

Surge arresters —

Part 5: Selection and application recommendations

The European Standard EN 60099-5:1996, with the incorporation of amendment A1:1999, has the status of a British Standard

ICS 29.120.50; 29.240.10

National foreword

This British Standard is the English language version of EN 60099-5:1996 including amendment 1:1999. It was derived by CENELEC from IEC 60099-5:1996.

The CENELEC common modifications have been implemented at the appropriate places in the text. The start and finish of each common modification is indicated in the text by tags **[C]** **<C>**.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **[A1]** **<A1>**. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by **[A1]** **<A1>**.

The UK participation in its preparation was entrusted by Technical Committee PEL/37, Surge arresters, to Subcommittee PEL/37/1, HV Surge arresters, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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Summary of pages

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Descriptors: Surge arresters, non-linear resistor type gapped surge arresters, gapless metal-oxide surge arresters, installation, application

English version

Surge arresters — Part 5: Selection and application recommendations

(including amendment A1:1999)
(IEC 60099-5:1996 +A1:1999, modified)

Parafoudres —
Partie 5: Recommandations pour
le choix et l'utilisation
(inclut l'amendement A1:1999)
(CEI 60099-5:1996 +A1:1999, modifiée)

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Teil 5: Anleitung für die Auswahl
und die Anwendung
(enthält Änderung A1:1999)
(IEC 60099-5:1996 +A1:1999, modifiziert)

This European Standard was approved by CENELEC on 1996-07-02. Amendment A1 was approved by CENELEC on 1999-12-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC

European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of the International Standard IEC 99-5:1996, prepared by IEC TC 37, Surge arresters, together with common modifications prepared by CENELEC Reporting Secretariat SR 37, was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 60099-5 on 1996-07-02.

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Annexes designated “normative” are part of the body of the standard.

Annexes designated “informative” are given for information only.

In this standard, Annex ZA is normative and Annex A, Annex B and Annex C are informative.

Annex ZA has been added by CENELEC.

Foreword to amendment A1

The text of document 37/224/FDIS, future amendment 1 to IEC 60099-5, prepared by IEC TC 37, Surge arresters, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 60099-5:1996 on 1999-12-01.

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Introduction

This part of IEC 99 is intended to allow optimal selection and application of surge arresters specified according to IEC 99-1 and IEC 99-4.

More complex calculation methods than those indicated here may be used in order to obtain more precise determination of the requirement for the system concerned; however, these calculations should be performed in accordance with the principles given in this standard.

The characteristics of surge arresters derived from the application of this standard are different for different systems. No particular numerical value may be favoured. It is likely, however, that for some systems, or in some countries, the system reliability requirements and design are sufficiently uniform that the recommendations of the present standard may lead to the definition of narrow ranges of arresters. The user of surge arresters will, in that case, not be required to apply the whole process introduced here, to any new installation and he may reproduce the selection of characteristics resulting from prior practice. Corresponding numerals may be introduced by national authorities in Annex B.

Section 1. General

1.1 Scope

This part of IEC 99 provides recommendations for the selection and application of surge arresters to be used in three-phase systems with nominal voltages above 1 kV. It applies to non-linear resistor type gapped surge arresters as defined in IEC 99-1 and to gapless metal-oxide surge arresters as defined in IEC 99-4.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 99. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 99 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 71-1:1993, *Insulation co-ordination — Part 1: Definitions, principles and rules.*

IEC 71-2:1976, *Insulation co-ordination — Part 2: Application guide.*

NOTE The third edition of this standard is presently under revision.

IEC 99-1:1991, *Surge arresters — Part 1: Non-linear resistor type gapped surge arresters for a.c. systems.*

IEC 99-3:1990, *Surge arresters — Part 3: Artificial pollution testing of surge arresters.*

NOTE This Technical Report applies to gapped surge arresters according to IEC 99-1.

