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SERIES K: PROTECTION AGAINST INTERFERENCE

Joint use of poles by telecommunication and solidly earthed power lines

Recommendation ITU-T K.108

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Joint use of poles by telecommunication and solidly earthed power lines

Summary

Recommendation ITU-T K.108 provides protective procedures against accidental contacts between power lines and telecommunication lines, when these lines use the same poles. These procedures are primarily intended to reduce the risk of an accidental contact (power-cross). However, in the case of a power cross, the protective procedures mitigate its consequences. This Recommendation provides a set of clearance values between power and telecommunication lines at the joint-use pole and the rules for achieving the insulation coordination between the lines. In the case of a power-cross, the earthing and bonding procedures are intended to assure the immediate tripping of the power line circuit breaker. As a backup protection, this Recommendation requires the use of surge protective devices at the customer premises whenever there is a joint-use of poles with medium voltage power lines.

History

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Keywords

Clearances, earthing, insulation coordination, joint-use of poles, power-cross, power lines.

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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, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Joint use of poles by telecommunication and solidly earthed power lines

1 Scope

This Recommendation provides technical procedures in order to protect the telecommunication lines installed in poles that are also used by solidly earthed power distribution lines, with special reference to the accidental contact between these lines (power-cross). For the protection regarding the interference produced by electric power lines on telecommunication lines, the user shall refer to [b-ITU-T K.26].

The telecommunication lines considered are those made of cables containing one or more twisted metallic pairs with and without a metallic sheath and covered by an outer plastic sheath. These cables are supported by a steel or composite strand that may be incorporated in the same cable or may be independent. In the latter case, the steel strand may be bare or insulated by a plastic outer sheath, and the telecommunication cable is attached to the steel strand usually by a lashing wire.

The power distribution lines considered are those operating in alternating currents with nominal voltages up to 25 kV (phase-to-phase). The lines may have one, two, or three phases, with and without a neutral conductor. It is considered that the power transformer at the distribution substation has its windings in the secondary side connected in Y configuration and that the neutral of the transformer (central point of the Y) is connected directly to earth (solidly earthed). Substation power transformers which are secondary side-earthed through a resistor, non-earthed, or earthed by resonant systems (e.g., Petersen coil) are out of the scope of this Recommendation.

NOTE – The distribution substation referred above is the origin of the distribution medium voltage feeders that provide power to the medium voltage / low voltage transformers.

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.

[ITU-T K.20] Recommendation ITU-T K.20 (2015), *Resistibility of telecommunication equipment installed in a telecommunications centre to overvoltages and overcurrents.*

[ITU-T K.21] Recommendation ITU-T K.21 (2015), *Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents*.

[ITU-T K.45] Recommendation ITU-T K.45 (2015), *Resistibility of telecommunication equipment installed in the access and trunk networks to overvoltages and overcurrents.*

[ITU-T K.65] Recommendation ITU-T K.65 (2011), *Overvoltage and overcurrent requirements for termination modules with contacts for test ports or surge protective devices*.

[ITU-T K.66] Recommendation ITU-T K.66 (2011), *Protection of customer premises from overvoltages.*

[IEC 60060-1]	IEC 60060-1 (2010), *High-voltage test techniques – Part 1: General definitions and test requirements.*
[IEC 61643-21]	IEC 61643-21 (2008), *Low voltage surge protective devices – Part 21: Surge protective devices connected to telecommunications and signalling networks – Performance requirements and testing methods.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 breakdown voltage [b-IEC 60050]: Voltage at which electric breakdown occurs under prescribed test conditions, or in use.

3.1.2 insulation coordination [b-IEC 60050]: Selection of the electric strength of equipment in relation to the voltages which can appear on the system for which the equipment is intended, and taking into account the service environment and the characteristics of the available protective devices.

3.1.3 low voltage [b-IEC 60050]: Voltage having a value below a conventionally adopted limit.

NOTE – For the distribution of AC electric power, the upper limit is generally accepted to be 1000 V.

3.1.4 medium voltage (MV) [IEC 60050-601:2001, 601-01-28]: (not used in the UK in this sense, nor in Australia). Any set of voltage levels lying between low and high voltage.

NOTE 1 – The boundaries between medium and high voltage levels overlap and depend on local circumstances and history or common usage. Nevertheless the band 30 kV to 100 kV frequently contains the accepted boundary.

