PD IEC/TR 62713:2013

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Safety procedures for reduction of risk outside a structure

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National foreword

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colour inside

Safety procedures for reduction of risk outside a structure

Procédures de sécurité pour la réduction des risques à l'extérieur d'une structure

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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SAFETY PROCEDURES FOR REDUCTION OF RISK OUTSIDE A STRUCTURE

FOREWORD

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IEC/TR 62713, which is a technical report, has been prepared by IEC technical committee 81: Lightning protection.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
81/427/DTR	81/429/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

IEC/TR 62713, which is a technical report, is informative, with the purpose of giving the lay person, i. e. a non-specialist in lightning protection and a non-medically trained person, appropriate action to reduce risk from lightning to people outside fixed structures, i. e. in a variety of everyday outdoor activities, including immediate action to take in the event of a person being injured by lightning. Part of these precautions includes taking shelter in either a lightning protected structure or an unprotected structure. Any action in the long term to ensure that such structures are suitably protected should be designed by a lightning protection specialist based on the requirements of the appropriate parts of IEC 62305 as listed in the normative references of this report. It is not the purpose of this report to quantify the risk reduction achieved by taking the precautions suggested in it.

SAFETY PROCEDURES FOR REDUCTION OF RISK OUTSIDE A STRUCTURE

1 Scope

This technical report introduces lightning to the layman, noting the right action in the presence of thunderstorms, as well as protective measures against lightning. It also contributes to the prevention of lightning injuries and damages.

It should be noted that so far there are no means to avoid lightning. However, by following some elementary rules, people can be protected against its deleterious effects.

2 Normative references

None.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
aphasia
inability to express thought in words or inability to understand thought as expressed in spoken or written words or others

3.2
apnoea
cessation of breathing, asphyxia

3.3
arrhythmia
irregularity of the heartbeat

3.4
asystolic
relating to the inability of the heart to empty itself

3.5
ataxia
inability to co-ordinate voluntary movements

3.6
barotrauma
damage to the ears caused by rapid change of pressure

3.7
bradycardia
slowness of the heartbeat

3.8
bronchospasm
sustained involuntary muscular contractions of the windpipe

3.9
cardiopulmonary
relating to the heart and lungs

3.10
cardiovascular
relating to the heart and vessels

3.11
cutaneous
belonging to or relating to the skin

3.12
electrization
process of electrification, not necessarily resulting in death (electrocution)

3.13
erythemateous
reddening of the skin

3.14
hypertension
high blood pressure

3.15
hypotension
low blood pressure

3.16
keraunoparalysis
paralysis caused by thunderstorms

3.17
macular puncture
puncturing of the eye's macula, or 'yellow spot', a small area at the centre of the retina at which vision is most distinct

3.18
nystagmus
spasmodic involuntary lateral oscillatory movement of the eyes

3.19
otorrhea
discharge from the ear

3.20
papillary
like, or of the nature of, or having papillae – small nipple like protuberances

3.21
paeresthesia
paresthesia
abnormal sensation in any part of the body

3.22
pathognomic
indicative of a particular disease

3.23
sequela
any abnormal condition following or relating to a previous disease; the psychological after-effect of any trauma

3.24
tachycardia
abnormal rapidity of the heartbeat

3.25
tympanic membrane
membrane separating the middle ear form the outer ear

3.26
ventricular fibrillation
uncontrolled rapid electric activity of a heart ventricle

4 General

4.1 Introductory remark

Generally, the instantaneous power brought by lightning is very high. Indeed, this energy acts on an object for less than a few milliseconds (ms). High voltages can occur and currents as large as 200 kA can flow. Consequently, thin wires melt and objects are heated up so strongly that highly flammable substances ignite or explode.

If the lightning current finds its way into structures containing trapped moisture such as damp walls, joists, roofs or trees these can suddenly explode. Indeed, objects struck by lightning can explode or ignite (see Figure 1).

Lightning currents can penetrate into buildings and structures, along telecommunication lines and power lines, destroying electrical and electronic equipments.

IEC 811/13

Figure 1 – Examples of roofs and facades damaged by lightning

4.2 Lightning damage to human beings

4.2.1 General

In open spaces, people are susceptible to direct strikes (more likely when they are standing up), to side flashes, induced discharges, touch voltages and step voltages.

