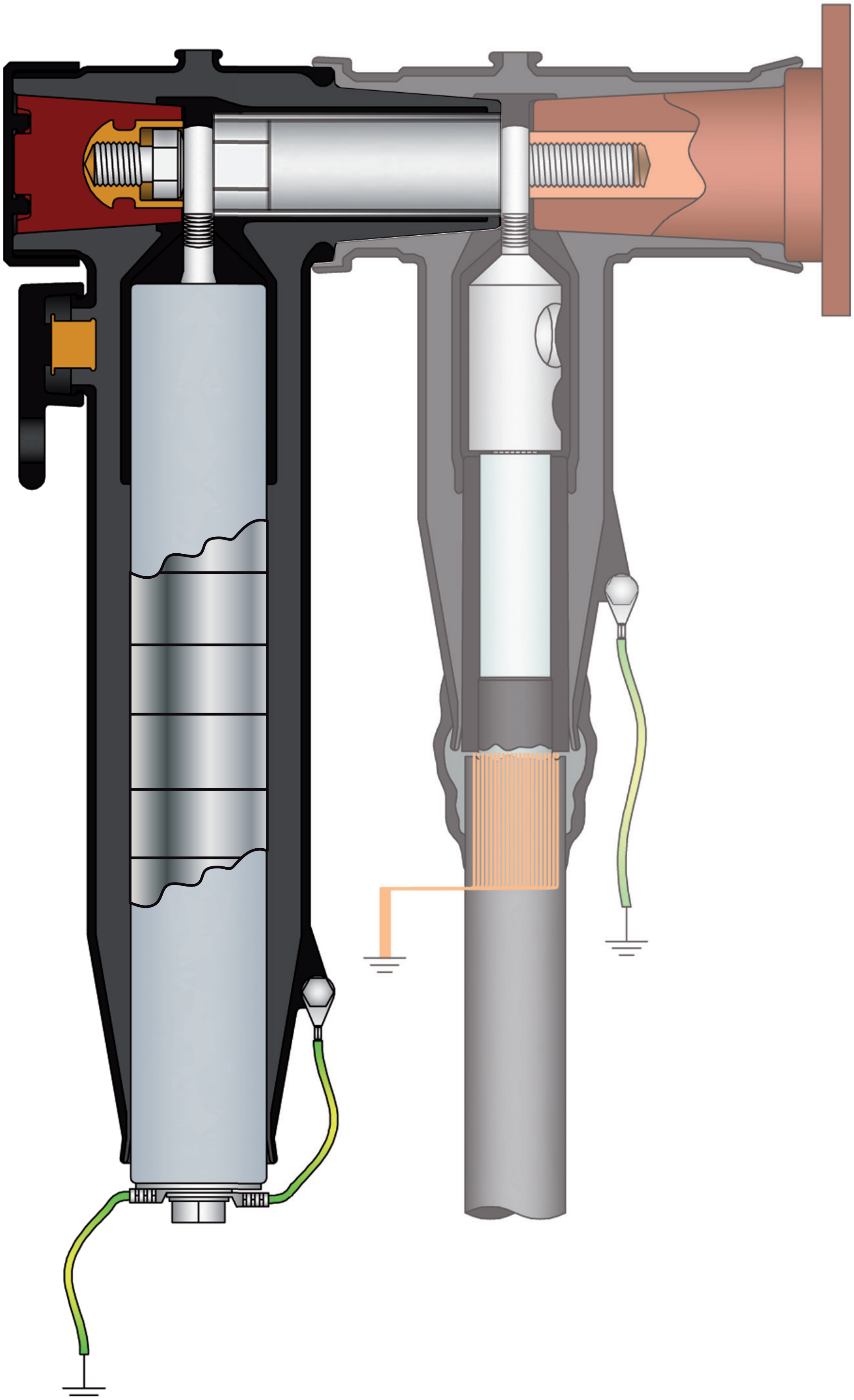
LIWV	LIWV "lightning impulse withstand value" also BIL "Basic Impulse Level"; at U_m 24 kV, LIWV is: 125 kV)
K_S	Safety factor, reduction of the lightning impulse withstand level, based on experience , KS = 1.2 should be selected [4]
U_e	Voltage occurring at the equipment insulation
U_{res}	Residual voltage = Protection level of the surge arrester
S	Front slope of the incoming lightning surge wave
v	Propagation speed of the overvoltage, approx. 300 m/ms
$L=L_1+L_2$	Protective distance of the arrester

4 | HANDLING OF THIS DOCUMENT – DISCLAIMER

This document is an information brochure which is intended to illustrate how to handle and use surge arresters. Due to the simplicity of this document, it is not possible to cover and describe all applications that may occur. The brochure intentionally and explicitly does not serve as a specific guide to help with selection, since BBC Cellpack, as a supplier, does not have the information required on the network parameters and other conditions (in addition to rated voltage and operating voltage, as well as parameters, such as switch-off times, overvoltage levels, installation locations and which equipment is to be protected, etc.). **The selection is and remains the responsibility of the respective network operator.** The operator alone is in a position to assess the potential loads that may occur and to prepare internal specifications for corresponding products. For this reason, no specific selection tables have been provided. We therefore will not accept any liability whatsoever for an unsuitable selection and the resulting consequences.

As is the case with all electrotechnical products, in addition to correct selection and calculation, only specially trained personnel with the relevant specialist expertise may be used for installation.

5 | SCHEMATIC IMAGE OF A COUPLING CONSTRUCTION CTS+CTKSA 630A TYPE C



6 | TERMS AND ABBREVIATIONS

Lightning current impulse
Current impulse 8/20 µs, for which the equipment must be designed to produce a front time between 7 µs and 9 µs and a time to half-value between 18 µs and 22 µs.

Earth fault factor
Ratio of the highest RMS value of the phase-to-earth voltage during an earth fault on an unaffected phase to the RMS value of the phase-to-earth voltage during normal operation without an earth fault.

IEC
International Electrotechnical Commission, based in Geneva.

LIWV
Lightning impulse withstand value, also BIL "Basic Impulse Level"; at U_m 24 kV, LIWV is: 125 kV).

Residual voltage
U_{res} Peak value of the voltage at the terminals of an arrester when a current impulse flows

Switching current impulse
Peak value of the current impulse with a front time between 30 µs and 100 µs and a time to half-value of approximately twice the front time

Protective area, protective distance
Area or distance from the surge arrester within which a high-voltage equipment must be located so that it is protected from atmospheric overvoltages through the surge arrester's voltage-limiting effect. The protection is valid up to a maximum lightning impulse amplitude and lightning impulse rise slope.

TOV
Temporary overvoltage

7 | REFERENCE DOCUMENTS

7.1 | STANDARDS

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