NOTE 2 – The medium voltage is not a standardized term. It is specified as a system voltage class by IEEE [b-Terms].

NOTE 3 – The preferred medium nominal (line-to-line) voltages in North America: 4.16 kV, 12.46 kV, 13.8 kV, 34.5 kV and 69 kV [b-Terms]. Typical MV system voltages for public distribution: in Europe 10 kV (mainly underground) 20 kV and 35 kV (mainly overhead) [b-Lacroix], in Japan 6.6 kV.

3.1.5 solidly earthed (neutral) system [b-IEC 60050]: A system whose neutral point(s) is(are) earthed directly.

3.1.6 withstand voltage [b-IEC 60050]: Voltage applied to a specimen under prescribed test conditions which does not cause breakdown.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 power-cross: line-to-earth short-circuit in a power line whose current path to earth involves a telecommunication line.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

SPD Surge Protective Device

V_E Phase-to-earth voltage of the power line

5 General considerations

Telecommunication operators that wish to use the poles already in use for power distribution lines are recommended, when national laws and regulations permit such an arrangement, to take the following general considerations into account:

- There are economic and aesthetic advantages to be derived from the joint-use of poles by telecommunication operators and power utilities.
- When suitable joint construction methods are used, there is, nevertheless, some increased likelihood of danger by comparison with non-joint-use lines, both to staff working on the telecommunication line and to the telecommunication installation connected thereto. Special training of personnel working on such lines is highly desirable, especially when the nominal power line voltage is above 1 kV.
- Special formal agreements are desirable between the telecommunication operator and the power utility in the case of joint-use of poles, in order to define responsibilities.
- Joint-use of poles with power lines having nominal voltages above 25 kV is not recommended.

6 Possible protection approaches

In order to protect the telecommunication lines against the likelihood of accidental contact with the directly-earthed power distribution lines in joint-use of poles (power-cross), there are two distinct approaches, which are briefly described in this clause.

6.1 Integrated protection

In this approach, the telecommunication operator and the power utility develop together a set of procedures to be applied in both networks in order to achieve the desired level of protection against power-crosses. The resulting procedures may involve the joint-use of earthing connections and the bonding between metallic conductors of both lines (e.g., to bond the telecommunication line supporting strand to the power line neutral conductor). As this approach has to take into account the specificities of both networks, it is not considered in this Recommendation.

NOTE – This approach is used in North America, based on a comprehensive study that settled the procedures and responsibilities for both networks.

6.2 Coordinated protection

In this approach, the telecommunication operator implements the protection procedures while taking into account some relevant parameters of the power line, but does not integrate its network with the power network. The resulting procedures do not involve the joint-use of earth connections nor the bonding between metallic conductors of both lines. This Recommendation considers this approach, where the characteristics of the power line are used in order to develop the protection procedures of the telecommunication line in joint-use of poles, resulting in a coordinated protection scheme.

7 The power-cross problem

The main source of danger in a joint-use installation between telecommunication and solidly earthed power lines is the power-cross, i.e., the accidental contact between the power line and the telecommunication line. As the power system is directly earthed, a power-cross leads to a very high short-circuit current. The power-cross may take place due to a number of reasons, some of which are summarized below:

- The clearance between the lines is too small, so that an overload on the power conductor reduces its height (sag) and causes a contact with the telecommunication line installed below. This type of power-cross is more likely to involve low voltage power lines.

- The power conductor breaks and falls on the telecommunication line. This type of power-cross is more common in rural areas, due to the longer spans used.
- The power line insulation fails and leads to a current path involving the telecommunication line. The insulation may fail due to several reasons, such as: cracks or pollution on the insulator, objects falling across the insulator (e.g., tree branches), and lightning surges. This type of power-cross is more likely to involve medium voltage power lines installed on conductive poles (e.g., concrete poles with steel framework).

Figure 1 shows an example of power-cross due to the failure of the power line insulator. The line is typically a medium voltage distribution line (e.g., 15 kV nominal voltage) and the pole is conductive (e.g., concrete with steel reinforcement). In this figure, the electric arc formed across the insulator conducts the current to earth through the pole steel core and part of this current flows through the telecommunication line that is attached to the pole. It is worth mentioning that the insulation provided by the concrete cover is negligible, so that there is little difference between a steel-reinforced pole and a metallic pole from the power-cross point of view. If the insulation failure is caused by a lightning surge, the power frequency current will follow the arc formed by lightning and may keep it on until the power line is switched off.