4.2.2 Direct strikes

The direct lightning strike is the most dangerous of the lightning threats. The lightning current flows through a person and causes unconsciousness, inner or outer burning, apnoea, cardiac arrest or paralysis (see Figure 2).

Figure 2 – Direct strike

4.2.3 Side flash

It is dangerous to stay under an isolated tree (or by a mast) because if the human body is less than several metres from the trunk, it may experience a side flash at the head or shoulder level (see Figure 3).

Figure 3 – Side flash

Generally, all unprotected structures should be avoided as a means of shelter, especially small isolated structures such as huts and small barns. Structures with metallic roofs and non-metallic supports may give rise to an electrical discharge (see Figure 4).

IEC 814/13

Figure 4 – Unsuitability of metallic structures when not earthed

4.2.4 Touch or contact voltages

Metallic structures not only present a threat due to arcing resulting from induced voltages but also due to touch or contact voltages. To reduce the risk of electrical shock due to touch voltages it is advisable to stay away from potential lightning current conductors when storms are in the vicinity. Electrization by touch voltages (or contact voltages) occurs when people, with feet in contact with sufficiently conductive ground, touch a conductive structure that may be at a different potential due to a lightning strike (see Figure 5).

IEC 815/13

Figure 5 – Electrization by touch voltage

4.2.5 Step voltages

When lightning strikes the ground, the lightning current is spread out through the various layers of the soil. A high potential rise occurs at the point of strike. Step voltage can be experienced near this point. However, when lightning strikes buildings, structures or trees, the lightning current flows into the ground through the earthing devices of buildings or structures, or the roots of trees, and produces dangerously high potentials on the ground. Human beings may suffer dangerous step voltages close to buildings, structures or trees.

People can experience step voltage when standing with their feet apart or when walking (see Figure 6), when lightning strikes in the vicinity. This situation is more hazardous if the ground resistivity is higher, the distance to the strike point is smaller and/or the distance between the two feet is larger.