IEC 99-4:1991, *Surge arresters — Part 4: Metal-oxide surge arresters without gaps for a.c. systems.*

IEC 507:1991, *Artificial pollution tests on high-voltage insulators to be used on a.c. systems.*

IEC 815:1986, *Guide for the selection of insulators in respect of polluted conditions.*

1.3 General principles for the application of surge arresters

IEC 71-1 specifies withstand voltages for two ranges of highest voltages for equipment:

- range I: above 1 kV to 245 kV included;
- range II: above 245 kV.

For range I systems containing overhead lines, the main risk to equipment arises from induced and direct lightning strokes to the connected overhead lines. In cable systems not connected to overhead lines, overvoltages due to faults or switching operations are most likely to occur. In rare cases, however, lightning induced overvoltages may also be generated. In systems of range II, in addition to range I factors, switching overvoltages become important, increasing with higher system voltages. Overvoltages may cause flashovers and serious damage to the equipment and thereby jeopardize the supply of power to users. It is essential to prevent this by the proper co-ordination of surge arresters with the insulation. It is, therefore, recommended to use surge arresters if there are possibilities of lightning overvoltages or high switching overvoltages which may be dangerous to the equipment.

These surge arresters should constitute a reliable part of the system. They are designed to withstand the voltages and the resulting currents through them with a sufficiently high reliability taking into account pollution and other site matters. In each system such voltage stresses are (see IEC 71-1):

- operating voltage;
- temporary overvoltages;
- slow-front overvoltages;
- fast-front overvoltages;

where the slow-front overvoltages due to switching are of particular importance for arresters protecting range II equipment.

As a general principle, the best protection of equipment and high surge arrester rated voltages are contradicting requirements. Thus the selection of an adequate arrester constitutes an optimization process, which has to consider a great number of system and equipment parameters.

Gapless metal-oxide surge arresters are of particular advantage for earthed neutral systems, because they offer better protection against slow-front overvoltages. This arrester type is today widely installed in these systems and the application of arresters for such systems tends to concentrate on metal-oxide surge arresters. In some isolated or resonant earthed neutral systems, where earth fault temporary overvoltages may have long durations, gapped surge arresters may offer advantages, if protective levels are required to be low. While being the surge arrester traditionally used in all voltage ranges, the consideration of gapped arresters may be adequate for systems of range I, especially in the lower voltage range.

1.4 General procedure for the selection of surge arresters

The following iterative procedure, shown in the flow diagram of Figure 1, is recommended for the selection of surge arresters:

- determine the continuous operating voltage of the arrester with respect to the highest system operating voltage;
 - determine the rated voltage of the arrester with respect to the temporary overvoltages;
 - estimate the magnitude and probability of the expected lightning discharge currents through the arrester, determine the transmission line discharge requirements and select the nominal discharge current, the high current impulse value and the line discharge class of the arrester;
- NOTE If high current impulse values different from the standardized values are necessary (see IEC 99-4, Table 6, note), these values should be selected according to the lightning discharge current.
- select the pressure relief class of the arrester with respect to the expected fault current;
 - select a surge arrester that fulfills the above requirement;
 - determine the lightning and switching impulse protection characteristics of the arrester;
 - locate the arrester as close as possible to the apparatus to be protected;
 - determine the co-ordination switching impulse withstand voltage of the protected equipment taking into account the representative slow-front overvoltages and system layout;
 - determine the co-ordination lightning impulse withstand voltage considering:
 - the representative impinging lightning overvoltage surge as determined by the lightning performance of the overhead line connected to the arrester and the acceptable failure rate of the protected equipment;
 - the substation layout;
 - the distance between surge arrester and protected equipment;
 - determine the rated insulation level of the equipment from IEC 71-1;
 - if a lower rated insulation level of the equipment is desired, then a lower continuous operating voltage, a lower rated voltage, a higher nominal discharge current, a higher line discharge class, a different arrester design or a reduced distance between arrester and protected object should be investigated.

NOTE A lower continuous operating voltage or a lower rated voltage may reduce the service reliability of the arresters.

