International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

K.64
(06/2020)

SERIES K: PROTECTION AGAINST INTERFERENCE

Safe working practices for outside equipment installed in particular environments

Recommendation ITU-T K.64

ITU-T

Recommendation ITU-T K.64

Safe working practices for outside equipment installed in particular environments

Summary

Recommendation ITU-T K.64 describes working practices for service personnel to help them work safely in telecommunication installations in three specific environments.

The specific environments covered in this Recommendation are characterized by wet conditions or close proximity to exposed metallic parts.

The working practices apply to telecommunication plants with voltage levels higher than the limits defined for analogue PSTN circuits, such as remote feeding telecommunication current or voltage (RFT-C or RFT-V) circuits.

This version of Recommendation ITU-T K.64 includes a warning regarding contact with terminals carrying RFT circuits with small parts of the body, e.g., back of the hand. The references have been updated to include the IEC 62368 series.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T K.64	2004-02-29	5	11.1002/1000/7147
2.0	ITU-T K.64	2011-01-13	5	11.1002/1000/11035
3.0	ITU-T K.64	2016-06-29	5	11.1002/1000/12874
4.0	ITU-T K.64	2020-06-29	5	11.1002/1000/14294

Keywords

ITU-T K.50, IEC 60950, IEC 62368, RFT, RFT-C, RFT-V, safe, TNV, work practices.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). 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, 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/.

Table of Contents

Introduction

Network operators, in their telecommunication infrastructure, use equipment that is remotely powered by symmetrical or coaxial pair cables. The voltages and currents that power these systems differ among them and comply with the limit values defined in [IEC 60950-1], [[IEC 60950-21], and [IEC 62368] series for symmetrical pair cables and in [IEC 60728-11] for coaxial cables. The limits in these standards have been defined to allow service personnel to work safely on these lines without de-energizing the circuits.

Nevertheless, there are telecommunication environments that necessitate additional precautions to enable service personnel to work safely on circuits that are usually considered safe to touch. These environments are characterized as wet conditions, sometimes associated with standing water. This Recommendation lists three practical situations where additional precautions are needed and defines how the service personnel should perform work to reduce risk associated with these situations.

Specific applications, local conditions or regulations may give rise to a need for additional safeguards or modifications to practices presented in this Recommendation.

Recommendation ITU-T K.64

Safe working practices for outside equipment installed in particular environments

1 Scope

The scope of this Recommendation is to provide working procedures for maintenance activities in specific environments for telecommunication plants with voltage levels higher than the limits defined for analogue public switched telephone network (PSTN) circuits. The specific environments covered in this Recommendation are characterized by wet conditions or close proximity to exposed metallic parts.

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.50] Recommendation ITU-T K.50 (2018), *Safe limits for operating voltages and currents for telecommunication systems powered over the network*.

[IEC 60479-1] IEC 60479-1 Ed. 4.0 :2018, *Effects of current on human beings and livestock – Part 1: General aspects*.

[IEC 60728-11] IEC 60728-11: Ed. 3.0: 2016, *Cable networks for television signals, sound signals and interactive services – Part 11: Safety*.

[IEC 60950-1] IEC 60950-1: Ed. 2.0: 2005, *Information technology equipment – Safety – Part 1: General requirements*.

[IEC 60950-21] IEC 60950-21: Ed. 1.0: 2002, *Information technology equipment – Safety – Part 21: Remote power feeding*.

[IEC 62368-1] IEC 62368-1: 2018, *Audio/video, information and communication technology equipment – Part 1: Safety requirements.*

[IEC 62368-3] IEC 62368-3: 2017, *Audio/video, information and communication technology equipment – Part 3: Safety aspects for DC power transfer through communication cables and ports.*

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 analogue public switched telephone network (PSTN) circuit: A telecommunication network voltage (TNV) circuit (see clause 3.2.9) operating at voltages less than or equal to 90 V d.c. with cadenced ringing signals complying with [IEC 60950-1].

3.2.2 cable TV (CATV) circuit: An interface circuit for a cable distribution system intended for transmission of video, data and/or audio signals between separate buildings or between outdoor antennas and buildings.

NOTE – CATV circuits remotely powered, i.e., circuits on feeder between the optical node unit and the last line amplifier, are only considered in this Recommendation.

3.2.3 dry conditions: An environmental condition in which the resistance of the skin and to the body is not reduced with respect to the value defined in [IEC 60479-1].

3.2.4 environment classification: The environments considered by this Recommendation are classified as follows:

– Environment type 1: environment with the floor in wet conditions, sometimes with standing water (for example, manholes, vaults, trenches);

– Environment type 2: environment with wet walls and confined working space (for example, vaults) such that the wet wall may be in contact with the person's body and producing (in the case of hand contact with an energized part) a current path different to the hand-to-feet current path;

– Environment type 3: environment with confined working space and existing extraneous metallic parts (for example, facilities of other services); during the operations, large areas of the metallic parts (e.g., metallic tower for radio link) are in continuous contact with the body.

3.2.5 insulated tool: A tool, such as a screwdriver, scissor, or pliers, having an insulated handle that may be used by service personnel during his operations on telecommunication equipment or cable.

3.2.6 RFT-C circuit: A remote feeding telecommunication circuit that is so designed and protected that under normal operating conditions and single fault conditions, the currents in the circuit do not exceed defined values.

NOTE – The current limit values under normal operating and single fault conditions are specified in [ITU-T K.50] or [IEC 60950-21] or [IEC 62368-3].

3.2.7 RFT-V circuit: A remote feeding telecommunication circuit that is so designed and protected that under normal operating conditions and single fault conditions, the voltages are limited and the accessible area of contact is limited.

NOTE – The voltage limit values under normal operating and single fault conditions are specified in [ITU-T K.50] or [IEC 60950-21] or [IEC 62368-3].

3.2.8 service personnel: A person having appropriate technical training and experience necessary to be aware of hazards, to which that person may be exposed in performing a task, and of measures to minimize the risks to that person or other persons.

3.2.9 telecommunication network voltage (TNV) circuit: A circuit in the equipment to which the accessible area of contact is limited and that is so designed and protected that, under normal operating conditions and single fault conditions, the voltages do not exceed specified limit values.

3.2.10 user: Any person other than service personnel.

3.2.11 vault: An underground chamber (manhole, pit, exchange or high rise building cable entry) or above ground pedestal or cabinet used to accommodate communication equipment such as joint closures, housings and/or electronic equipment installed in the external plant environment.

3.2.12 wet condition: An environmental condition in which the resistance of the skin and to the body is reduced with respect to the value defined in [IEC 60479-1].

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC Alternating Current

CATV Cable TV

CCP Cross-Connection Point

ES Energy Source

ES1 Energy Source class 1

ES2 Energy Source class 2

MDF Main Distribution Frame

PSTN Public Switched Telephone Network

RFT-C Remote Feeding Telecommunication – Current circuit

RFT-V Remote Feeding Telecommunication – Voltage circuit

RMS Root Mean Square

SELV Safety Extra Low Voltage

TLC Telecommunication

TNV Telecommunication Network Voltage

DC Direct Current

5 Conventions

None.

