INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

K.46

(07/2003)

SERIES K: PROTECTION AGAINST INTERFERENCE

Protection of telecommunication lines using metallic symmetric conductors against lightning-induced surges

ITU-T Recommendation K.46

ITU-T Recommendation K.46

Protection of telecommunication lines using metallic symmetric conductors against lightning-induced surges

Summary

This Recommendation gives a procedure in order to protect the telecommunication lines using metallic symmetric conductors against the overvoltages and overcurrents imposed on the lines due to nearby lightning discharges. The protection procedure is related to the exposure of the line to the effects of nearby lightning discharges, and includes the bonding of the cable shield and the installation of surge protective devices (SPD).

Source

ITU-T Recommendation K.46 was approved by ITU-T Study Group 5 (2001-2004) under the ITU-T Recommendation A.8 procedure on 29 July 2003.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

CONTENTS

ITU-T Recommendation K.46

Protection of telecommunication lines using metallic symmetric conductors against lightning-induced surges

1 Scope

This Recommendation gives a procedure in order to protect the telecommunication lines using metallic symmetric conductors against the overvoltages and overcurrents imposed on the lines due to nearby lightning discharges. For lines exposed to direct lightning discharges, either to the line itself or to the structures where the line enters, in addition to the procedures of this Recommendation, the user shall refer to ITU-T Rec. K.47 [1] in order to select the complementary protection procedures.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[1] ITU-T Recommendation K.47 (2000), *Protection of telecommunication lines using metallic conductors against direct lightning discharges*.

[2] IEC 61663-2:2001, *Lightning Protection – Telecommunication lines – Part 2: Lines using metallic conductors*.

[3] ITU-T Recommendation K.20 (2003), *Resistibility of telecommunication equipment installed in a telecommunications centre to overvoltages and overcurrents*.

[4] ITU-T Recommendation K.21 (2003), *Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents*.

[5] ITU-T Recommendation K.22 (1995), *Overvoltage resistibility of equipment connected to an ISDN T/S bus*.

[6] ITU-T Recommendation K.12 (2000), *Characteristics of gas discharge tubes for the protection of telecommunications installations*.

[7] ITU-T Recommendation K.28 (1993), *Characteristics of semi-conductor arrester assemblies for the protection of telecommunications installation*.

[8] ITU-T Recommendation K.31 (1993), *Bonding configurations and earthing of telecommunications installations inside a subscriber's building*.

[9] ITU-T Recommendation K.27 (1996), *Bonding configurations and earthing inside a telecommunication building*.

[10] ITU-T Recommendation K.45 (2003), *Resistibility of telecommunication equipment installed in the access and trunk networks to overvoltages and overcurrents*.

3 Definitions

3.1 metallic symmetric conductors: Transmission media consisting of a pair of twisted wires balanced with respect to earth, usually assembled in groups in order to form a telecommunication cable.

3.2 shielded cable: Group of one or more pairs of twisted wires balanced with respect to earth, assembled together and covered by a continuous metallic sheath.

3.3 unshielded cable: Group of one or more pairs of twisted wires balanced with respect to earth and assembled together without a metallic sheath.

3.4 shielded node: Reference point of the telecommunication line where the cable(s) is (are) shielded.

3.5 unshielded node: Reference point of the telecommunication line where the cable(s) is (are) unshielded.

3.6 Surge Protective Device (SPD): A device that is intended to limit overvoltages and divert overcurrents across its terminals. The gas discharge tube (GDT) is a common type of SPD.

3.7 protection factor of SPD (Kp): Factor taking into account the effect on a given node of SPD's installation in that node.

3.8 surge: Overvoltage and/or overcurrent of a transient nature that may be imposed on a conductor as a consequence of an electromagnetic disturbance.

4 Reference configurations

Figure 1 shows the reference configurations for the telecommunication lines with metallic symmetric conductors, where the reference nodes and the cable sections between them can be seen. Usually, the telecommunication line starts at Node E (exchange) and ends at Node S (subscriber premises) but the following situations have also to be considered:

a) If equipment installed in the telecommunication line has intrinsic protection against common mode overvoltages given by SPD installed between conductors of the telecommunication line (at both input and output ports) and equipment reference earth, then this equipment can be treated as an ending point for the line that comes from Node E and a starting point for the line that goes to the subscriber premises. This is usually the case of access network equipment (Node M).

b) If equipment installed in the telecommunication line has no earthed metallic parts and its intrinsic protection against common mode overvoltages is given by the insulation to ground of the telecommunication line and by SPD installed inside the equipment between input and output ports, then the presence of this equipment can be neglected for the purpose of this Recommendation.

c) If telecommunication or signal lines are connecting equipment located in different buildings within the subscriber's premises (ISDN lines or signal lines between computers), then this telecommunication line starts and ends within the subscriber premises (Section S/I).