Details of this iterative procedure are given in sections 2, 3 and 4 of this document.

1.5 Polluted housing arrester withstand

Pollution on the arrester housing may cause sparkover or temperature increase of grading components in gapped arresters and high temperature increase of the varistors in metal-oxide arresters. To prevent arrester failures in polluted areas, arresters able to withstand the relevant polluted conditions have to be chosen. Although not explicitly specified in IEC 99-1 and IEC 99-4, arresters used in normal operating conditions should withstand the medium pollution stresses according to pollution level II of IEC 71-2. If the arrester installation area is subjected to a higher pollution, the surge arrester performance may be adversely affected. If arresters of inadequate design are used in heavy (pollution level III) or very heavy (pollution level IV) polluted areas, periodic cleaning or greasing may be effective in preventing the events stated above.

When live washing of arresters is intended, arresters designed for such service conditions are required.

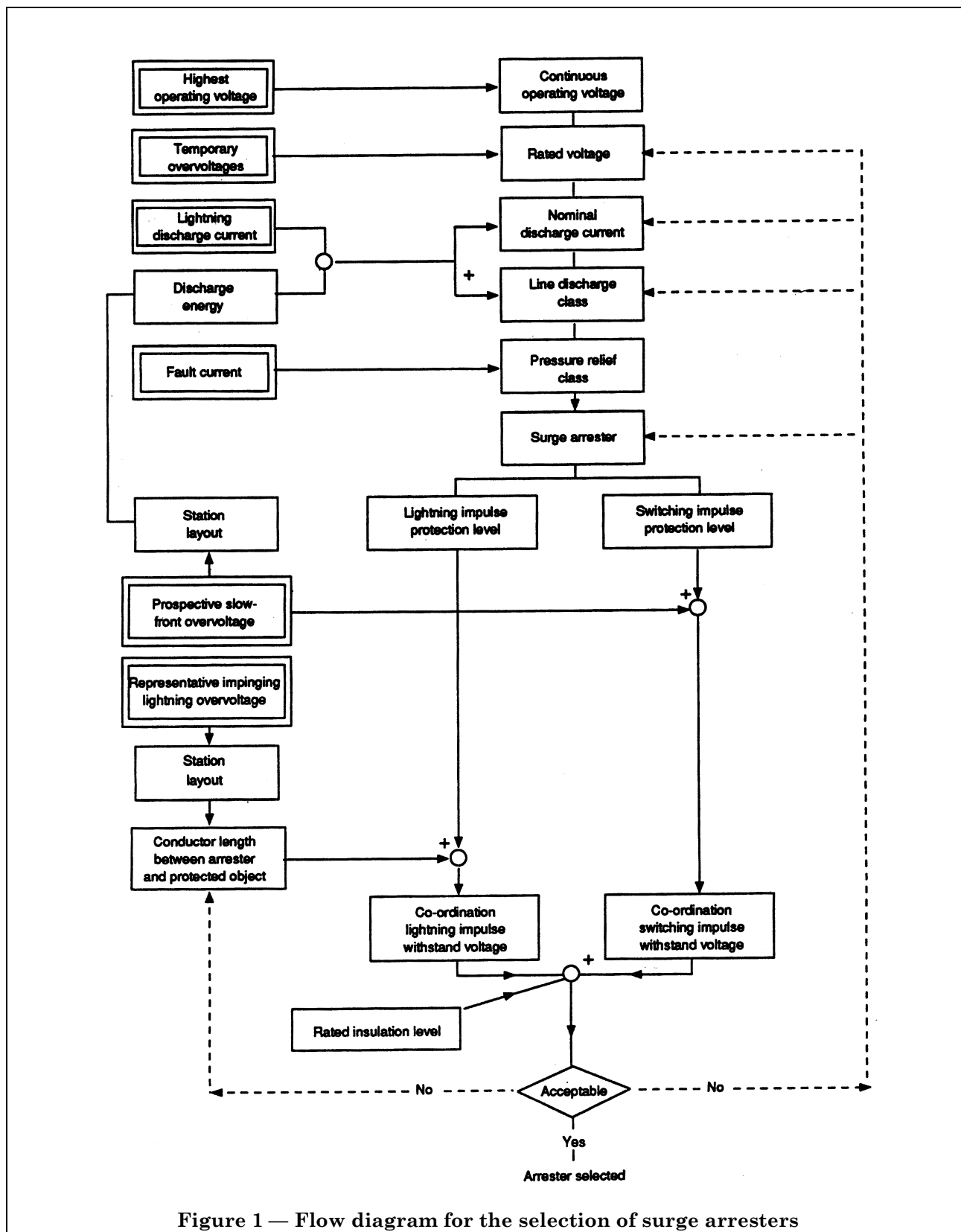


Figure 1 — Flow diagram for the selection of surge arresters

Section 2. Non-linear resistor type gapped surge arresters according to IEC 99-1

2.1 Characteristic data of gapped surge arresters

2.1.1 General

Basic characteristics of surge arresters with series spark gaps are their rated voltage, their sparkover voltages, their nominal discharge currents and their residual voltages at these currents.

The protective performance is characterized by the sparkover voltages for front-of-wave, lightning impulse and, when applicable, switching impulses; and is also characterized by the residual voltages at nominal discharge current and, when applicable, at switching impulse currents. For a given rated voltage, different types of arresters and, therefore, different protection levels exist.

Additional characteristics of an arrester to be considered are continuous operating voltage, long duration discharge class, pressure relief class, pollution withstand capability, live washing capability and special mechanical properties.

2.1.2 Rated voltage

The maximum permissible r.m.s. value of the power frequency voltage between the arrester terminals, at which it is designed to operate correctly as established in the operating duty test. The rated voltage is used as a reference parameter for the specification of operating characteristics.