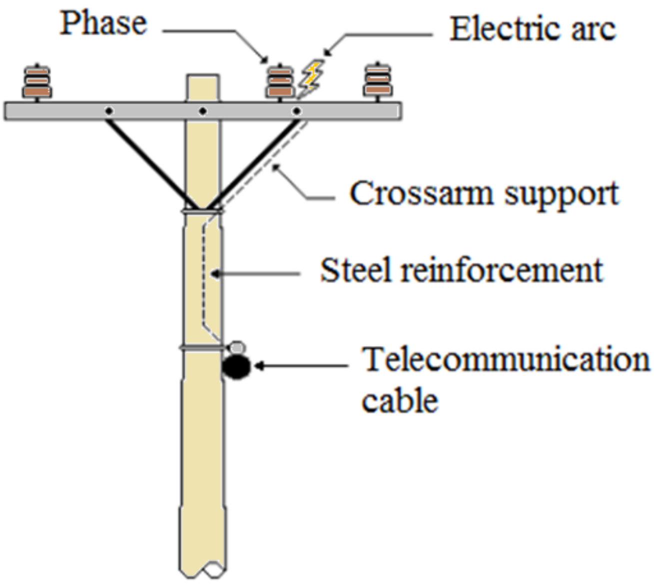

Figure 1 – Example of power-cross due to insulation failure

8 Minimum clearances

In order to reduce the likelihood of power-cross due to the proximity between the lines, a minimum clearance shall be maintained between the telecommunication line and the power line. This clearance also provides some protection to the linemen.

- The minimum clearance between the telecommunication line and the lighting fixture attached to the pole shall be 0.2 m.
- The minimum clearance between telecommunication and low voltage power conductors at the mid-span shall be 0.3 m if the power conductor is insulated and 0.6 m otherwise.
- The minimum clearances between power and telecommunication conductors at the joint-use pole, as a function of the power line nominal voltage, are shown in Table 1.

The minimum clearances for the joint-use with low voltage lines are shown in Figure 2.

Table 1 – Minimum clearances between power and telecommunication conductors

Phase-to-phase nominal voltage (kV)	Minimum clearance (m)	
	Insulated conductor	Bare conductor
V ≤ 1	0.5	1.0
1 < V ≤ 15	1.0	1.5
15 < V ≤ 25	1.5	2.0

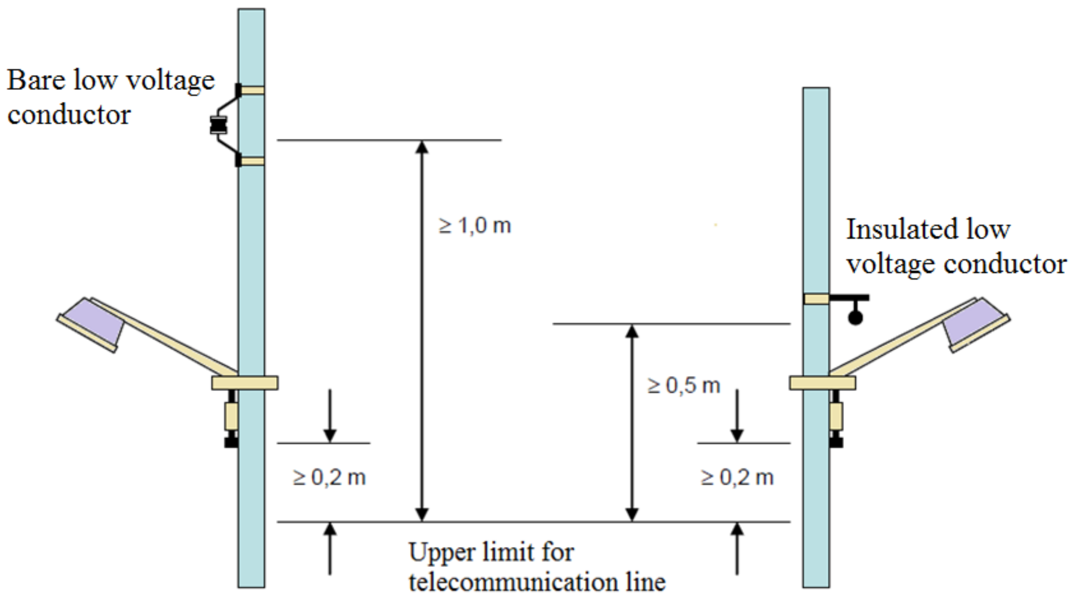

Figure 2 – Minimum clearances for joint-use of poles with low voltage power lines