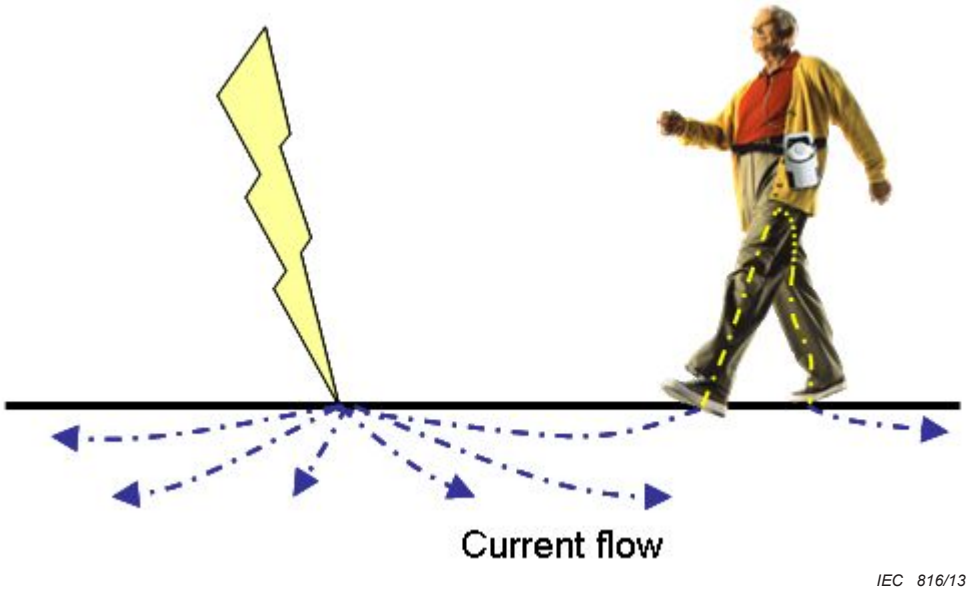


Figure 6 – Current flow through body due to by step voltage

5 Effects of lightning strikes to human beings

5.1 Possible injuries

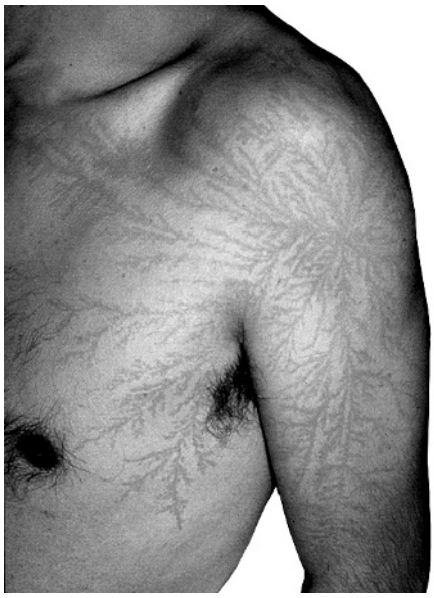
When a human being is directly struck by lightning, the voltage climbs up to about 300 kV (100 kV to 500 kV) from feet to head. The far larger portion of the lightning current does not flow through the body but on its surface. Due to this effect, many people have survived after a direct lightning strike.

Physiological effects range from being dazzled to almost instantaneous death (full cardiac arrest), through neurological troubles, visual loss or cataract, deafness or ruptured eardrum, paralysis, temporary fainting (sometimes with short respiratory arrest) and short or long-duration comas.

The body-crossing from feet (tree-like burns) to head (electrically, the human body behaves like a gel, with an internal resistance of about 300 Ω) leads to serious or even fatal injuries. Nevertheless, ionized skin and wet clothes represent a preferred path for the electrical discharge, which licks the body under the clothes, avoiding the whole lightning current crossing through the body itself. Clothes tear under the violently generated pressure wave. Even shoes can be blown to large distances. This thermal shock is so short that only superficial burns can occur, but metallic objects (e. g. necklaces) can reach high temperatures (at least superficially) leading to deeper burns.

Generally, burns are superficial (deeply cutaneous close to the incoming and outgoing points, linearly superficial, corresponding to the quickly bypassing electrical discharge, or superficial but spread out by the electrical arc). Those occurring through hot metallic objects are more serious.

Lightning victims can also have erythemateous tree-like discharges or Lichtenberg figures (see Figure 7), which are initiated by a leader circulating between clothes and skin. These pathognomonic figures, which testify to the current flow, do not become white on pressure and disappear after one or two days. The lightning current also burns hair.



IEC 817/13

Figure 7 – Lichtenberg figures on human skin [1][1]

A lightning strike can cause abrupt loss of consciousness and sometimes incontinence of urine and/or ejaculation of semen. Commonly, there is cessation of heart action and breathing so that the victim appears clinically dead. Injury to the cardiovascular system can lead to cardiorespiratory arrest (asystolic arrest) which requires urgent medical treatment. Other arrhythmias (such as tachycardia and bradycardia) and ventricular fibrillation have been reported. Brain injury is often present as well (such as amnesia, papillary abnormalities, painful paeresthesiae, aphasia, headaches).

Latent injuries may also occur only after some days or even months. These include chronic pains, high blood pressure, memory failures and even personality changes.

Injuries can include the following:

a) burns (flash burns, feathering, erythema, linear streaking, punctuated full-thickness skin loss, contact burn from metal),

b) heart (cardiac arrest, ventricular fibrillation, heart damage, hypertension),

c) brain (central nervous system failures, brain damage, keraunoparalysis, unconsciousness, amnesia, personality changes),

d) respiratory system (respiratory arrest, bronchospasm, pulmonary oedema, apnoea),

e) musculoskeletal system (keraunoparalysis, contusions, lacerations, fractures of bones, chronic pains),

f) eyes (corneal flash burns, vitreous haemorrhage, retinal tear, macular puncture, retinal detachment, nystagmus),

g) ears (barotrauma, ruptured tympanic membrane, deafness, otorrhea, ataxia).

5.2 How injured people can be helped

Call the emergency services immediately and obtain medical help. First aid can be life-saving. The emergency treatment shall be appropriate to the level of injury.

Lightning injuries can generally be grouped into three classes of severity: mild, moderate and severe. The mildly injured person is often just stunned by the lightning strike. He is usually