6 Telecommunication particular workplaces

Safety standards recognize that voltage levels defined as safe to touch in normal conditions may present a hazard to service personnel in damp conditions. For example, it is recognized that even safety extra low voltage (SELV) circuit limits may present a risk of electric shock for a person when such circuits are used in a wet environment. For this reason, the voltage limit for parts touchable by a person is equal to half the value of the limit applicable in dry environments.

Obviously, it is not possible to reduce the voltages usually present on a telecommunication line in order to have the same safe conditions within a wet environment when contacted by service personnel. In such cases, recognizing the presence of potentially harmful energy sources, the behaviour of service personnel becomes an effective means to prevent injury. Therefore, there is the need to follow safe working practices when equipment maintenance is necessary and a dry environment is not possible. This approach is possible because the service personnel are skilled and trained.

An example of such work is the maintenance activities inside a manhole or, in general, in a vault where the presence of water at the bottom is as likely as that of infiltration water on the internal walls. Sometimes, the confined space of the workplace hinders the maintenance of the equipment and increases the likelihood that the current path through the person's body will differ from the hand-to-feet current path. Lastly, service personnel may accidentally make an adverse, large-area contact with energized conductors. This could happen, for instance, if one hand holds a tool fastened to the energized conductor while the other hand, or another body part, is in full contact with an earthed conductor.

Summarizing, there are three particular environments that may present safety hazards to the service personnel that operates a telecommunication (TLC) plant:

1) Environment type 1: wet conditions (see clause 3.2.4);
2) Environment type 2: confined working space in wet conditions (see clause 3.2.4);
3) Environment type 3: confined working space contacting extraneous metallic parts (see clause 3.2.4).

To reduce the risk of electric shock associated with the maintenance activities performed in such an environment, service personnel shall follow simple and effective working practices, as described in clause 8.

7 Voltage levels on TLC installations

[IEC 60950-1] allows voltage levels, not higher than 70.7 V (peak) or 120 V d.c., on symmetrical pair cables of telecommunication networks type TNV-2 and TNV-3. These TNV circuits, accessible to skilled personnel only, are safe for an ordinary environment (dry conditions) but in wet conditions the contact with TNV circuits at voltages greater than analogue PSTN voltages (see clause 3.2.1) may be dangerous for service personnel due to a reduction of the contact impedance.

[IEC 62368-1] has energy sources (ESs) with maximum DC operating voltages equivalent to TNV levels. ES1 limits are DC 60 V at DC 2 mA and 70 V rms at 0.5 mA rms. ES2 limits are DC 120 V at DC 25 mA and 140 V rms at 5 mA rms.

The voltage levels used in a coaxial cable distribution network are defined in [IEC 60728-11]. Voltage levels between the inner and outer conductor of up to 65 V rms, 120 V d.c. are allowed. It must be considered that such voltage levels shall be completely inaccessible to the user and service personnel may access these voltages only after removing, with a tool, the equipment cover.

[IEC 60950-21] has introduced remote feeding telecommunication circuits limited in current (RFT-C) or in voltage (RFT-V). Both circuits are suitable for barehanded contact by service personnel in powered state, in line with [ITU-T K.50]. [IEC 62368-3] also incorporates RFT-V and RFT-C limits.

Table 1 summarizes the voltage levels that may be present on a telecommunication line under normal conditions for different types of circuits in the network [IEC 60950-1], [ITU-T K.50], [IEC 60728-11], [IEC 60950-21], [IEC 62368-1] and [IEC 62368-3]. These voltage levels are based on the assumption that the surface contact area is not greater than 1 cm^2 in order to limit body impedance in the hand-to-feet path to more than 5 kΩ.

Table 1 – Voltages on TLC lines in normal conditions for different types of circuits in the equipment powering the network

Type of circuit	V d.c. max [V]	V a.c. max [V]
TNV	120 (ES2)	70.7 (peak value)
RFT-C	±400 (Note 1)	N.A.
RFT-V	±140 (Note 2)	N.A.
CATV	120	65 (rms)

NOTE 1 – This value applies if the voltage rating of the wiring of the telecommunication network is not specified. If it is specified, the supply voltage shall be limited to this value or to a maximum value of 1500 V (see [ITU-T K.50]).

NOTE 2 – Or ±200 V if the short circuit current is limited to 10 mA d.c. (see [ITU-T K.50]).

Essentially, the current flowing through the body determines human responses to electrical stimuli. Voltage is important because, together with the body impedance, it determines the current through the body.

The previous voltage and current limits have been calculated using the 'let-go' limit. This defines the threshold at which inability to release the energized conductor occurs. In the case of limited voltage circuits, e.g., TNV and RFT-V circuits, the voltage limits have been defined using a body impedance of 5 kΩ. This introduces a margin of safety into the limit in case a current path through a body is created because higher values of body impedance may be encountered in practice, as indicated by [IEC TS 60479-1] (small contact surface area).

Working practices performed on live conductors affect the likelihood that a possible physiological response may occur. The likelihood of specific response of the body occurring at a specific voltage level depends on the precautions adopted whilst working on those live parts. These precautions may be very simple for lower voltages but can include the disconnection of the power feeding on the cable or on the equipment before working.

The safety precautions described below allow service personnel to work safely in the specific environments defined in this Recommendation.

NOTE – The possible effects of induced voltages on telecommunication lines are under study.

8 Work practices on TLC plants in particular environments

Work on telecommunication installations under normal conditions as well as in the specific environments considered in this Recommendation (Environment types 1, 2 or 3) shall only be performed by skilled service personnel following well-defined safe working procedures.

This Recommendation requires, first of all, the classification of the telecommunication installation where it is necessary to work; practically the installations with voltages from TNV, RFT-C, RFT-V or coaxial cable circuits have to be indicated. Prior to starting work, this Recommendation requires that service personnel assess the risk by determining the voltage classification in the telecommunication facilities (e.g., by consulting records/maps (plans) of the TLC facilities in which information on the type of service is reported).

For conductors with voltages higher than that of the analogue PSTN service, labels or insulated markers (e.g., coloured plastic collets) should be installed at the main distribution frame (MDF) and at accessible cross-connection points (CCPs) along the route to clearly indicate both the service and the voltage. In these cases, the safety precautions described in clauses 8.1 and 8.2 (Figure 1) shall be followed.

8.1 Switching off the power supply

Electrical works on TLC installations in environment types 1, 2 or 3 should be performed, preferentially, with the power supply switched off or by using insulating or disconnect or shorting devices at the MDF and other suitable CCPs, on the conductors carrying the potentially hazardous voltage levels that fall within the scope of this Recommendation.

Where practicable, a temporary notice should also be placed at the MDF clearly indicating the necessity to leave in place the insulating or disconnect devices or not to change the switch position due to works in progress on the line.

Nevertheless, the warning shall be considered sufficient only if the disabling devices are used in places where the access is limited to service personnel; otherwise, it is required to lock the disabling devices in their "Off" position.

Once the work has been completed, the power supply may be reconnected only after the service personnel have made the installation safe.