NOTE Some types of arresters to be used in range II are designed to reseal at power frequency voltages higher than the rated voltage. This voltage is generally called the “temporary overvoltage reseal voltage”. Since IEC 99-1 does not specify tests to assure the correct operation of such arresters, test details and application should be agreed between user and manufacturer.

In some cases, e.g. for the pollution test according to IEC 99-3, the maximum r.m.s. value of power frequency voltage which can be applied continuously between the arrester terminals should be known. For arresters to be used in range I according to IEC 71-1, this voltage may be equal to the rated voltage of the arrester. For arresters to be used in range II it is usually lower. As IEC 99-1 does not specify tests to assure this voltage, the applicable value should be obtained from the manufacturer.

2.1.3 Protective levels

The lightning impulse protective level of the surge arrester is the maximum of the following values:

- the standard lightning impulse sparkover voltage;
- the residual voltage at nominal discharge current.

NOTE When considering the protection of equipment from fast front overvoltages it is assumed that the withstand strength of the oil-immersed insulation in the transformers is at least 15 % above its full lightning impulse withstand strength for voltage durations shorter than 3 μ s. Therefore, the maximum voltages specified in IEC 99-1, Table 8, for the front-of-wave sparkover are 15 % higher than those for the standard lightning impulse.

Other types of insulation as in instrument transformers, cables or gas insulated substations (GIS) may have different withstand characteristics and the front-of-wave sparkover voltage may need special consideration.

The switching impulse protective level is applicable to the protection of equipment from slow-front overvoltages. It is the maximum of the switching impulse sparkover voltage and the switching impulse residual voltage.

NOTE When the switching impulse sparkover characteristic of an arrester type is not known, only approximate information about this is obtained from the power frequency sparkover voltage.

2.1.4 Nominal discharge current

The peak value of a discharge current having a 8/20 shape, which is used to classify an arrester. It is also the discharge current which is used to initiate the follow current in the operating duty test and to establish the protective level of the arrester for lightning overvoltages.