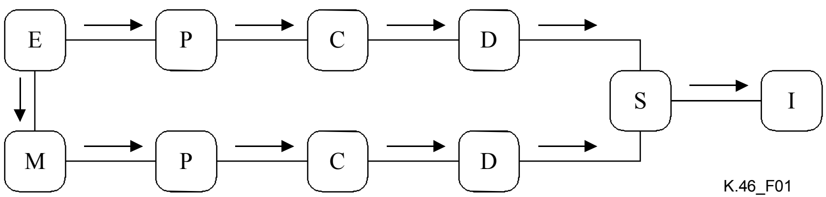

Figure 1/K.46 – Reference configurations (arrows show downstream direction)

The nodes of Figure 1 have the following description:

- Node E: Exchange building, where is located the main switching equipment;
- Node M: Access network equipment, usually installed in shelters at the outside plant;
- Node P: Transition between paper insulated and plastic insulated cables;
- Node C: Transition between buried and aerial cables;
- Node D: Transition between shielded and unshielded cables;
- Node S: Subscriber's equipment connected to external lines;
- Node I: Subscriber's equipment connected to lines between buildings.

NOTE – The use of the term "node" is equivalent to that of "transition point" in IEC [2].

Sometimes two or more transitions may occur at the same node or they may occur with a different sequence from that shown in Figure 1. The notation PC, for example, may be used to identify a node where there is a transition in the line from paper to plastic insulation and from buried to aerial installation.

Additional nodes can be added to the line configuration in order to identify other changes in the line characteristics, such as type of cable (number of pairs), environment (urban/suburban), etc. These nodes are called "virtual nodes" V1, V2, etc. However, the assessment of the protection need shall be performed only for the nodes that can be classified according to the reference configuration. Table 1 shows some typical reference configurations:

Table 1/K.46 – Typical reference configurations

Nodes E/PC/D/S	Nodes E/P/CD/S	Nodes E/C/D/S
Nodes E/CD/S	Nodes E/C/S	Nodes E/S
Nodes M/C/D/S	Nodes M/CD/S	Nodes M/C/S
Nodes M/S	Nodes E/M	Nodes S/I

The direction from Node E to Node I is designated as downstream. The opposite direction is designated as upstream. For a given line, it is considered that the shielded sections (if any) start at the first node (for example, Node E) and follow the downstream direction until the transition with an unshielded section (Node D) or the last node (for example, Node S). Therefore, lines with more than one transition between shielded and unshielded sections (Node D) are not treated by this Recommendation.

5 General requirements

5.1 Resistibility levels

In order to provide adequate protection by use of the procedures of this Recommendation, the following resistibility levels shall be observed:

- Cables with paper insulation: the insulation between any two conductors shall withstand an overvoltage of 1.5 kV peak, 10/700 µs wave shape.
- Cables with plastic insulation: the insulation between any two conductors shall withstand an overvoltage of 5.0 kV peak, 10/700 µs wave shape.
- Exchange equipment: shall comply with ITU-T Rec. K.20 [3] impulse test.
- Subscriber equipment connected to external lines: shall comply with ITU-T Rec. K.21 [4] impulse test.

– Subscriber equipment connected to internal lines: shall comply with ITU-T Rec. K.22 [5] impulse test.

– Access network equipment: shall comply with ITU-T Rec. K.45 [10] impulse test.

If the equipment or cable does not comply with these requirements, the owner of the equipment or cable shall take complementary protective measures in order to achieve compliance.

5.2 Selection of SPD

a) The SPD shall comply with ITU-T Rec. K.12 [6] when using gas discharge technology or with ITU-T Rec. K.28 [7] when using semi-conductor technology.

b) The minimum DC breakdown voltage of the SPD shall be greater than the maximum line voltage expected, both to earth and between the line terminals (the latter in the case of three electrode devices). It shall be observed that, in some equipment, the ringing voltage may add to the DC powering voltage. Due to the possibility of variations on the line voltage and/or the presence of power frequency voltage induced on the line, a safety margin shall be provided between the maximum line voltage and the minimum DC breakdown voltage of the SPD.

c) The maximum impulse breakdown voltage of the SDP shall be consistent with the resistibility of the protected unit.

6 Characterization of the environment

6.1 Environmental factor (K_e) and exposure factor (K_x)

The number and magnitudes of the lightning-induced surges on a telecommunication line are related to some aspects of the environment, mainly the lightning activity, the soil resistivity and the shielding provided by the structures around the line. In order to take these parameters into account, the exposure factor of the line (K_x) is defined, as given by Equation 1:

$$K_x = K_e \cdot Td \cdot \rho^{1/2} \cdot 10^{-3} \tag{1}$$

where:

ρ average soil resistivity, in Ω.m;

Td keraunic level (number of thunderstorm days per year);

K_e environment factor:

$K_e = 0$ for an unexposed area;

$K_e = 1$ for an exposed area.