At the MDF, those conductors carrying voltage levels from RFT-V or RFT-C circuits should be labelled. Unintentional contact between conductors from different power feeding circuits, even of the same type, should be avoided, e.g., by providing insulating shielding covers.

Prior to the commencement of work, service personnel are required to verify, through use of an appropriate measuring instrument, the absence of voltages exceeding analogue PSTN limits (see clause 3.2.1) on all conductors where it is necessary to operate.

8.2 Practices to be used when working on live telecommunication circuits

Where it is not practicable to disconnect the power feed to those parts that may be touched barehanded by service personnel under the specified environment, tools with insulated handles or other effective insulated protection devices (e.g., insulated gloves and/or rubber boots in type 1 environment) should be used.

For the different environment types defined in this Recommendation, it is necessary to adopt the following safety precautions[1]:

– Environment type 1: if voltages on TNV or RFT-V circuits with no current limitation are higher than 105 V d.c., it is necessary to use insulated connectors or tools with insulated handles to avoid bare hand contact with conductors, and/or rubber insulating boots to prevent moisture contact with the feet/legs.

– Environment types 2 and 3: if voltages on TNV or RFT-V circuits with no current limitation are higher than 90 V d.c., it is necessary to use insulated connectors or tools with insulated handles, insulated boots or insulated gloves.

  Environment types 2 and 3: if voltages on coaxial cables are higher than 60 V rms, it is necessary to use insulated connectors or tools with insulated handles.

When work is performed on live parts, it is essential that possible earth faults or leakage currents (see [ITU-T K.50]), in particular with floating power systems that may originate dangerous touch currents (RFT-C circuits), be detected by measurement, and that the low impedance to earth fault of the one line conductor be removed before beginning work.

These safety precautions for live working on different types of environment are summarized in Table 2.

When working close to other telecommunication live parts different from PSTN circuits, if service personnel is unable to use special protection devices, the worker should be careful to maintain his hands sufficiently far away from those live parts.

Particular care should be taken when working on, or near, terminals carrying RFT circuits. If terminals carrying an RFT circuit are bridged to a small part of the body, e.g., back of the hand or a finger, a higher than normal current can occur, resulting in a painful shock and a burn at the contact points. This higher than normal current is due to the lower resistance between the contact points, compared to a hand-to-hand contact.

[1] The values indicated are calculated in Appendix I.

Table 2 – Safety precautions for live working in different types of environment

Environment	TNV circuit	RFT-C circuit	RFT-V circuit with no current limitation	CATV circuit
Environment type 1: wet conditions.	If above 105 V d.c., use insulated connectors or tool handles.	Touch only one conductor and check for earth faults on the line.	If above 105 V d.c., use insulated connectors or tool handles.	No specific precautions given.
Environment type 2: confined working space in wet conditions.	If above 90 V d.c., use insulated connectors or tool handles.	Touch only one conductor and check for earth faults on the line.	If above 90 V d.c., use insulated connectors or tool handles, insulated gloves, or boots.	If voltages are above 60 V rms, use insulated connectors or tool handles.
Environment type 3: confined working space contacting extraneous metallic parts.	If above 90 V d.c., use insulated connectors or tool handles.	Touch only one conductor and check for earth faults on the line.	If above 90 V d.c., use insulated connectors or tool handles, insulated gloves, or boots.	If voltages are above 60 V rms, use insulated connectors or tool handles.

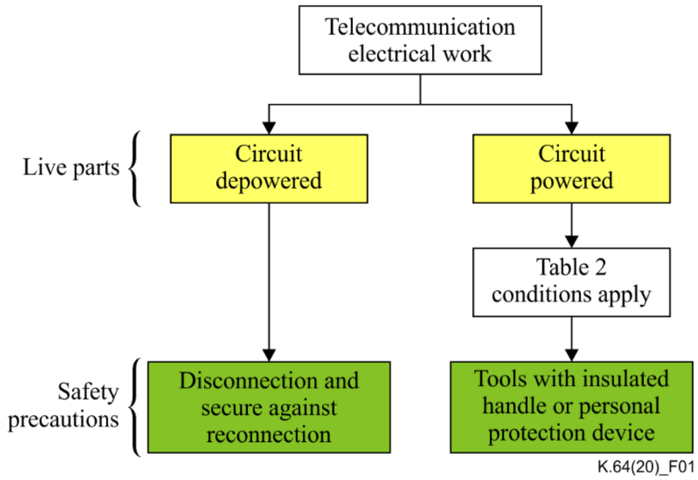


Figure 1 – Scheme for safety procedures in particular environments (see clause 3.4)

9 Work on telecommunication installations at risk of electric shock

Usually, work performed on a telecommunication plant may consist of one of the following activities:

– maintenance or replacement of equipment;

– operations on cables.

NOTE – This Recommendation is concerned only with the above two points because it is considered that prior to the plant's first activation, it is switched off and so is not dangerous in the sense given in this Recommendation.

9.1 Work on equipment or devices (terminal box, etc.)

Equipment installed in environments at risk of electric shock shall have a warning mark clearly visible on its enclosure to remind service personnel of the need to use the appropriate safety procedures.

In an environment like a manhole, installation and siting of equipment should take into account the need to perform maintenance activities. Where possible, consideration should also be given in the installation and siting of equipment to allow ease of operations in the workplace. One example of this is the use of cables long enough to allow equipment within the manhole to be either:

– temporarily removed from the manhole entirely and placed on the road surface;
– raised from the floor of the manhole to a level at which maintenance may be performed from the outside.

Unless the road surface is wet, the operation in these conditions is comparable to that performed in an ordinary environment.

When it is necessary to operate in an environment such as a vault, then, considering the likely limited freedom of movement, the working procedure must be subordinated to the nature of the operation.

For such a purpose, as far as maintenance activities on line or terminal equipment are concerned, it is possible to distinguish the following cases:

1) Electrical measurements: it is required that the measurement instruments and their accessories have an insulation level adequate to the expected voltages present on the telecommunication line.
2) Maintenance by removal or insertion of components directly extractable.
3) Maintenance with action by hand directly on components without accessible parts at dangerous voltages.
4) Maintenance with action by hand on components having accessible parts at dangerous voltages.

Only when the operation should be performed on accessible parts of live equipment is it necessary to use tools with insulated handle. In other cases, service personnel will not experience harmful effects and so bare hand operation is possible.

Replacement of equipment shall be performed only after the power supply has been switched off.

9.2 Work on cables

Generally, work on a cable can be safely carried out if the cable sheath is not open or, after its opening, it is not possible to touch the internal conductors with remote power feeding voltages higher than analogue PSTN limits.

The external conductor of a coaxial cable or the plastic insulation of pair cable conductors shall not be damaged during the work.

During normal activities performed on cables, e.g., splice making, contact may occur with the entire span of the hand or even hand to hand. Such possibilities shall be avoided. Therefore, splicing techniques that do not remove the insulation of the conductors are preferred.

Two kinds of splicing are possible on cables:

1) making a new splice involving all the conductors of the cable;
2) remaking a splice involving some conductors of the cable.

The first case may occur, e.g., when a cable has been cut in the field, and since the telephone service is down, it may be convenient to disconnect the power supply on all conductors with voltage levels higher than analogue limits (PSTN services) to protect service personnel making the splice in an environment at risk of electric shock.