2.1.5 Long duration discharge class

A number related to the energy absorption capability of an arrester to discharge long lines. Increasing class numbers (see IEC 99-1, Table 5) indicate increasing system voltages and line length and decreasing surge impedance and overvoltage factors.

2.1.6 Pressure relief class

A number related to the capability of an arrester to withstand internal fault currents after a failure without violent shattering of the housing. Reference is made to clause 8.7 of IEC 99-1.

2.1.7 Pollution withstand characteristics

For arresters to be used in polluted areas according to IEC 71-2, pollution levels III and IV, a pollution test according to IEC 99-3 is necessary. From this test, information about the sparkover performance is obtained. The flashover performance of the housing can be checked in accordance with IEC 507.

2.1.8 Live washing characteristics

Application of live washing may require a special arrester design and suitable tests have to be defined.

In the design, of the washing equipment, care should be taken on the following points:

- water with an adequate resistivity must be used;
- the pressure and the nozzle configuration should be arranged so that the arrester in its whole length and circumference is wetted as uniformly and simultaneously as possible. For this it is necessary to consider the maximum permissible wind speed.

2.2 Selection of gapped surge arresters phase-to-earth

2.2.1 Rated voltage

It has been common practice to select an arrester to withstand the stresses due to the temporary overvoltages resulting from an earth fault on one phase causing a voltage rise on unfaulted phases at a time when an arrester operation occurs on one of these phases. Other causes of temporary overvoltages have to be considered and the voltage rating of the arrester should be chosen on the basis of the highest of these overvoltage conditions. In some cases it may be necessary to consider temporary overvoltages arising from the simultaneous occurrence of different phenomena such as sudden loss of load together with an earth fault, taking into account their probability of occurrence.

The following causes for temporary overvoltages should always be considered:

- Earth faults:

These overvoltages occur in a large part of the system. Guidance for the determination of temporary overvoltage amplitudes is given in Annex A. The duration of the overvoltage corresponds to the duration of the fault (until fault clearing). In earthed neutral systems it is generally less than 1 s. In resonant earthed neutral systems with fault clearing it is generally less than 10 s. In systems without earth fault clearing the duration may be several hours.

- Load rejections:

After disconnection of loads, the voltage rises at the source side of the operating circuit breaker. The amplitude of the overvoltage depends on the disconnected load characteristics and on the short-circuit power of the feeding substation. The temporary overvoltages have particularly high amplitudes after full load rejection at generator transformers depending on magnetizing and overspeed conditions. The amplitude of load rejection overvoltages is usually not constant during its duration. Accurate calculations have to consider many parameters.

As a guidance, the following typical values may be used:

- In moderately extended systems, a full load rejection can give rise to phase-to-earth overvoltages with amplitude usually below 1,2 p.u. The overvoltage duration depends on the operation of voltage-control equipment and may be up to several minutes.
- In extended systems, after a full load rejection, the phase-to-earth overvoltages may reach 1,5 p.u. or even more when Ferranti or resonance effects occur. Their duration may be in the order of some seconds.
- For load rejection of generator transformers the temporary overvoltages may reach amplitudes up to 1,4 p.u. for turbo generators and up to 1,5 p.u. for hydro generators. The duration is approximately 3 s.

When the time dependence of the amplitudes is known, a suitable representation of the overvoltage is the maximum amplitude, with a duration equal to the time while the amplitudes exceed 90 % of this value.

In some systems the following causes of temporary overvoltages need consideration:

- resonance effects, e.g. when charging long unloaded lines or resonances between systems;
- voltage rise along long lines (Ferranti effect);
- harmonic overvoltages, e.g. when switching transformers;
- backfeed through interconnected transformer windings, e.g. dual transformer station with common secondary bus during fault clearing or single-phase switched three-phase transformer with an unbalanced secondary load.

Temporary overvoltages due to ferro-resonances should not form the basis for the surge arrester selection, but should be eliminated.

Combination of causes such as earth faults and load rejection may result in higher temporary overvoltage values than those from the single events. When such combinations are considered sufficiently probable, the overvoltages for each cause have to be compounded, taking into account the actual system configuration.