9 Installation of surge protective devices

The procedures contained in this Recommendation are intended to reduce the likelihood of a power-cross and to minimize its consequences if one occurs. However, in the joint-use of poles with power lines there is always a risk of the power current entering the cable core. Therefore, whenever the joint-use of poles with medium voltage power lines is used, it is necessary to install surge protective devices (SPDs) at the entrance of the subscriber premises and also at the telecommunications central office. The following procedures shall be observed:

- The installation of SPDs at the customer premises shall comply with [ITU-T K.66].
- The termination module for the SPD shall comply with [ITU-T K.65].
- The SPD shall be equipped with protection against overheating ("fail safe") according to [IEC 61643-21].
- Customer equipment shall comply with [ITU-T K.21].
- Central office equipment shall comply with [ITU-T K.20].
- Network equipment shall comply with [ITU-T K.45].

NOTE – For the protection against power-cross it is especially important that the telecommunication equipment comply with the Mains Power Contact test contained in [ITU-T K.20], [ITU-T K.21] and [ITU-T K.45].

It is worth mentioning that SPDs may be necessary at customer premises even if there is no joint-use of poles with medium voltage lines. For instance, SPDs may be necessary in lines exposed to the effects of lightning. For the assessment of the need for SPDs in these cases, the user shall refer to [b-ITU-T K.46] and [b-ITU-T K.47].

10 Insulation coordination

The coordination of the insulation levels of the lines in joint-use of poles is necessary in order to reduce the risk of power-cross due to insulation failure of the power line. Appendix I provides the rationale for the insulation coordination recommended in this clause.

The insulation coordination described in this clause applies to the joint-use of poles with power lines operating at voltages rated up to 25 kV (line-to-line). All insulation requirements refer to tests carried out under power frequency according to [IEC 60060-1]. The tests shall be carried out under artificial rain, with the test voltage applied for 10 seconds for withstand voltage assessment.

10.1 Insulation of the telecommunication cable outer sheath

Telecommunication cables are usually covered with an outer plastic sheath that has an insulation level that is sufficiently high to provide adequate protection against power-crosses. This insulation level may be assessed by testing, observing the following:

- The insulation under test is the one between the cable inner conductors (twisted pairs + metallic sheath, if any) and an outer electrode applied to the cable sample. This electrode shall not have sharp edges, in order to avoid local enhancement of the electric field.
- The insulation withstand voltage shall be equal to or higher than 4 kV or twice the phase-to-earth voltage of the power line ($V_{E)}$ in joint use of poles, whichever is higher.

10.2 Insulation of splices and distribution boxes

Splices and distribution boxes shall be insulated from the supporting strand and from the conductive poles. The insulation is between the inner metallic conductors (twisted pairs and metallic sheath) and the supporting strand or conductive pole. The insulation shall have the following characteristic:

- The insulation withstand voltage shall be equal to or higher than 4 kV or twice the phase-to-earth voltage of the power line in joint-use of poles, whichever is higher.

Preferably, splices and distribution boxes should inherently comply with this insulation requirement, so that no additional insulator or procedure would be required. Experience shows that conveniently designed splices and distribution boxes can comply with this requirement.

10.3 Insulation between the metallic supporting strand and the pole

If the joint-use pole is conductive, an insulation shall be provided between the metallic supporting strand of the telecommunication line and the pole. Poles made of galvanized steel or steel-reinforced concrete are examples of conductive poles.

If the joint-use pole is non-conductive, additional insulation is not required. Poles made of wood or composite materials (e.g., fibre-glass) are examples of non-conductive poles. If the pole is non-conductive, but it holds a bare vertical conductor of the power line (e.g., earthing conductor), then it shall be treated as a conductive pole.

The insulation between the metallic supporting strand and the conductive pole shall have the following characteristics:

- The insulation withstand voltage shall be equal to or higher than 4 kV or the phase-to-earth voltage of the power line in joint-use of poles, whichever is higher.

- When in joint-use with a medium voltage power line, the strand insulation breakdown voltage shall be lower than the withstand voltage of the other components (cable, splices, and distribution boxes).