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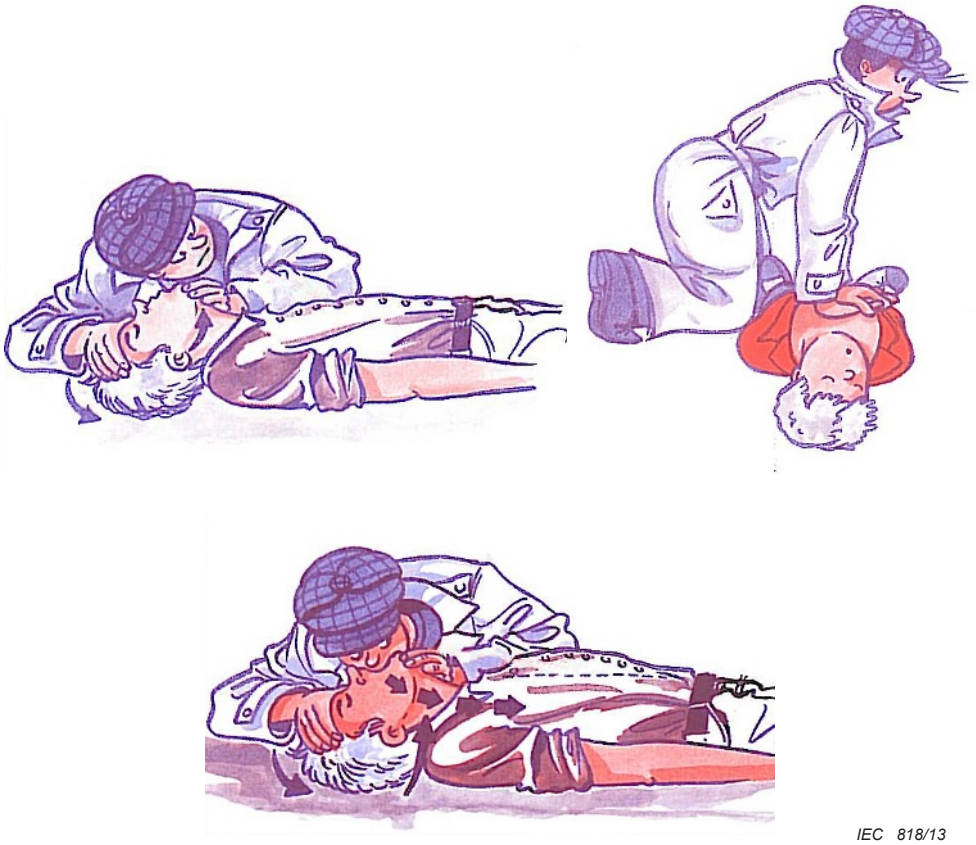
1 References in square brackets refer to the bibliography.

awake though confused and amnesic of the event. Recovery can be gradual, but he may complain of paraesthesia and muscular pain, lasting for several months. First of all, assess the situation. Then provide supportive and physical care to the person, urging him to be transported to the hospital for evaluation and treatment.

The moderately injured patient may be disoriented with keraunoparalysis of the extremities lasting for several hours. Hypotension, tympanic membrane injury, burns (first- and second-degree) are common. Though he is likely to survive, he may have permanent sequelae (such as sleep disorders, personality changes, difficulty with some mental functions). If the victim is not breathing, cardiopulmonary resuscitation should be started immediately.



IEC 818/13

Figure 8 – Cardiopulmonary resuscitation (CPR)

After calling emergency services, check the victim's breathing. If there is a cardiac electronic defibrillator available in the area, it may be used. Lay the victim on his back. Press the victim's forehead back with one hand, lift the jaw with two fingers of the second hand and check airway. If the breathing has stopped or is not normal, start resuscitation. Press the victim's breastbone with both hands (one over the other) with your arms stretched out, push 30 times in 20 seconds so that the breastbone is each time depressed 5 cm. Check airway again, press the victim's nostrils tight with two fingers, press your lips to his mouth and blow twice so that the breast rises. Repeat the cycle "30 pushes – 2 blows" until breathing is restored or other aid is available (see Figure 8). For children (aged 1 year to puberty), give five initial rescue breaths before proceeding to CPR as for an adult. For an infant (under 1 year), procedures are somewhat different from those for a child.

The severely injured victim often experiences a cardiac arrest with either ventricular standstill or fibrillation. Cardiac resuscitation may be successful. Direct brain damage may occur; blunt trauma, skull fracture and intracranial injuries are common. Recovery is generally poor in this case if a medical response team is not present early enough.