NOTE 1 The selection of the arrester rated voltage corresponding to the highest system temporary overvoltages is based on the assumption that the highest system voltage is not exceeded under normal operating conditions. If abnormal system voltages are likely to occur, thereby increasing the probability of arrester operations during such conditions, it may be necessary to use an arrester with a higher rated voltage than that recommended above.

NOTE 2 Operating voltages with frequencies other than 50 Hz or 60 Hz may require special consideration in the manufacture or application of surge arresters and should be a subject of discussion between manufacturer and user.

Arresters for isolated or resonant earthed neutral systems without automatic earth fault clearing should be able to withstand the rated voltage continuously due to the possible long duration of the temporary overvoltage. Arresters for systems with automatic earth fault clearing need only withstand the maximum phase-to-earth system voltage. This reduced value can be obtained from the manufacturer.

2.2.2 Nominal discharge current

2.2.2.1 Factors influencing the lightning discharge currents

As a general rule, arrester currents due to lightning strokes are less than the stroke current. In the case of direct strokes to lines, travelling waves propagate in opposite directions from the point of impact. Flashover of line insulation provides a parallel path to ground, which diverts a portion of the stroke current. In the case of strokes to more than one conductor, or flashovers between conductors, two or more surge arresters may operate and share the current. Only in the case of a direct stroke very near to the terminal of the arrester, where no flashover occurs before arrester operation, is the arrester called upon to discharge most of the lightning stroke current. The probability of such an occurrence can be significantly reduced by proper shielding. Information concerning lightning surge parameters can be obtained from general statistical data or from local statistical data. The relationship between lightning surges and surge arresters discharge currents may be obtained from travelling wave calculations.

Overhead lines may be protected against direct lightning strokes to the conductors by the use of shield (overhead ground) wires, which are positioned to intercept lightning strokes and to direct the stroke current to ground via metallic tower or pole structures. Where wood-pole structures are used, low-impedance conductors are used to connect the shield wires to ground.

Almost all direct strokes to line conductors are eliminated by the use of shield wires. When such a direct stroke (shielding failure) does occur, line flashover is almost certain in range I. The number of shielding failures and their severity can be controlled by number and location of the shield wires. When a lightning stroke terminates on a shield wire, the stroke current is diverted to ground through the structure-connecting conductors. The impedance of the current path, including the ground surge impedance, results in a voltage at the top of the line structure. A portion of this voltage is coupled to the phase conductors. The difference between the phase conductor potential and structure top potential is impressed directly across line insulation and may result in flashover. This type of flashover is called a back-flashover. The rate of occurrence of back-flashovers is controlled by selection of a proper insulation level, by keeping the structure ground resistance to an acceptably low value by providing adequate clearance from conductor to structure, conductor to shield wire and conductor to conductor and by optimizing tower geometry.

Procedures analogous to those used for shielding lines may also be used for shielding stations. Shielding methods include overhead ground wires, metallic masts, and lightning rods supported from the station structure. These methods may be used in many combinations.

In installations not shielded against direct lightning strokes, for example at distribution transformers or cable junctions on wood-pole lines, both the insulation and the arrester can be subjected to direct strokes producing extremely high discharge currents. In general the lightning current and a representative discharge current shall be based on their probability of occurrence.

The purpose of shielding in station applications is to reduce the risk of insulation failure to an acceptable level. In certain applications this may be achieved by shielding the station alone. In other cases it may be necessary to shield all incoming lines to the station. Shielding of the lines for a relatively short distance from the station affords the same benefits for station protection as complete line shielding.

With well-designed shielding, insulation, and grounding systems, the probability of direct strokes to phase conductors is reduced to a low level and the voltages across insulation in the event of strokes to the shielding system are reduced below flashover levels. As a result, arrester discharge currents are reduced, thereby permitting the arrester to provide better protection to equipment insulation and reducing arrester duty.