NOTE – The network operator or the owner of the installation shall evaluate the environmental factor value (K_e) for the line section under consideration. In order to help in this evaluation, this Recommendation suggests that an urban area shall be considered as unexposed environment and a rural area as exposed environment. An experimental method to evaluate K_e is shown in Appendix I.

6.2 Installation factor (K_i)

The installation factor is intended to take into account the reduction in the coupling between the lightning discharge and the telecommunication line due to the installation of the line underground, as compared with an aerial installation. For an aerial installation $K_i = 1$, while for a buried installation $K_i = 0.5$ (based on IEC 61663-2 [2]).

6.3 Shielding factor (K_s)

The use of properly earthed/bonded shielded cables attenuates the lightning induced surges on the telecommunication line. This attenuation can be expressed as a shielding factor (K_s), which is a number between 0 (for perfect shielding) and 1 (for no shielding). In order to evaluate the shielding factor, the shield must be continuous through all the extension of the shielded section(s) and connected to the bonding bar at both ends.

6.3.1 Shielding factor related to the shield (K_{ss})

If the protection need is considered for a shielded node, then the shielding factors of the shielded section(s) of the telecommunication line are related to the shield (K_{ss}). In this case, the shielding factor is a function of the DC shield's resistance per unit length. Equation 2 gives one approximate relationship, while in Appendix II values of shield resistance of typical telecommunication cables with metallic symmetric conductors are given, as a function of the conductor diameter and number of pairs.

$$K_{SS} = [1 + 46 / r]^{-1} \tag{2}$$

where:

r is the shield resistance in Ω/km.

6.3.2 Shielding factor related to earth (K_{se})

If the protection need is considered for an unshielded node or for Node D, then the shielding factors of the shielded section(s) of the telecommunication line are related to earth (K_{se}). In this case, the shielding factor is a function of the DC shield's resistance per unit length, the earthing configuration of the shield and the resistance of the shield's connections to earth.

Considering that the shield is connected to earth at least at both ends and the resistance of the earthing connections are of the order of a few tens of ohms, the shielding factor can be conservatively considered as equal to 0.5 ($K_{se} = 0.5$). A method for a more precise evaluation of the shielding factor related to earth is presented in Annex A.

6.4 Conventional length

In order to take into account the exposure of a cable section to the lightning induced surges, the conventional length of the section is defined. Let us consider, as a reference cable section, the one made of an unshielded cable ($K_s = 1$), in aerial installation ($K_i = 1$) and with 1 km in length. The average earth resistivity is 400 Ω.m, the keraunic level is 50 thunderstorm days per year and the cable is installed in a rural area ($K_x = 1$). Defining the convention length as in Equation 3 leads to the conclusion that this reference cable section will have a conventional length equal to its real length (1 km).

$$L_c{}^j = K_x \cdot K_s \cdot K_i \cdot L^j \tag{3}$$

where:

$L_c{}^j$ is the conventional length of the section j;

L^j is the real length of the section j.

As can be seen from Equation 3, for the same real length, the conventional length will increase as the section exposure to the lightning-induced surges increases, and vice versa. For example, if an aerial cable section is buried, its conventional length will be reduced by half. In other words, letting the other conditions the same, a buried section would have to have twice the real length of an aerial section in order to experience the same level of lightning induced surges.

If a line is composed of n cable sections with different parameters, the conventional length of a given node is the sum of the conventional lengths of all the sections of the line, as shown in Equation 4.

$$L_C = \sum_{j=1}^{n} L_C{}^{j} \tag{4}$$

This Recommendation requires that the conventional length be calculated for every node of the reference configuration (see Figure 1) considering the following rules:

a) For a shielded node, the shielding factor of the shielded sections shall be related to the shield (K_{ss}). See 6.3.1 for the calculation of K_{ss}.

b) For an unshielded node and for a transition between shielded and unshielded sections (Node D), the shielding factor of the shielded sections shall be related to earth (K_{se}). See 6.3.2 for the calculation of K_{se}.

7 Bonding procedures

7.1 Exchange (Node E)

All shielded cables coming into the exchange's building shall have their metallic sheaths continuous, which means that the sheath shall be bonded across all splices. At the entrance of the building (cable chamber), all metallic sheaths shall be bonded to the building's main earthing terminal located near this point, according to ITU-T Rec. K.27. This bonding shall be made using low-impedance conductors (short and wide).

NOTE – In some particular cases, where there is evidence of galvanic corrosion in the cable plant, it is acceptable to perform this bonding by means of SPD, provided that they are adequately dimensioned.

If the cable arriving at the MDF has a metallic sheath, it shall be bonded to the MDF bonding bar. The MDF bonding bar shall be connected to the main earthing terminal by means of a low impedance conductor.