In the second case, two methods may be used:

1) identify the pairs in the splice with voltages exceeding analogue PSTN limits using instruments like "pair-finders" or by traditional methods that require service personnel to proceed by trial and error, contacting the conductors one by one in order to identify them at the exchange on the network side. Label them to avoid unwanted contacts. This may be the easiest method with paper insulated conductors;

2) use insulated tools to avoid conductive paths to earth. This may be the most practicable method for plastic insulated conductors.

The conductors with voltage levels higher than the analogue limits (PSTN services) shall be interrupted at the MDF/CCP with suitable insulators/disconnectors or shorting devices unless splicing is performed without the likelihood of skin contact with bare conductors by using suitable personal protective devices and practices described in clause 8.2.

As for equipment, the service personnel shall ensure, first of all, that cable conductors are not powered. Operation on the cable prior to verification that the power remote feeding has been switched off shall be performed using insulated tools.

Appendix I

Rationale of safe voltage limit values for workplace at major risk of electric shock

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

This appendix describes the rationale leading to the safe voltage limit values shown in Table 2 for human safety while operating on TNV, RFT-V and CATV circuits in a workplace at major risk of electric shock.

The calculations are done according to [IEC 60479-1] determining voltage and current values that, in the case of human body contact with active parts of a telecommunication plant, do not generate dangerous situations for trained personnel.

I.1 Operating cases

With reference to the environment type classification for electric shock risk, defined in clause 3.2.4, different operating conditions, which could determine different effects on the human body, have been identified.

They depend substantially on the type of contact of the body with the telecommunication plant and the ground, and the site's environmental conditions.

The body parts which can come into contact with the telecommunication plant and the ground are:

– hands;

– back;

– seat;

– feet.

I.2 Calculation assumption

Calculations have to determine the contact voltage limit originated by touching the telecommunication plant that, based on the human body impedance value in the contact path (Z), generates no dangerous current for people.

For this, refer to [IEC 60479-1], which considers this impedance Z constituted by:

$$Z = Z_b + Z_c$$

where:

Z_b is a partition of human body impedance, function of surface contact and touch voltage, developing through the current path considered;

Z_c is the touch ground impedance.

Figure I.1 shows the human body impedance, function of surface contact and touch voltage Z_T, through the hand-to-hand path.

To obtain the Z_b value, it is necessary to calculate the human body impedance partition, in the path interested by the contact, with respect to such impedance Z_T.

Such partition can be obtained by using Figure I.2.

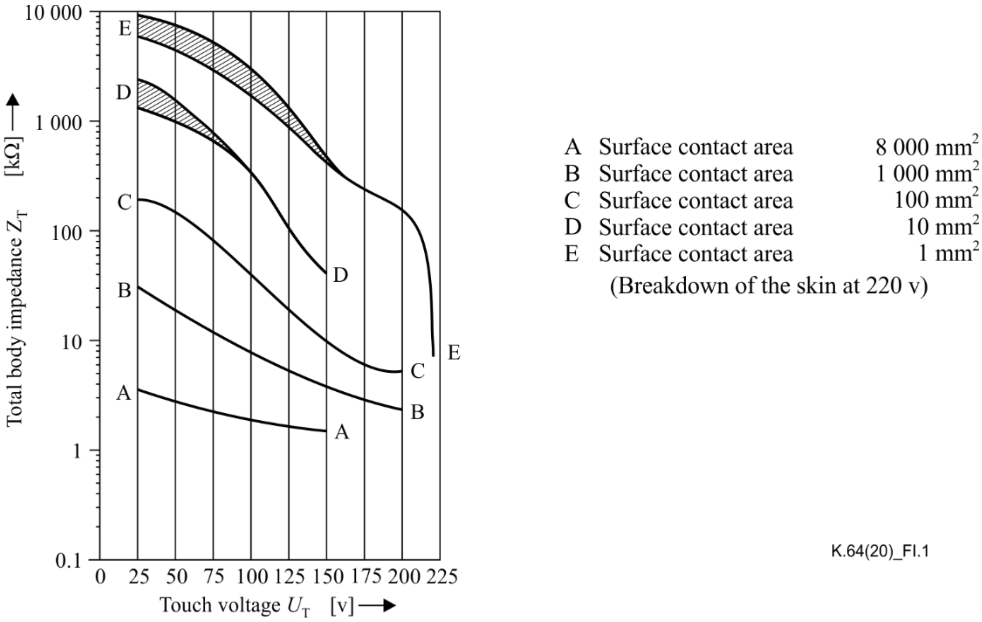


Figure I.1 – Human body impedance for hand-to-hand path

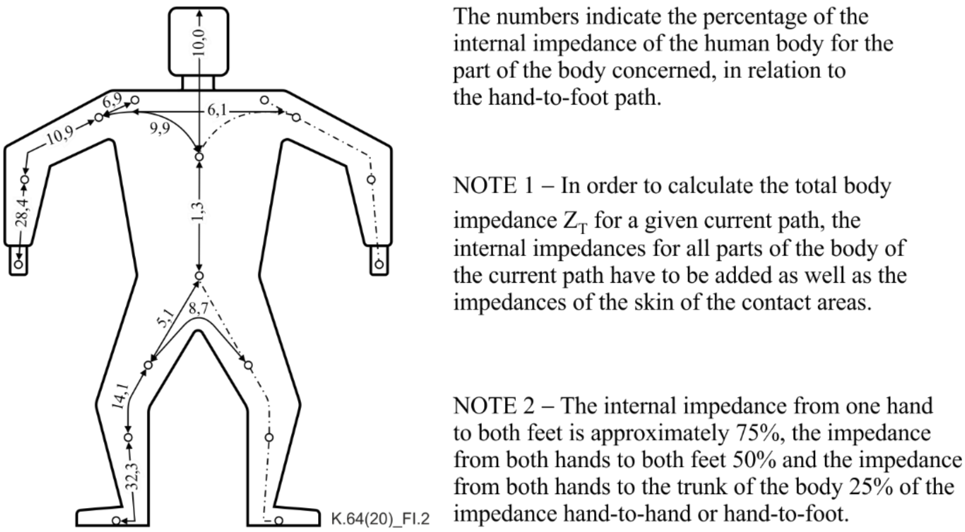


Figure I.2 – Percentage of the human body internal impedance in relation to the hand-to-foot path

Therefore:

$$Z_b = k \times Z_T$$

where *k* is the sum of percentages met in the considered path.

Although, according to [IEC 60950-1], the surface contact to be considered is 100 mm^2 (fingertip dimension), this calculation should take into consideration the possibility that the operator, while using insulated tools, accidentally touches active telecommunication parts with the whole finger. Therefore, this surface is assumed to be 1 000 mm^2, and consequently curve B of Figure I.1 should be taken into account.

Regarding body impedance contact with ground Z_c, it is assumed that:

– floor and walls are always wet or damped and their impedance is assumed no greater than 200 Ω;

– the impedance of wet or damp shoes is 1 000 Ω [b-CENELEC HD 637];

– metallic parts impedance is assumed to be 0 Ω.