The strand insulation may be provided by inserting an insulator between the strand and the pole. Ceramic insulators are commonly used for this purpose.

The relations between the insulating characteristics of the telecommunication line components are summarized in Table 2. These relations are intended to achieve the insulation coordination for a telecommunication cable supported by a metallic strand in joint-use of conductive poles with a medium voltage power line. Parameter V_E in Table 2 is the phase-to-earth voltage of the power line. Figure 3 shows a simplified view of a line span, where the most relevant insulations are indicated.

NOTE – If a serviceable telecommunication accessory is installed close to the supporting strand, then it is recommended to apply a low voltage insulating cover on the strand for an extension up to 1 m on each side of the accessory, in order to improve the safety of the service personnel.

Table 2 – Requirements for insulation coordination with a medium voltage line

Insulation	Withstand voltage	Breakdown voltage
Cable outer sheath	$\geq 2\ V_E$ and ≥ 4 kV	–
Strand / pole	$\geq V_E$ and ≥ 4 kV	Smaller than the withstand voltage of the other components
Distribution box / pole	$\geq 2\ V_E$ and ≥ 4 kV	–
Splice / strand or pole	$\geq 2\ V_E$ and ≥ 4 kV	–

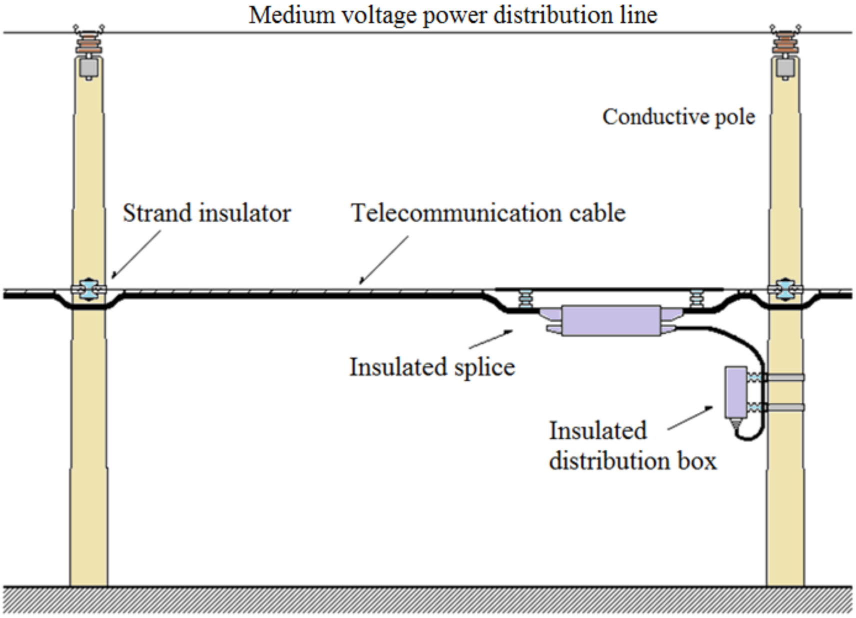

Figure 3 – Simplified joint-use span with the most relevant insulations indicated

11 Bonding and earthing

11.1 Bonding

The adjacent sections of the telecommunication cable metallic sheath shall be bonded together, in order to maintain its electrical continuity. This may require the installation of bonding conductors across the cable splices. The bonding conductor shall have a current carrying capacity equal to or higher than the capacity of the relevant cable sheath.

The adjacent sections of the metallic supporting strand shall be bonded together, in order to maintain its electrical continuity. This may require the installation of bonding conductors across the poles where the strand is terminated. The bonding conductor shall have a current carrying capacity equal to or higher than the capacity of the strand.

The telecommunication cable metallic sheath and the metallic supporting strand shall not be bonded together, in order to maintain the insulation coordination as per clause 10.

11.2 Earthing

The telecommunication cable metallic sheath and the metallic supporting strand shall have independent earthing connections.

The telecommunication cable metallic sheath shall be connected to earth at least at the central office. Additional earthing connections along the line may be necessary in order to provide the desired protection against lightning (e.g., at the transition between underground and aerial installations). Refer to [b-ITU-T K.46] and [b-ITU-T K.47] for details about the lightning protection of telecommunication lines.