7.2 Outside plant (Nodes M, P, C and D)

At the transition between two shielded cables, the shield shall be bonded across the transition by means of an adequate bonding conductor. In the case of aluminium sheath, care shall be taken in order to assure good and permanent contact between the sheath and the bonding conductor, which can be accomplished by the use of an adequate clamp. If the transition takes place at a cross-connect cabinet, it is recommended that a bonding bar is provided close to the cable entrance point and that all the metallic sheaths are bonded to this bar.

If the transition between a shielded and an unshielded cable is made by means of a distribution box, its bonding terminal shall be bonded to the cable shield directly or through the metallic sheath of a stub cable. If the cable connected to the access network equipment is shielded, its shield shall be bonded to the equipment bonding bar located at the entrance of the shelter.

7.3 Subscriber premises (Nodes S and I)

If the cable that arrives at the subscriber premises is shielded, its shield shall be bonded to the subscriber's equipotential bonding bar, according to ITU-T Rec. K.31. The other metallic parts of the subscriber premises (such as metallic water and/or gas pipes and metal framework of the building) shall be connected to the equipotential bonding bar, in order to reduce the overvoltages between accessible parts.

8 Surge protective devices (SPD)

8.1 Installation of surge protective devices (SPD)

For the installation of SPD at a node, their line terminals shall be connected to the conductors of the telecommunication line and their earth terminals shall be connected to the bonding bar of the node. Figure 2 shows the connections of SPD at a shielded node (Figure 2a), at Node D (Figure 2b) and at an unshielded node (Figure 2c). If a local earthing system is available, the bonding bar shall be connected to it. However, if there is no earthing system available at an unshielded node, one has to be constructed in order to allow the proper installation of the SPD.

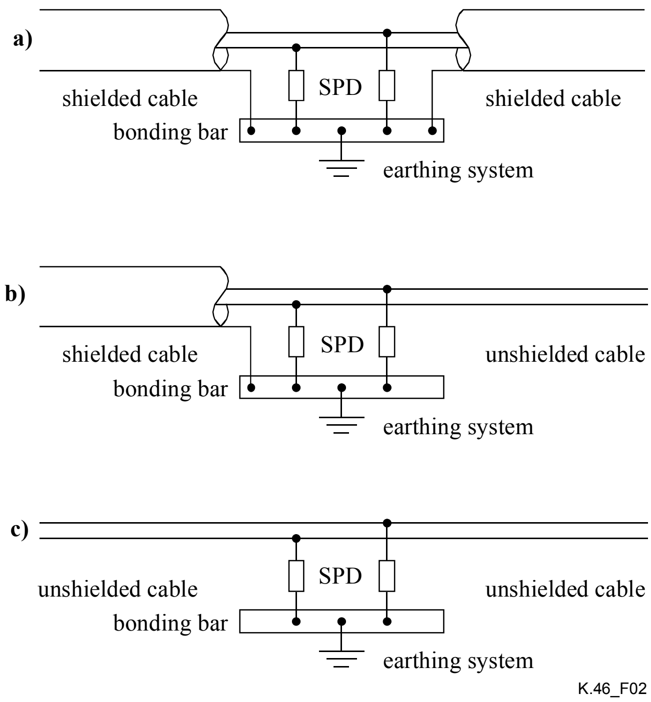

Figure 2/K.46 – Installation of surge protective devices (SPD)

8.2 Assessment of the node's protection need

The conventional length concept is used to assess the need of protecting the nodes of the telecommunication line. The limit values given in this clause are based on IEC 61663-2 [2] and have been derived considering technical and economical aspects. Depending on the desired reliability for the lines, the repair cost and the field experience, the operator can adjust these limits in order to match local requirements. Table 2 shows the limits for the nodes of a telecommunication line, in terms of conventional length.

Table 2/K.46 – Conventional length limits for the nodes of a telecommunication line

Node	Conventional length limit
E	360 m
M	330 m
P	80 m
C	670 m
D	940 m
S	330 m
I	150 m

In the application of Table 2, the following rules shall be considered:

a) If more than one transition occurs at the same node, its limit is given by the lower value among the limits of the transitions. For example, for a node PC the limit is 80 m (lower value between 80 and 670) and for a node CD the limit is 670 m (lower value between 670 and 940).

b) If the line is composed of only one section with buried shielded paper insulated cable, the limit value for the nodes at both ends of the line shall be considered equal to 80 m.

The conventional length limit value of each node of the line shall be compared with the conventional length of the node. If the conventional length of the node is greater than the limit value, then the node needs protection against the lightning induced surges.

8.3 Determination of the protection schemes

Once the nodes needing protection are known, it is necessary to determine where SPD shall be installed. It is often possible to obtain more than one scheme for the installation of SPD that protects the line. Therefore, the decision about which scheme to use shall be based on economic considerations. The following rules shall be considered in determining the protection scheme:

a) The installation of SPD at a node reduces its conventional length to zero (see Figure 3a) and, therefore, protects the node.