Therefore, cases to be analysed are those shown in Table I.1, considering negligible the difference between back and seat path (1.3%).

Table I.1 – Analysis cases

Case	Environment type	Contact path	Condition of shoes	Impedance contact with floor, wall or metallic parts	% impedance of human body with respect to the path [K]
1	1	hand-feet	wet or damp	1 200 Ω	75
2		hands-feet			50
3		hand-foot			100
4	2	hand-hand		200 Ω	100
5		hand-seat			50
6		hands-seat			25
7	3	hand-hand		0 Ω	100
8		hand-seat			50
9		hands-seat			25

I.3 Limit current calculation

The level of danger of current flowing through the human body is related to its intensity and its duration.

Figure I.3 shows the zone limits for different physiological effects for the human body and their description related to alternating current.

Figure I.4 shows the zone limits for different physiological effects for the human body and their description related to direct current.

Such current values can change depending on the different current paths through the human body; the factor taking into account this fact is the so-called "heart-current factor", *F*, whose value is specified in Table I.2.

Therefore:

$$I_h = \frac{I_{ref}}{F}$$

where:

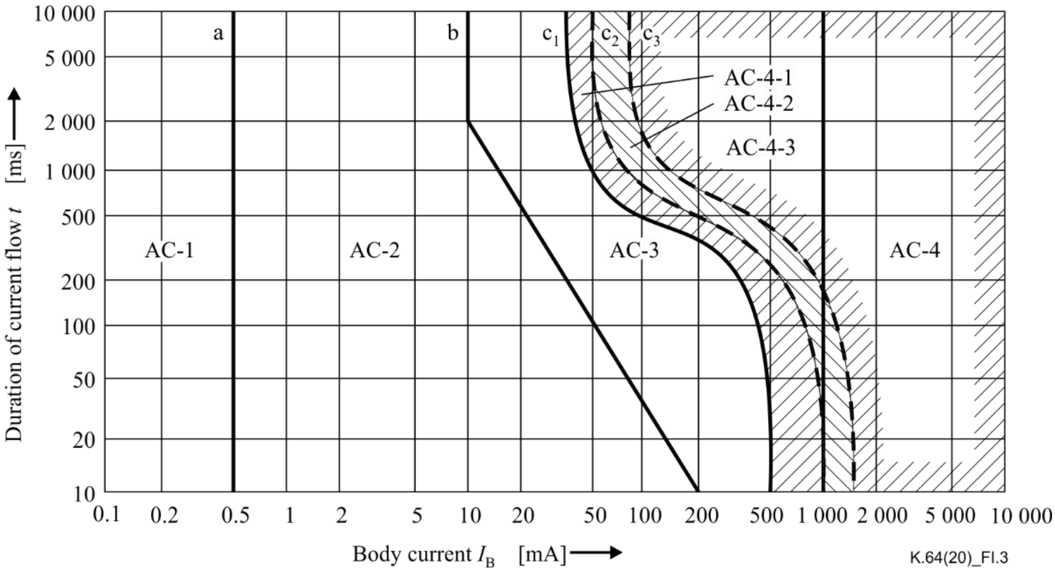
I_{ref} is the reference current in Figures I.3 and I.4

I_h is the current for different paths indicated in Table I.2

In case of similar paths, the most precautionary *F* value has to be considered.

Table I.3 shows the limit values for a.c. and d.c. with respect to the "b" curve.

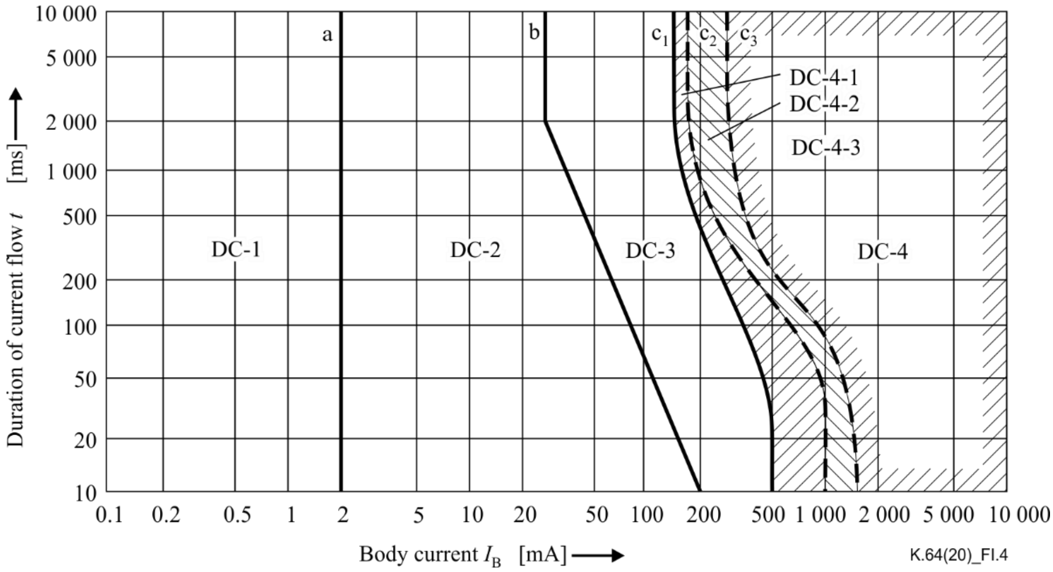
Table I.4 shows the limit values for a.c. and d.c. with respect to the "c_1" curve.



Zone descriptions

Zone designation	Zone limits	Physiological effects
AC-1	Up to 0.5 mA line a	Usually no reaction.
AC-2	0.5 mA up to line b (Note)	Usually no harmful physiological effects.
AC-3	Line b up to curve c_1	Usually no organic damage to be expected. Likelihood of cramp like muscular contractions and difficulty in breathing for durations of current-flow longer than 2 s. Reversible disturbances of formation and conduction of impulses in the heart, including a trial fibrillation and transient cardiac arrest without ventricular fibrillation increasing with current magnitude and time.
AC-4	Above curve c_1	Increasing with magnitude and time, dangerous pathophysiological effects such as cardiac arrest, breathing arrest and severe burns may occur in addition to the effects of zone 3.
AC-4.1	$c_1 – c_2$	Probability of ventricular fibrillation increasing up to about 5%.
AC-4.2	$c_2 – c_3$	Probability of ventricular fibrillation up to about 50%.
AC-4.3	Beyond curve c_3	Probability of ventricular fibrillation above 50%.
NOTE – For durations of current-flow below 10 ms, the limit for the body current for line b remains constant at a value of 200 mA.		