The metallic supporting strand shall have earthing connections distributed along the line, so that any power-cross with a medium voltage power line will drain a current sufficiently high to trip the overcurrent protection of the power line. In order to do that, the following is required:

- The resistance to earth at every point of the supporting strand shall be significantly lower than the fault resistance value considered by the power utility to set the tripping threshold of its protective equipment (e.g., circuit breaker), in case of a line-to-earth fault.

It should be highlighted that the resistance to earth of the supporting strand (R_{eq}) refers to the parallel association of all earthing resistances (R_g) connected to the strand network, taking into account the series resistance (R_s) of the strand itself, as shown in Figure 4. For instance, considering $R_g = 30\ \Omega$ and $R_s = 5\ \Omega$, the resistance to earth of the supporting strand in Figure 3 has the following values:

$$R_{eq}(1) = R_{eq}(5) = 14.2\ \Omega,$$

$$R_{eq}(2) = R_{eq}(4) = 13.6\ \Omega, \text{ and}$$

$$R_{eq}(3) = 12\ \Omega.$$

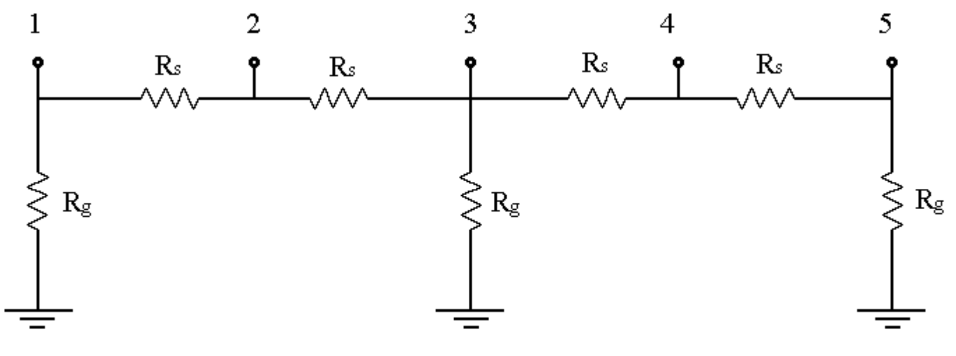

Figure 4 – Resistance to earth of the telecommunication supporting strand

The maximum value of the resistance to earth provided by the telecommunication supporting strand shall be significantly lower than the value considered by the power utility in order to allow a safety margin due to the seasonal variations of earthing resistances and also due to the accidental loss of an earthing connection. This Recommendation suggests a safety factor of 0.5, which means that an upper limit value of 20 Ω should be used for joint-use of poles with a power utility that considers 40 Ω as the maximum earth fault impedance.

The earthing connections of the telecommunication line shall be insulated from the joint-use conductive pole by means of an insulated down-conductor or by a bare down-conductor inserted inside a plastic conduit. In both cases, the insulation level shall comply with the cable insulation requirement, as per clause 10.1. This insulation shall be maintained at least up to 0.2 m at the aerial extremity and 2 m at the pole base, as shown in Figure 5.

There shall be no earthing connection of the telecommunication line at poles that carry an earthing conductor of the power line (e.g., neutral earthing).