NOTE – IEC 61663-2 [2] states that the installation of SPD at a node reduces its conventional length to a value equal to the product between the conventional length of the node and the protection factor K_p of the SPD. For SPD coordinated with equipment resistibility and installed in agreement with ITU-T Recs K.27 and K.31 [8], [9], IEC 61663-2 gives a value of $K_p = 0.01$. Therefore, this Recommendation considers $K_p = 0$ as a simplified approach with respect to IEC 61663-2, which will lead to the same results in most practical cases.

b) The unshielded nodes needing protection shall be protected with SPD. The installation of SPD at an unshielded node does not affect the conventional length of the other nodes (see Figure 3a).

c) The Node D needing protection shall be protected with SPD. The installation of SPD at Node D reduces the conventional lengths of the upstream shielded nodes. The new conventional lengths shall be calculated neglecting the unshielded sections downstream the SPD (see Figure 3b).

d) The installation of SPD at a shielded node affects the conventional length of the other shielded nodes. The conventional length of the shielded nodes downstream and upstream an SPD shall be calculated as if the SPD had divided the line into two independent lines (see Figure 3c).

e) The installation of SPD at a shielded node does not affect the conventional length of Node D or of the unshielded nodes (see Figure 3d).

f) The installation of SPD at two shielded nodes or at a shielded node and Node D protects the nodes situated between the SPD (see Figure 3e).

In Appendix III there are some examples of application of this procedure.