Figure I.3 – Physiological effects of alternating current on human body



Zone descriptions

Zone designation	Zone limits	Physiological effects
DC-1	Up to 2 mA line a	Usually no reaction. Slight pricking pain when switching on or off.
DC-2	2 mA up to line b (Note)	Usually no harmful physiological effects.
DC-3	Line b up to curve c_1	Usually no organic damage to be expected. Increasing with current magnitude and time, reversible disturbances of formation and conduction of impulses in the heart may occur.
DC-4	Above curve c_1	Increasing with current magnitude and time, dangerous pathophysiological effects for example, severe burns, are to be expected in addition to the effects of zone 3.
DC-4.1	$c_1 – c_2$	Probability of ventricular fibrillation increasing up to about 5%.
DC-4.2	$c_2 – c_3$	Probability of ventricular fibrillation up to about 50%.
DC-4.3	Beyond curve c_3	Probability of ventricular fibrillation above 50%.
NOTE – For durations of current-flow below 10 ms, the limit for the body current for line b remains constant at a value of 200 mA.		

Figure I.4 – Physiological effects of direct current on human body

Table I.2 – Heart-current factor

Current path	Heart-current factor *F*
Left hand to left foot, right foot or both feet	1.0
Both hands to both feet	1.0
Left hand to right hand	0.4
Right hand to left foot, right foot or to both feet	0.8
Back to right hand	0.3
Back to left hand	0.7
Chest to right hand	1.3
Chest to left hand	1.5
Seat to left hand, right hand or to both hands	0.7

Table I.3 – a.c. and d.c. limit values with respect to curve b

Case	Environ-ment type	Path contact	Condition of shoes	Impedance contact with floor, wall or metallic parts [Ω]	% impedance of human body with respect to the path [k]	Heart-current factor F	Current reference a.c. for 'b' curve [mA]	Limit current a.c. for 'b' curve [mA]	Current reference d.c. for 'b' curve [mA]	Limit current d.c. for 'b' curve [mA]
1	1	hand-feet	wet or damp	1200	75	1.0	10.0	10.00	30.0	30.00
2		hands-feet			50					
3		hand-foot			100					
4	2	hand-hand		200	100	0.4		25.00		75.00
5		hand-seat			50	0.7		14.29		42.86
6		hands-seat			25					
7	3	hand-hand		0	100	0.4		25.00		75.00
8		hand-seat			50	0.7		14.29		42.86
9		hands-seat			25					

Table I.4 – a.c. and d.c. limit values with respect to curve c_1

Case	Environ-ment type	Path contact	Condition of shoes	Impedance contact with floor, wall or metallic parts [Ω]	% impedance of human body with respect to the path [k]	Heart-current factor F	Current reference a.c. for c_1 curve [mA]	Limit current a.c. for c_1 curve [mA]	Current reference d.c. for c_1 curve [mA]	Limit current d.c. for c_1 curve [mA]
1	1	hand-feet	wet or damp	1 200	75	1.0	40.0	40.00	150.0	150.00
2		hands-feet			50					
3		hand-foot			100					
4	2	hand-hand		200	100	0.4		100.00		375.00
5		hand-seat			50	0.7		57.14		214.29
6		hands-seat			25					
7	3	hand-hand		0	100	0.4		100.00		375.00
8		hand-seat			50	0.7		57.14		214.29
9		hands-seat			25					

I.4 Voltage limit calculation

Voltage limits to be calculated, with respect to identified cases, correspond to the values generating the body impedances in Figure I.1 whose current flowing through the contact path has to be less than the limits shown in Tables I.3 and I.4.

Such calculations are summarized in Table I.5 where voltage value ranges are shown to identify the voltage corresponding to current limit value with respect to "b" curve and to "c_1" curve.

Therefore, it is possible to deduce the following conclusions:

– For environment type 1, there are no critical cases for a.c. voltage because there is no value less than 65 V a.c.; regarding d.c. voltage, the most critical case is the second one because it presents the smallest range of voltage values with respect to the other one having less than 140 V d.c.

– For environment types 2 and 3, the most critical cases are the 6th and the 9th regarding a.c. voltage and d.c. voltage because they present the smallest range of voltage values with respect to the other ones having less than 65 V a.c. and 140 V d.c., respectively.

Via mathematical analysis of the values reported in Table I.5, it is possible to associate the limit current value to the relative voltage and define the following critical values:

– Environment type 1 (Case 2): 105 V d.c.

– Environment types 2 and 3 (Cases 6 and 9): 90 V d.c., 60 V a.c.

Table I.5 – Corresponding voltage limits for curves "b" and "c_1"

Voltage contact [Volt]					25	50	75	100	125	150	175	200	Limit current a.c. for 'b' curve [mA]	Voltage range corres-ponding to limit current a.c. [V]	Limit current d.c. for 'b' curve [mA]	Voltage range corres-ponding to limit current d.c. [V]	Limit current a.c. for 'c_1' curve [mA]	Voltage range corres-ponding to limit current a.c. [V]	Limit current d.c. for 'c_1' curve [mA]	Voltage range corres-ponding to limit current d.c. [V]
Impedance of human body with respect to surface contact and voltage contact [ohm]					**32 000**	**19 000**	**12 500**	**7 800**	**5 000**	**3 800**	**2 900**	**2 200**								
Case	**Environ-ment type**	**Condition of shoes**	**Path contact**																	
1	1	wet or damp	hand-feet	k	75								10	75-100	30	125-150	40	150-175	150	> 200
				Z_b	24 000	14 250	9 375	5 850	3 750	2 850	2 175	1 650								
				Z_c	1200															
				Z	25 200	15 450	10 575	7 050	4 950	4 050	3 375	2850								
				I	**0.99**	**3.24**	**7.09**	**14.18**	**25.25**	**37.04**	**51.85**	**70.18**								
2			hands-feet	k	50									75		100-125		125-150		> 200
				Z_b	1 6000	9 500	6 250	3 900	2 500	1 900	1 450	1 100								
				Z_c	1200															
				Z	17 200	10 700	7 450	5 100	3 700	3 100	2 650	2 300								
				I	**1.45**	**4.67**	**10.07**	**19.61**	**33.78**	**48.39**	**66.04**	**86.96**								
3			hand-foot	k	100									75-100		150		150-175		> 200
				Z_b	32 000	19 000	12 500	7 800	5 000	3 800	2 900	2 200								
				Z_c	1200															
				Z	33 200	20 200	13 700	9 000	6 200	5 000	4 100	3 400								
				I	**0.75**	**2.48**	**5.47**	**11.11**	**20.16**	**30.00**	**42.68**	**58.82**								
4	2		hand-hand	k	100								25	125-150	75	175-200	100	> 200	375	> 200
				Z_b	32 000	19 000	12 500	7 800	5 000	3 800	2900	2200								
				Z_c	200															
				Z	32 200	19 200	12 700	8 000	5 200	4 000	3 100	2 400								
				I	**0.78**	**2.60**	**5.91**	**12.50**	**24.04**	**37.50**	**56.45**	**83.33**								
5			hand-seat	k	50								14.29	75-100	42.86	100-125	57.14	125-150	214.29	> 200
				Z_b	16 000	9 500	6 250	3 900	2 500	1 900	1 450	1100								
				Z_c	200															
				Z	16 200	9 700	6 450	4 100	2 700	2 100	1 650	1 300								
				I	**1.54**	**5.15**	**11.63**	**24.39**	**46.30**	**71.43**	**106.06**	**153.85**								
6			hands-seat	k	25									50-75		75-100		100-125		175-200
				Z_b	8 000	4 750	3 125	1 950	1 250	950	725	550								
				Z_c	200															
				Z	8 200	4 950	3 325	2 150	1 450	1 150	925	750								
				I	**3.05**	**10.10**	**22.56**	**46.51**	**86.21**	**130.43**	**189.19**	**266.67**								