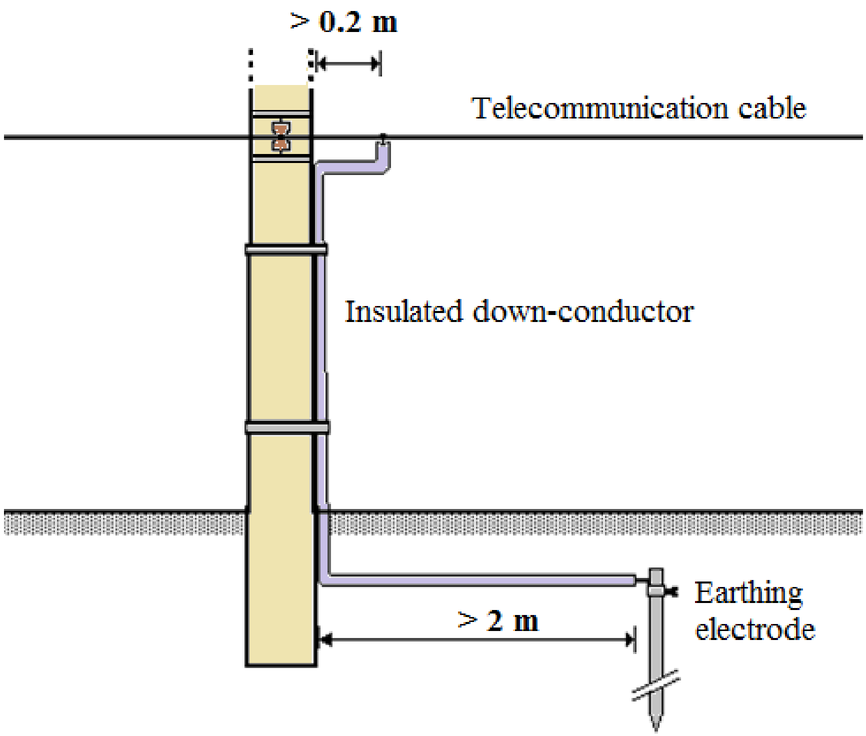

Figure 5 – Insulated down-conductor for telecommunication line earthing

Appendix I

Rationale for the insulation coordination

(This appendix does not form an integral part of this Recommendation.)

The insulation coordination is intended to direct the overcurrent through a path away from the telecommunication cable core when there is an insulation failure in the power line. There are several reasons that can cause such overcurrent, such as a crack in the power line insulator, a tree branch falling across the insulator, flashover due to lightning, etc.

Once there is a failure of the insulation between the power line conductor and a conductive pole, an overcurrent will flow to the ground through the pole foot. As a result, the pole potential will rise. If the insulation failure is due to mechanical reasons (e.g., crack of a ceramic insulator), the pole potential will be limited to the line-to-earth voltage of the power line. Therefore, if the insulation between the telecommunication strand and the pole can withstand this voltage, the current flow will not involve the telecommunication line.

This situation is illustrated in Figure I.1, where a failure of the power conductor leads to a current flow through the pole, but the insulation between the telecommunication strand and the pole prevents the power current from reaching the telecommunication cable. For instance, if the power line is rated at 13.8 kV, then its line-to-earth voltage is 8.0 kV. If the insulator of the telecommunication strand can withstand 8.0 kV, then the power current will not flow through the telecommunication line and the insulation coordination is achieved.

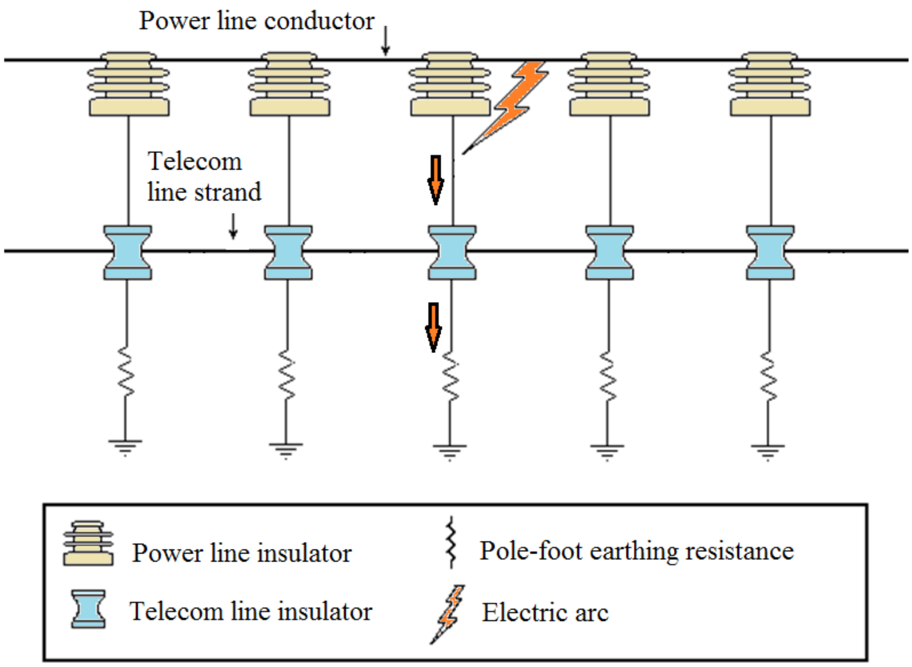

Figure I.1 – Insulation coordination resulting from a mechanical failure of the power line insulation

Besides mechanical failure, the power line insulation may also breakdown due to overvoltages. The most common causes of such overvoltages are lightning flashes, either striking the line directly or striking nearby structures. In this case, the potential rise of the pole is not limited to the power line voltage, as part of the lightning surge may flow through the pole. Therefore, a flashover may occur across the telecommunication strand insulator. This effect is similar to the back-flashover of an overhead power transmission lines struck by lightning.