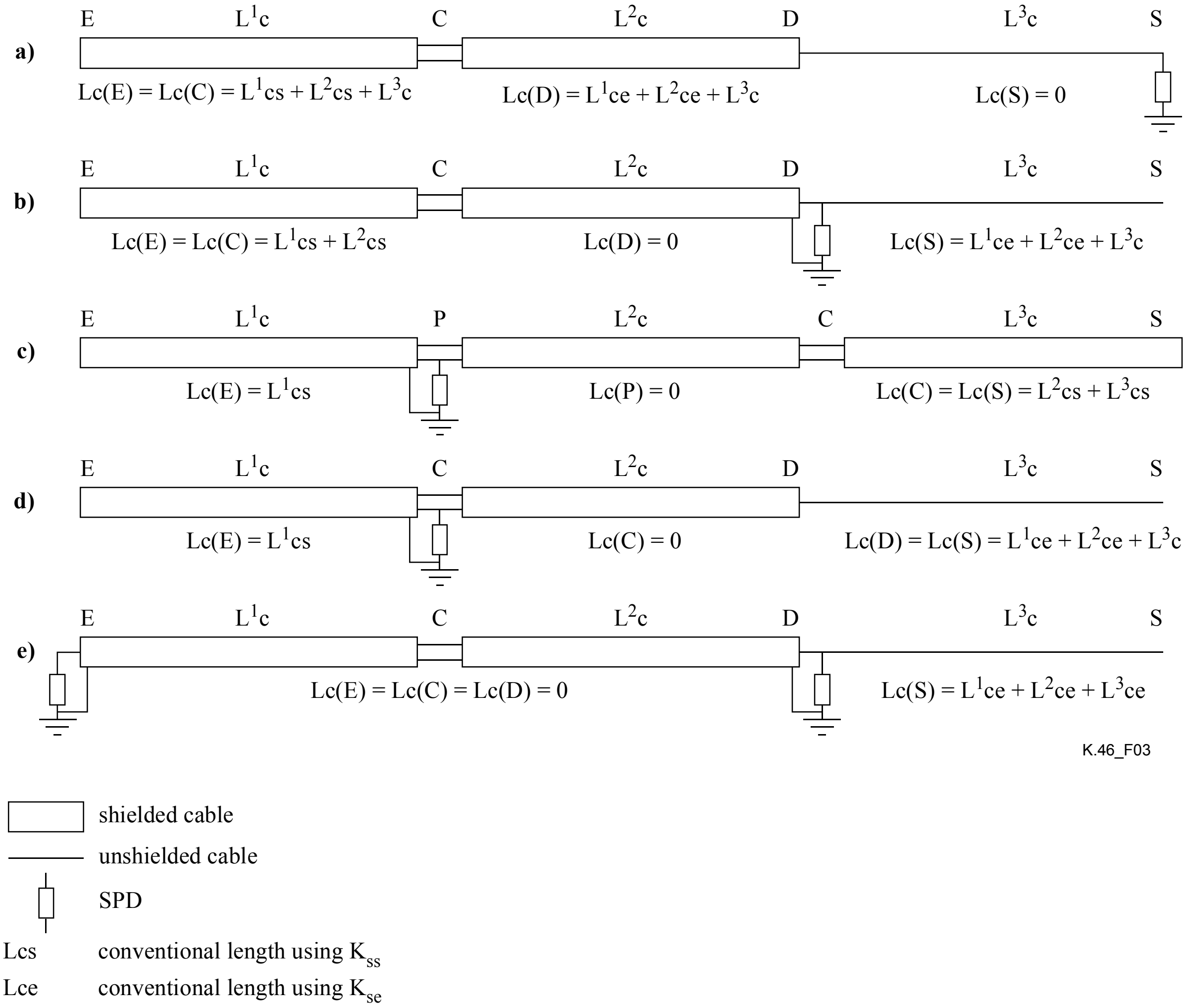

Figure 3/K.46 – Effect of SPD on the evaluation of the conventional length

Annex A

Shielding factor related to earth (K_{se})

Equation A.1 gives the shielding factor related to earth of a shielded section when the shield is earthed at the end of the section:

$$K_{se} = R/(R+Z) \tag{A.1}$$

where:

R: earth resistance of the shield near end [Ω];

Z: surge impedance of the metallic sheath with respect to earth [Ω].

The surge impedance can be calculated by the following equation:

$$Z = 60 \ln\left\{\left[b + 648(\rho / f)^{1/2}\right] / r\right\} \quad \text{(A.2)}$$

where:

ρ: earth resistivity [Ω.m];

f: frequency representative of lightning induced surges [Hz];

r: radius of the metallic sheath [m];

b: height of the line (for aerial line) [m];
distance from conductor to earth (for buried line) [m]

NOTE – It is suggested to use f = 100 kHz.

Appendix I

Environmental factor (K_e)

The evaluation of the environmental factor K_e is based on the typical construction parameters of the region considered. It shall be classified into one of the following categories:

– Urban area with tall buildings (above 6 floors): $K_e = 0$;

– Urban area with medium buildings (between 3 to 6 floors): $K_e = 0.1$;

– Suburban area with houses (one or two floors): $K_e = 0.5$;

– Rural area without constructions (flat ground): $K_e = 1.0$.

If the area is not fully occupied, the value of K_e shall be corrected to take this into account. Therefore, it is defined the construction factor (φ) which is 1 for an area fully occupied with constructions and 0 for an area with no construction. The expression for K_e becomes:

$$K_e = 1 + \varphi(k_e' - 1) \quad \text{(I.1)}$$

where:

K_e' is the environmental factor evaluated by the typical construction parameters;

K_e is the corrected environmental factor, considering the actual occupation of the area.

For example, consider a typical old suburb, where most of the land is occupied by houses. In this case, the environmental factor $K_e = 0.5$. However, if it is a new suburb, where half of the land (φ = 0.5) is still to be constructed, then $K_e = 0.75$.

Appendix II

Shield resistance for cables with metallic symmetric conductors

Table II.1/K.46 – Shield resistance in Ω/km for lead sheath

Conductor diameter (mm) / Number of pairs	0.40	0.50	0.65	0.90
10	6.2	5.4	4.8	3.4
20	5.0	4.2	3.4	2.4
30	4.4	3.4	2.8	2.0
50	3.4	2.7	2.2	1.5
75	2.8	2.3	1.8	1.2
100	2.4	2.0	1.5	1.0
200	1.7	1.4	1.0	0.65
300	1.3	1.1	0.79	0.49
400	1.1	0.91	0.66	0.40
600	0.87	0.70	0.49	–
900	0.66	0.54	0.38	–
1200	0.54	0.43	–	–
1500	0.46	–	–	–
1800	0.40	–	–	–
2400	0.33	–	–	–
NOTE –Values valid for sheath thickness T = 2 mm. For other thickness T'(mm), multiply the value of the table by 2/T'.				

Table II.2/K.46 – Shield resistance in Ω/km for aluminium sheath

Conductor diameter (mm) / Number of pairs	0.40	0.51	0.64	0.91
10	5.2	4.9	4.2	3.1
20	4.0	3.6	3.1	2.3
30	3.5	3.1	2.6	1.9
50	2.9	2.6	2.1	1.6
75	2.4	2.2	1.8	1.3
100	2.0	1.9	1.6	1.1
200	1.5	1.4	1.1	0.80
300	1.2	1.1	0.92	0.64
400	1.1	1.0	0.80	0.56
600	0.89	0.80	0.64	–
NOTE – Values valid for sheath thickness T = 0.2 mm. For other thickness T'(mm), multiply the value of the table by 0.2/T'.				

Appendix III

Examples of application

III.1 Telecommunication line with shielded and unshielded sections in suburban environment

Consider a subscriber line located in an old suburb, where the land is occupied by houses. The environmental factor according to Appendix I is 0.5 ($K_e = 0.5$). The keraunic level of the region is 60 thunderstorm days per year ($Td = 60$) and the average earth resistivity is 500 Ω.m. Therefore, the exposure factor is $K_x = 0.67$ (see Equation 1). It shall be observed that this value of K_x has to be evaluated only once and applies to every line constructed in this region. The line fits into the configuration E/PC/D/S (see Figure 1). The characteristics of the sections are tabulated in Table III.1.