2.2.2.2 Selection of the nominal discharge current

As a general rule, the nominal discharge current of an arrester is selected after considering:

- the importance and degree of protection desired. Basing protection levels on higher current magnitudes and rates-of-rise increases the reliability of protection;
- the number of lines connected during arrester operation. Owing to reflections of travelling waves, the discharge current of the arrester is affected by the parallel-connected surge impedance of lines and cables;
- the line insulation. The prospective lightning discharge currents increase with higher line insulations (e.g. fully insulated wood-poles), unless the stroke occurs so close to the arrester that the impedance and insulation of the line cannot influence the surge. When arresters are used in a station to which wood-pole lines with unearthed crossarms or insulator pins are connected, then at least one pole, preferably the last one in this line, should have earthed crossarms or pins, with low earthing impedance. In case of high earthing impedances several poles within a distance of about five spans from the station should be earthed;
- the probability of occurrence of the higher stroke currents. The magnitude of lightning currents varies over a wide range of values. Lines in areas of high lightning ground flash density have an increased chance of being struck by lightning with high current magnitudes;
- line performance and lightning environment. Lightning discharge currents and rates-of-rise are functions of the back-flashover and shielding failure rates of the lines (or flashover rates of unshielded lines) which are within some limiting distance from the station. Higher (lower) failure rates increase (decrease) the probable lightning discharge current magnitude and rate-of-rise.

For the standard nominal discharge currents according to IEC 99-1, experience indicates that a satisfactory degree of protection is achieved if the following recommendations are observed.

Range I (above 1 kV to 245 kV): 5 kA or 10 kA

In systems in range I of IEC 71-1 where the line distances between arresters are small (below 5 km), surge arresters at distribution transformers with a nominal discharge current of 5 kA have proven sufficiently reliable, even when the transformers are connected to wood-pole lines with unearthed cross-arms.

In systems with highest voltages of 72,5 kV and below, surge arresters with a nominal discharge current of 5 kA may be sufficient for areas with low ground flash density and effectively shielded incoming overhead-lines with low tower footing impedances. Arresters with a nominal discharge current of 10 kA may be preferable for important installations (need for the best protection) particularly in areas with high lightning flash density or high earth resistances.

In systems with highest voltages above 72,5 kV, surge arresters with a nominal discharge current of 10 kA are generally recommended.

Range II: (above 245 kV): 10 kA or 20 kA

For systems with highest voltages of 420 kV and below, surge arresters with a nominal discharge current of 10 kA are generally sufficient.

For systems with highest voltages above 420 kV, 20 kA arresters may be required.

2.2.3 Long duration discharge capability

In installations where long lines or cables or high capacitances are connected, the arrester must be capable of withstanding the discharge current and energy due to switching overvoltages. For heavy duty 10 kA arresters, therefore, test data have been specified for various ranges of system voltages (see 8.5.3 of IEC 99-1), which represent typical energy dissipation through arresters in the system concerned. Heavy duty arresters are generally used for equipment of range II. For equipment of range I, heavy duty arresters are used in case of important stations, in case of required low protective levels or in case of long overhead lines, cables or capacitor banks connected to the busbar. For other cases, e.g. where incoming lines are relatively short (less than 100 km), 10 kA light duty arresters or 5 kA arresters are generally used.

2.2.3.1 Heavy duty arresters

The test requirements shown in Table 5 of IEC 99-1 are based on the duty involved in discharging transmission lines and on an arrester rating equal to 1,4 times the highest system voltage phase-to-earth.

Normally, the long duration discharge class is based on the corresponding system voltage, see Table 1. However, where line characteristics vary appreciably from those in Table 1, the energy dissipated in the arrester during service conditions has to be compared with that in the test according to Table 1. In such cases, a study of the particular circumstances is recommended.