However, as the strand is held by the same insulator in nearby poles, there will be flashovers from the strand to earth in these poles. As a result, the strand will act as an overhead earth wire and limit its potential with respect to earth at a value close to the breakdown voltage of its insulator. Therefore, if the withstand voltage of the cable conductors with respect to the strand and to the pole is higher than the breakdown voltage of the strand insulator, then no overcurrent will reach the cable core.

This situation is shown in Figure I.2, where the power line insulation flashes over under a lightning induced voltage. The overcurrent reaches the strand due to the breakdown of the strand insulator at the central pole, and leaves the strand toward the earth due to the breakdown of the nearby strand insulators. For instance, if the breakdown voltage of the strand insulator is 15 kV and the withstand voltage of the cable outer sheath is 20 kV, then the insulation coordination is achieved.

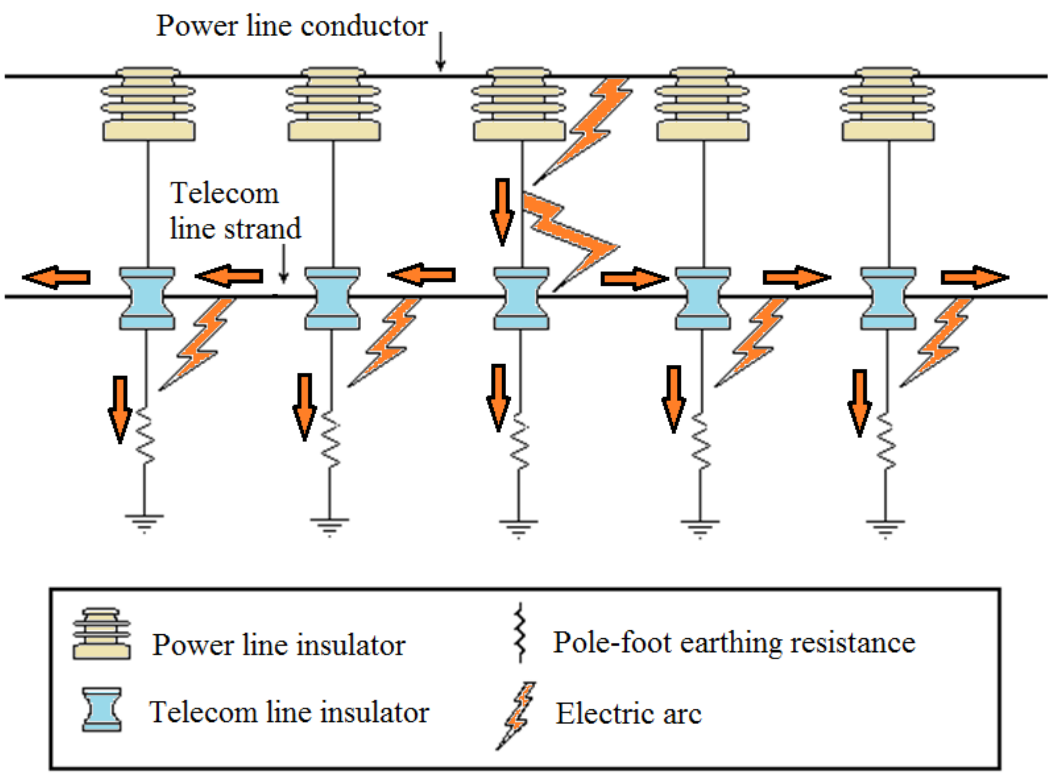

Figure I.2 – Insulation coordination resulting from a flashover of the power insulator due to an overvoltage

Bibliography

[b-ITU-T K.26]	Recommendation ITU-T K.26 (2008), *Protection of telecommunication lines against harmful effects from electric power and electrified railway lines.*

[b-ITU-T K.46]	Recommendation ITU-T K.46 (2012), *Protection of telecommunication lines using metallic symmetric conductors against lightning-induced surges.*

[b-ITU-T K.47]	Recommendation ITU-T K.47 (2012), *Protection of telecommunication lines against direct lightning flashes.*

[b-IEC 60050]	IEC 60050 (2010), *International Electrotechnical Vocabulary*.

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