Table III.1/K.46 – Characteristics of the line

Section	Insulation	Sheath material	Sheath thickness	Number of pairs	Cond. diameter	Length	Installation
E/PC	Paper	Lead	2 mm	1200	0.40	3200 m	Buried
PC/D	Plastic	Aluminium	0.2 mm	100	0.40	500 m	Aerial
D/S	Plastic	No sheath	–	1	0.80	140 m	Aerial

The installation factor (K_i) is 0.5 for the buried section and 1.0 for the aerial sections (see 6.2). The sheath resistance per unit length (r) can be obtained from Appendix II, based on the sheath material, thickness, conductor diameter and number of pairs. For the sections E/PC and PC/D Appendix II gives $r = 0.54$ Ω/km and $r = 2.0$ Ω/km. These values can be used in Equation 2 to calculate the shielding factors related to the shield (K_{ss}), which are shown in Table III.2. It shall be observed that for the unshielded section $K_{ss} = 1$, which can be obtained by considering a shield of infinite resistance in Equation 2.

Let us suppose that the operator does not control the earth resistance at the ends of the shield but that it is reasonable to consider that this resistance is of the order of a few tens of ohms. Therefore, the shielding factor related to earth (K_{se}) shall be considered equal to 0.5 (see 6.3.2). Using Equation 3 it is possible to obtain the conventional lengths of the sections, which are shown in Table III.2.

Table III.2/K.46 – Conventional lengths

Section	Sheath resistance	Nodes E and PC		Nodes D and S	
		K_{ss}	L_{cs}	K_{se}	L_{ce}
E/PC	0.54 Ω/km	0.012	13 m	0.5	536 m
PC/D	2.0 Ω/km	0.042	14 m	0.5	168 m
D/S	–	1.0	94 m	1.0	94 m

The next step is to assess the node's limits and conventional lengths. The node's limits obtained from Table 2 are shown in Table III.3. The conventional length of each node depends on the shield condition of the node and can be calculated with Equation 4. The calculated values are shown in Table III.3.

Table III.3/K.46 –Protection schemes

Node	Conventional length limit	Conventional length	Need of protection	Installation of SPD	
				Scheme 1	Scheme 2
E	360 m	121 m	No	No	No
PC	80 m	121 m	Yes	No	Yes
D	940 m	798 m	No	Yes	No
S	330 m	798 m	Yes	Yes	Yes

In Table III.3 the nodes needing protection can be seen. However, not every node needing protection will require the installation of SPD. The first step to obtain a protection scheme is to install SPD at the unshielded nodes and Node D requiring protection. In this case, there is only one unshielded node requiring protection (Node S). The installation of SPD at Node S does not affect the conventional length of the other nodes.

However, if SPD is installed at Node D, it will reduce the conventional length of Nodes E and PC by removing the contribution of the unshielded section. Using Table III.2, it can be seen that the conventional length of Nodes E and PC will be reduced to 27 m, which are lower than the limit values for these nodes. Therefore, a protection scheme (Scheme 1 in Table III.3) for this line will require the installation of SPD at Nodes D and S.

Another possibility is to install SPD at Node PC instead of Node D. In this case, the conventional length of Nodes E and PC will be reduced to 13 m and zero, respectively, which are lower than the limit. This possibility is shown as Scheme 2 in Table III.3. The decision about which scheme to use will depend on an economic analysis.

III.2 Telecommunication line with only shielded sections in suburban environment

Consider a subscriber line located in a new suburb, where about half of the land is occupied by houses. Based on Appendix I, the environmental factor is 0.75 ($K_e = 0.75$). The keraunic level of the region is 50 thunderstorm days per year ($Td = 50$) and the average earth resistivity is 400 Ω.m. Therefore, the exposure factor is $K_x = 0.75$ (see Equation 1). The line fits into the configuration M/V/S (see clause 4). The characteristics of the sections are tabulated in Table III.4.

Table III.4/K.46 – Characteristics of the line

Section	Insulation	Sheath material	Sheath thickness	Number of pairs	Cond. diameter	Length	Installation
M/V	Plastic	Aluminium	0.2 mm	100	0.40	2000 m	Aerial
V/S	Plastic	Aluminium	0.2 mm	10	0.40	250 m	Aerial

The installation factor (K_i) is 1.0 for the aerial sections (see 6.2). The sheath resistance per unit length (r) can be obtained from Appendix II, based on the sheath material, thickness, conductor diameter and number of pairs. For sections M/V and V/S, Appendix II gives $r = 2.0$ Ω/km and 5.2 Ω/km. These values can be used in Equation 2 to calculate the shielding factors related to the shield (K_{ss}). Using Equation 3, it is possible to obtain the conventional lengths of the sections, which are shown in Table III.5.