6 How to act in the presence of a thunderstorm

6.1 How to detect a lightning risk

Advance information on the probability and corresponding approach of lightning is available from local weather forecasts in many regions and internet sites are available to provide near real-time lightning location information. Lightning warning systems can also be used, both for industrial sites and private activities. Networks of detectors exist in some countries and provide, by internet or by other means (such as fax, phone, e-mail, dedicated communication lines), a warning of the occurrence of a lightning event. A dangerous industrial activity can be stopped, people can be transferred to safe shelters and exposed activity (for example, on roof or tanks) can be avoided. Local detectors also exist. Some sensors can be portable but are generally less reliable than others. Being light and quite inexpensive, they can be used as a last resort for people involved in outdoor activity. Fixed sensors are more bulky but also more reliable, especially in their capability of giving an early warning. They can be used for industrial sites but are also efficient for golf courses and camping sites, for example. The warning time is generally less than 30 min, so a safe shelter on the site is strongly recommended.

You can evaluate the risk for your activity, by watching the approach of the thunderclouds with the accompanying far flashes and by listening to the thunder. The actual distance of a thunderstorm can be roughly estimated: the number of seconds between the flash and the thunder divided by 3 gives you the distance in kilometres. From 5 km, an outdoor sports event should be interrupted and you should avoid dangerous places, like isolated trees.

Half an hour after the last flash you see or the thunder you hear, you can assume that the lightning risk is over.

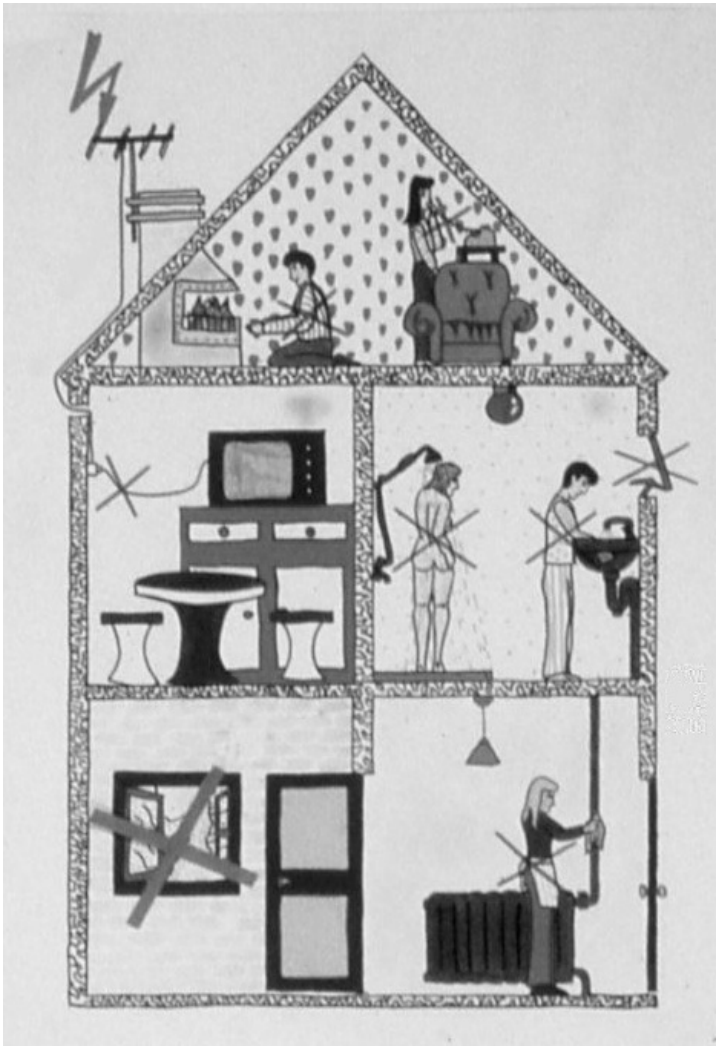
Correct behaviour considerably reduces the risk of being injured by lightning. Lightning is unpredictable; don’t trust your good luck!

6.2 Where to find safe locations

The safest location to seek shelter is inside a building equipped with lightning protection systems (external and internal). For homes without lightning protection (see Figure 9), it is advised to close doors and windows to repel air streams, to sit away from fireside or other chimneys and to avoid using water where the structure is equipped with metallic water pipes. Avoid open spaces such as balconies.

Use mobile phones and cordless telephones. Don’t call from a corded phone. Keep clear of electrical power lines, telecommunication lines, water or gas metallic pipes and metallic chimneys as well as household electrical equipment (e.g. extractor hoods, dishwashers, electric heaters). Don’t take a shower or bath during a thunderstorm.