Table 1 — Relationship between long duration discharge class and transmission line characteristics (see Table C.1 of IEC 99-1)

Long duration discharge class	Approximate range of highest system voltages kV	Approximate line length km	Approximate line surge impedance Ω	Approximate overvoltage factor (p.u.) ^a
1	Up to 245	300	450	3,0
2	Up to 300	300	400	2,6
3	Up to 420	360	350	2,6
4	Up to 525	420	325	2,4
5	Up to 765	480	300	2,2

^a The base for the per unit values is the peak value of the highest system voltage phase-to-earth.

2.2.3.2 Light duty 10 kA and 5 kA arresters

For light duty 10 kA and for 5 kA arresters, no differentiation of system voltages is made but only one test current with rectangular wave shape is specified.

2.2.4 Pressure relief class

In case of internal failure of a surge arrester, the fault current through the arrester should not cause violent shattering of the arrester housing. Therefore the fault current withstand of the arrester should be equal to or greater than the maximum fault current through the arrester at the installation point of the arrester.

If higher values than those listed in Table 7 of IEC 99-1 are required, the user should consult the manufacturer.

Section 3. Gapless metal-oxide surge arresters according to IEC 99-4

3.1 Characteristic data of gapless metal-oxide surge arresters

3.1.1 General

Basic characteristics of metal-oxide surge arresters are the continuous operating voltage, the rated voltage, the nominal discharge current and the residual voltages at nominal discharge current, at switching impulse current and at steep front current.

For given continuous operating and rated voltages, different types of arresters, and therefore different protection levels, exist.

Further characteristics which have to be considered in a particular application are line discharge class, pressure relief class, pollution withstand capability, live washing capability and special mechanical properties.

3.1.2 Continuous operating voltage

The continuous operating voltage is the maximum permissible value of a sinusoidal power frequency voltage, which may be continuously applied between the arrester terminals.

The continuous operating voltage of the complete arrester may be lower per section than that used in the operating duty test, for the ageing procedure, and for verifying thermal stability. The lower continuous operating voltage may be due to the pollution strength of the arrester housing or to large non-linearities in the voltage distribution along the varistor stack due to less effective grading caused by proximity effects of other objects.

3.1.3 Rated voltage

The rated voltage is the maximum power frequency voltage that is applied in the operating duty test for 10 s (see clause 2.8 of IEC 99-4). It is, furthermore, the reference parameter to establish the power frequency voltage versus time characteristic of the arrester, and for defining the test requirements for the line discharge test.

3.1.4 Nominal discharge current

The nominal discharge current is used for the surge arrester classification. It is the main parameter for the protective characteristics and the energy absorption capability of the arrester.

3.1.5 Protective levels

The lightning impulse protective level of an arrester is the maximum residual voltage at nominal discharge current. It is applicable to the protection of equipment from fast-front overvoltages.

The switching impulse protective level is the maximum residual voltage at the specified switching impulse currents. It is applicable to the protection of equipment from slow-front overvoltages.

For the protection performance of metal-oxide surge arresters for fast-front overvoltages the time delay in the conduction mechanism of the varistors as tested in the steep current impulse test has to be considered [2]¹⁾.

NOTE In the first edition of IEC 99-4:1991, the necessary test procedure for a reliable determination of the residual voltage at steep current impulse has been incompletely specified. More precise specification of test conditions is under consideration which will take care of inductance effects and the intrinsic material time delay.

3.1.6 Line discharge class

A number related to the energy absorption capability of 10 kA and 20 kA arresters for the discharge of long lines. Five classes exist according to IEC 99-4, Table 4, with an increasing number indicating increased energy absorption capability.

For arresters with line discharge class 2 and above, the resulting discharge current is used in the operating duty test to verify thermal stability after energy absorption. System events causing arrester currents with different shapes may be evaluated by comparison with energy and current of an equivalent line discharge.

3.1.7 Pressure relief class

A number related to the capability of an arrester to withstand internal fault currents without violent shattering of the housing. (Reference is made to clause 5.11 of IEC 99-4 and clause 8.7 of IEC 99-1.)

¹⁾ Numbers in brackets refer to Annex C: Bibliography.