Table III.5/K.46 – Conventional lengths

Section	Sheath resistance	K_{ss}	L_{cs}
M/V	2.0 Ω/km	0.042	63 m
V/S	5.2 Ω/km	0.10	19 m

The next step is to assess the node's limits and conventional lengths. The node's limits (see Table 2) are shown in Table III.6. The conventional length of each node is calculated with Equation 4, considering the shielding factor related to the shield. The calculated values are shown in Table III.6.

Table III.6/K.46 – Protection schemes

Node	Conventional length limit	Conventional length	Need of protection	Installation of SPD
M	330 m	82 m	No	No
V	–	–	–	–
S	330 m	82 m	No	No

NOTE – The assessment of the protection need shall not be performed for the Node V (see clause 4).

In Table III.6 it can be seen that there is no need for protection. Therefore, no SPD is needed at this line in order to protect it against lightning induced surges.

III.3 Telecommunication line with shielded and unshielded sections in rural environment

Consider a subscriber line located in a rural area. The environmental factor is 1.0 ($K_e = 1.0$). The keraunic level of the region is 50 thunderstorm days per year ($Td = 50$) and the average earth resistivity is 600 Ω.m. Therefore, the exposure factor is $K_x = 1.2$ (see Equation 1). The line fits into the configuration E/PC/D/S (see Figure 1). The characteristics of the sections are tabulated in Table III.7.

Table III.7/K.46 – Characteristics of the line

Section	Insulation	Sheath material	Sheath thickness	Number of pairs	Cond. diameter	Length	Installation
E/P	Paper	Lead	2 mm	400	0.40	1500 m	Buried
P/CD	Plastic	Aluminium	0.2 mm	50	0.40	2400 m	Buried
CD/S	Plastic	No sheath	–	2	0.80	400 m	Aerial

The installation factor (K_i) is 0.5 for the buried sections and 1.0 for the aerial section (see 6.2). The sheath resistance per unit length (r) can be obtained from Appendix II, based on the sheath material, thickness, conductor diameter and number of pairs. For sections E/P and P/CD, Appendix II gives $r = 1.1$ Ω/km and $r = 2.9$ Ω/km. These values can be used in Equation 2 to calculate the shielding factors related to the shield (K_{ss}), which are shown in Table III.8. Using Equation 3, it is possible to obtain the conventional lengths of the sections, which are shown in Table III.8.

Let us suppose that the operator controls the earth resistance of the shield at the outside plant (Node CD) to a value below 30 Ω. Neglecting the resistance at Node E, the shielding factor related to earth (K_{se}) can be obtained by the procedure given in Annex A as K_{se} = 0.05. The resultant conventional length related to earth is shown in Table III.8.

Table III.8/K.46 – Conventional lengths

Section	Sheath resistance	Nodes E and P		Nodes CD and S	
		K_{ss}	L_{cs}	K_{se}	L_{ce}
E/P	1.1 Ω/km	0.023	21 m	0.05	45 m
P/CD	2.9 Ω/km	0.059	85 m	0.05	72 m
CD/S	–	1.0	480 m	1.0	480 m

The next step is to assess the node's limits and conventional lengths. The node's limits (see Table 1) are shown in Table III.9. The conventional length of each node depends on the shield condition of the node and can be calculated with Equation 4. The calculated values are shown in Table III.9.

Table III.9/K.46 – Protection schemes

Node	Conventional length limit	Conventional length	Need of protection	Installation of SPD	
				Scheme 1	Scheme 2
E	360 m	586 m	Yes	No	Yes
P	80 m	586 m	Yes	Yes	No
CD	670 m	597 m	No	No	Yes
S	330 m	597 m	Yes	Yes	Yes

In Table III.9 it can be seen the nodes that need protection. The first step to obtain a protection scheme is to install SPD at the unshielded node requiring protection (Node S) and at Node P. The installation of SPD at Node S does not affect the conventional length of the other nodes. However, the installation of SPD at Node P reduces the conventional length of Node E. Using Table III.8 it can be seen that the conventional length of Node E will be reduced to 21 m, which is lower than the limit value for Node E. Another possibility is to install SPD at Node E and CD, in order to protect Node P, as it will be between two SPD. These protection schemes are shown in Table III.9. The decision about which scheme to use will depend on an economic analysis.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series B	Means of expression: definitions, symbols, classification
Series C	General telecommunication statistics
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	**Protection against interference**
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	TMN and network maintenance: international transmission systems, telephone circuits, telegraphy, facsimile and leased circuits
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks and open system communications
Series Y	Global information infrastructure and Internet protocol aspects
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2003