Table I.5 – Corresponding voltage limits for curves "b" and "c_1"

Voltage contact [Volt]					**25**	**50**	**75**	**100**	**125**	**150**	**175**	**200**	**Limit current a.c. for 'b' curve [mA]**	**Voltage range corres-ponding to limit current a.c. [V]**	**Limit current d.c. for 'b' curve [mA]**	**Voltage range corres-ponding to limit current d.c. [V]**	**Limit current a.c. for 'c_1' curve [mA]**	**Voltage range corres-ponding to limit current a.c. [V]**	**Limit current d.c. for 'c_1' curve [mA]**	**Voltage range corres-ponding to limit current d.c. [V]**
Impedance of human body with respect to surface contact and voltage contact [ohm]					**32 000**	**19 000**	**12 500**	**7 800**	**5 000**	**3 800**	**2 900**	**2 200**								
Case	**Environ-ment type**	**Condition of shoes**	**Path contact**																	
7	3		hand-hand	k	100								25	125	75	175-200	100	> 200	375	> 200
				Z_b	32 000	19 000	12 500	7 800	5 000	3 800	2 900	2 200								
				Z_c	0															
				Z	32 000	19 000	12 500	7 800	5 000	3 800	2 900	2 200								
				I	**0.78**	**2.63**	**6.00**	**12.82**	**25.00**	**39.47**	**60.34**	**90.91**								
8			hand-seat	k	50								14.29	75-100	42.86	100-125	57.14	125-150	214.29	> 200
				Z_b	16 000	9 500	6 250	3 900	2 500	1 900	1 450	1 100								
				Z_c	0															
				Z	16 000	9 500	6 250	3 900	2 500	1 900	1 450	1 100								
				I	**1.56**	**5.26**	**12.00**	**25.64**	**50.00**	**78.95**	**120.69**	**181.82**								
9			hands-seat	k	25									50-75		75-100		100-125		150-175
				Z_b	8 000	4 750	3 125	1 950	1 250	950	725	550								
				Z_c	0															
				Z	8 000	4 750	3 125	1 950	1 250	950	725	550								
				I	**3.13**	**10.53**	**24.00**	**51.28**	**100.00**	**157.89**	**241.38**	**363.64**								

Appendix II

Cross reference table of IEC 60950 and IEC 62368 terms

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

Comparison of terms and definitions from the IEC 60950 series that are quoted in this Recommendation and those of the IEC 62368 series. Terms not in the [IEC 62368-1] definitions, but described in the body text, are noted as SUMMARISED.

Table II.1 – Comparison of IEC 60950 series and IEC 62368 series terms

<table>
<tr><th>60950-1/-21 terms</th><th>Similar 62368-1/-3 term</th></tr>
<tr><td>SELV, Safety Extra Low Voltage, circuit
secondary circuit that is so designed and protected that under normal operating conditions and single fault conditions, its voltages do not exceed a safe value

Note 1 – The limit values of voltages under normal operating conditions and single fault conditions (see clause 1.4.14) are specified in clause 2.2. See also Table 1A.
Note 2 – This definition of an SELV circuit differs from the term "SELV system" as used in IEC 61140.
Table 1A – Voltage ranges of SELV and TNV circuits
<table>
<tr><th colspan="2">Overvoltages</th><th colspan="2">Normal operating voltages</th></tr>
<tr><th>Overvoltages from TELECOMMUNICATION NETWORKS possible?</th><th>Overvoltages from CABLE DISTRIBUTION SYSTEMS possible?</th><th>Within SELV CIRCUIT limits</th><th>Exceeding SELV CIRCUIT limits but within TNV CIRCUIT limits</th></tr>
<tr><td>Yes</td><td>Yes</td><td>TNV-1 CIRCUIT</td><td>TNV-3 CIRCUIT</td></tr>
<tr><td>No</td><td>Not applicable</td><td>SELV CIRCUIT</td><td>TNV-2 CIRCUIT</td></tr>
</table>
</td><td>ES1, electrical Energy Source class 1
class 1 electrical energy source with levels not exceeding ES1 limits under normal operating conditions and abnormal operating conditions that do not lead to a single fault conditions and not exceeding ES2 limits under single fault conditions of a basic safeguard
Note 1 – ES1 may be accessible to an ordinary person (user in [IEC 60950-1] terms). ES1 effects are not painful on the body but may be detectable and ignition of combustible materials not likely.
Note 2 – SUMMARISED</td></tr>
</table>

Table II.1 – Comparison of IEC 60950 series and IEC 62368 series terms

<table>
<tr><th>60950-1/-21 terms</th><th>Similar 62368-1/-3 term</th></tr>
<tr><td>TNV, Telecommunication Network Voltage, circuit
circuit that is in the equipment and to which the accessible area of contact is limited and that is so designed and protected that, under normal operating conditions and single fault conditions (see clause 1.4.14), the voltages do not exceed specified limit values
A TNV circuit is considered to be a secondary circuit in the meaning of this standard.
Note 1 – The specified limit values of voltages under normal operating conditions and single fault conditions (see clause 1.4.14) are given in clause 2.3.1. Requirements regarding accessibility of TNV circuits are given in clause 2.1.1.1.
Note 2 – Conductive parts of an interconnecting cable may be part of a circuit as stated in clause 1.2.11.6.
TNV circuits are classified as TNV-1 circuits, TNV-2 circuits and TNV-3 circuits as defined in clauses 1.2.8.12, 1.2.8.13 and 1.2.8.14.
Note 3 – The voltage relationships between SELV and TNV circuits are shown in Table 1A.
Table 1A – Voltage ranges of SELV and TNV circuits
<table>
<tr><th colspan="2">Overvoltages</th><th colspan="2">Normal operating voltages</th></tr>
<tr><th>Overvoltages from TELECOMMUNICATION NETWORKS possible?</th><th>Overvoltages from CABLE DISTRIBUTION SYSTEMS possible?</th><th>Within SELV CIRCUIT limits</th><th>Exceeding SELV CIRCUIT limits but within TNV CIRCUIT limits</th></tr>
<tr><td>Yes</td><td>Yes</td><td>TNV-1 CIRCUIT</td><td>TNV-3 CIRCUIT</td></tr>
<tr><td>No</td><td>Not applicable</td><td>SELV CIRCUIT</td><td>TNV-2 CIRCUIT</td></tr>
</table></td><td>See detailed TNV classes for comparison.</td></tr>
<tr><td>TNV-1, Telecommunication Network Voltage class 1, circuit
TNV circuit
– whose normal operating voltages do not exceed the limits for an SELV circuit under normal operating conditions and
– on which overvoltages from telecommunication networks and cable distribution systems are possible</td><td>ES1 DC voltage on which overvoltages from telecommunication networks and cable distribution systems are possible.
Note – The electrical characteristics are not identical to TNV circuits but will give equivalent level of voltage safety.
ES1, electrical Energy Source class 1
class 1 electrical energy source with levels not exceeding ES1 limits under normal operating conditions and abnormal operating conditions that do not lead to a single fault conditions and not exceeding ES2 limits under single fault conditions of a basic safeguard
Note 1 – ES1 may be accessible to an ordinary person (user in [IEC 60950-1] terms). ES1 effects are not painful on the body but may be detectable and ignition of combustible materials not likely.
Note 2 – SUMMARISED</td></tr>
</table>

Table II.1 – Comparison of IEC 60950 series and IEC 62368 series terms

60950-1/-21 terms	Similar 62368-1/-3 term
TNV-2, Telecommunication Network Voltage class 2, circuit TNV circuit – whose normal operating voltages exceed the limits for an SELV circuit under normal operating conditions and – which is not subject to overvoltages from telecommunication networks	ES2 DC voltage not subject to overvoltages from telecommunication networks. ES2, electrical energy source class 2 class 2 electrical energy source with levels not exceeding ES2 limits under normal operating conditions, abnormal operating conditions, and single fault conditions, but is not ES1. Note1 – ES2 may be accessible to an instructed person (no [IEC 60950-1] equivalent to someone under supervision). ES2 effects are; painful on the body, but not an injury Ignition of combustible materials possible, but limited growth and spread of fire Note 2 – ES2 circuits are not identical to TNV circuits but will give equivalent level of voltage safety. Note 3 – SUMMARISED
TNV-3, Telecommunication Network Voltage class 3, circuit TNV circuit – whose normal operating voltages exceed the limits for an SELV circuit under normal operating conditions and – on which overvoltages from telecommunication networks and cable distribution systems are possible	ES2 DC voltage subject to overvoltages from telecommunication networks. ES2, electrical energy source class 2 class 2 electrical energy source with levels not exceeding ES2 limits under normal operating conditions, abnormal operating conditions, and single fault conditions, but is not ES1. Note 1 – ES2 may be accessible to an instructed person (no [IEC 60950-1] equivalent to someone under supervision). ES2 effects are; painful on the body, but not an injury Ignition of combustible materials possible, but limited growth and spread of fire Note 2 – ES2 circuits are not identical to TNV circuits but will give equivalent level of voltage safety. Note 3 – SUMMARISED
user any person, other than a service person. The term user in this standard is the same as the term operator and the two terms can be interchanged	ordinary person person who is neither a skilled person nor an instructed person
operator see user	See ordinary person

Table II.1 – Comparison of IEC 60950 series and IEC 62368 series terms

60950-1/-21 terms	Similar 62368-1/-3 term
telecommunication network metallically terminated transmission medium intended for communication between equipment that may be located in separate buildings, excluding: – the mains system for supply, transmission and distribution of electrical power, if used as a telecommunication transmission medium; – cable distribution systems; – SELV circuits connecting units of information technology equipment Note 1 – The term telecommunication network is defined in terms of its functionality, not its electrical characteristics. A telecommunication network is not itself defined as being either an SELV circuit or a TNV circuit. Only the circuits in the equipment are so classified. Note 2 – A telecommunication network may be: – publicly or privately owned; – subject to transient overvoltages due to atmospheric discharges and faults in power distribution systems; – subject to longitudinal (common mode) voltages induced from nearby power lines or electric traction lines. Note 3 – Examples of telecommunication networks are: – a public switched telephone network; – a public data network; – an Integrated Services Digital Network (ISDN); – a private network with electrical interface characteristics similar to the above.	information and communication technology network, ICT network metallically terminated transmission medium and its associated equipment and communication cables Note 1 – to entry: The cable consists of two or more conductors intended for communication and/or power transfer between the various pieces of equipment. The equipment may be located within the same or separate structures, buildings or locations, excluding: – the mains system for supply, transmission and distribution of electrical power, if used as a communication transmission medium; – a dedicated HBES/BACS network. Note 2 – to entry: This may include twisted pairs, and may include circuits, that are subjected to transients as indicated by ID1 in Table 14 of [IEC 62368-1]:2014 (assumed to be 1,5 kV). Note 3 – to entry: An ICT network may be: – publicly or privately owned; – subject to longitudinal (common mode) voltages induced from nearby power lines or electric traction lines. Note 4 to entry: Examples of ICT networks are: – a public switched telephone network; – a public data network; – an Integrated Services Digital Network (ISDN); – a private network with electrical interface characteristics similar to the above. Note 5 – to entry: For information about circuit voltages and signals which may be present, see Annex B of IEC 62949:2017.
None	instructed person person instructed or supervised by a skilled person as to energy sources and who can responsibly use equipment safeguards and precautionary safeguards with respect to those energy sources Note 1 – to entry: Supervised, as used in the definition, means having the direction and oversight of the performance of others. Note 2 – to entry: In Germany, in many cases, a person may only be regarded as an instructed person if certain legal requirements are fulfilled.
service person person having appropriate technical training and experience necessary to be aware of hazards to which that person may be exposed in performing a task and of measures to minimize the risks to that person or other persons	skilled person person with relevant education or experience to enable him or her to identify hazards and to take appropriate actions to reduce the risks of injury to themselves and others Note 1 – to entry: In Germany, in many cases, a person may only be regarded as a skilled person if certain legal requirements are fulfilled.

Table II.1 – Comparison of IEC 60950 series and IEC 62368 series terms

60950-1/-21 terms	Similar 62368-1/-3 term
cable distribution system metallically terminated transmission medium using coaxial cable, mainly intended for transmission of video and/or audio signals between separate buildings or between outdoor antennas and buildings, excluding: – the mains system for supply, transmission and distribution of electric power, if used as a communication transmission medium; – telecommunication networks; – SELV circuits connecting units of information technology equipment Note 1 – Examples of cable distribution systems are: – local area cable networks, community antenna television systems and master antenna television systems providing video and audio signal distribution; – outdoor antennas including satellite dishes, receiving antennas, and other similar devices. Note 2 – cable distribution systems may be subjected to greater transients than telecommunication networks (see clause 7.4.1).	None
secondary circuit circuit that has no direct connection to a primary circuit and derives its power from a transformer, converter or equivalent isolation device, or from a battery Note – Conductive parts of an interconnecting cable may be part of a secondary circuit as stated in clause 1.2.11.6.	external circuit electrical circuit that is external to the equipment and is not mains Note 1 – to entry: An external circuit is classified as ES1, ES2 or ES3, and PS1, PS2, or PS3.

Bibliography

[b-ITU-T K.51] Recommendation ITU-T K.51 (2016), *Safety criteria for telecommunication equipment*.

[b-ITU-T Directives-1] ITU-T Directives Vol. VI (2008), *Danger, damage and disturbance*.

[b-ITU-T Directives-2] ITU-T Directives Vol. VII (1990), *Protective measures and safety precautions*.

[b-CENELEC HD 637] CENELEC Standard HD 637 51 (1999), *Power installations exceeding 1 kV a.c.*

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	Tariff and accounting principles and international telecommunication/ICT economic and policy issues
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	Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
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, and associated measurements and tests
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, open system communications and security
Series Y	Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2020