You should stay in the middle of the room or open-sided building with feet together and even in the squatting position inside small barns, wood or stone huts without lightning protection systems. The preferred option is to install surge protective devices (SPDs) in the incoming panelboard to protect the electrical devices, TV, antennas or telecommunication cables (even when these cables are underground). An SPD should be provided at the entry of each power and telecommunication line. When this is not provided you should unplug those devices.



IEC 819/13

Figure 9 – How to avoid strikes inside a house

6.3 What to do outdoors

Although there is a higher probability of a lightning strike to tall objects, like trees or masts, don't forget that it may strike anywhere. When the possibility of a thunderstorm is great, take the precautions given below.

Avoid mountain climbing. Don't walk close to rivers and, more importantly, don't swim during a thunderstorm. Avoid horse riding, the use of a bicycle, motorcycle, convertible car or other open conveyance, a tractor or harvester (farmers have been struck by lightning).

Don't use sailing boats (unless properly protected against lightning), tents, open picnic pavilions, trams with open windows.

In the countryside, move away quickly from high points, don't stay in a group. In town, walk into a store or a public building where you are protected. Move away from street lights, towers and metallic fences as well as isolated trees. Metallic street lights and metallic towers provide a good protection against direct strikes (see Figure 10), but may cause dangerous step voltages. Keep a distance of at least 1 m – better 3 m – from a metallic street light or tower. Don't use umbrellas or golf clubs or hold long metallic or other conducting objects in your hands.

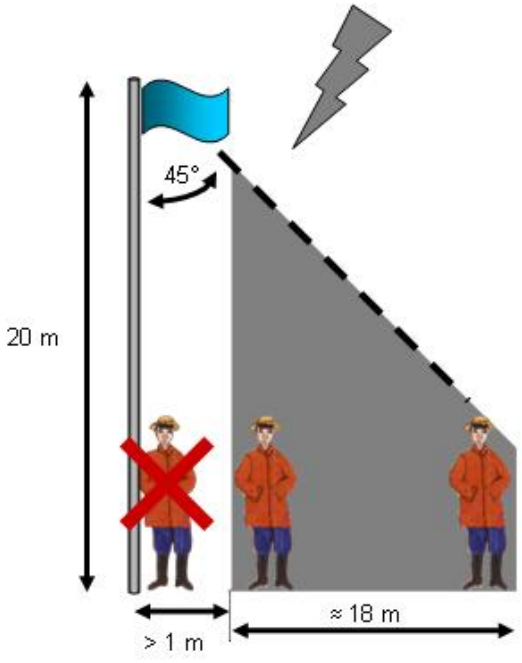


Figure 10 – Avoid the highest point in this area

Isolated trees are particularly hazardous. A safety distance of 10 m should be kept from the trunk and from the tree branches (see Figure 11).

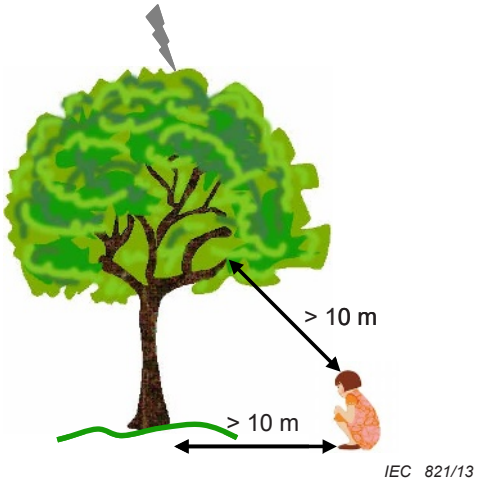


Figure 11 – Safety distance (10 m) under a tree

The ideal position to be adopted in the open air is certainly not standing upright on the ground but ideally crouching down, with the head as close as possible to the ground and one's arms encircling one's legs. Human beings standing up, with feet together can be hit by a direct strike.

It is also dangerous to stay at the edge of a forest; in this case, it is better to stay inside the woods in the middle of the trees.

Keep away from fences and other metallic structures, ditches and other wet places, open fields, hilltops and shores.

If you are absolutely obliged to move in a thunderstorm, take short steps or run (in which case only one foot touches the ground), avoiding unfolding any protruding metallic object (umbrellas).

You should stay at least 1 m and preferably 3 m from walls, supports, metal fences, particularly from parts of the lightning protection system.

Place your feet together to avoid a possible surface voltage gradient. If several persons stand together, they should not touch one another but keep a distance of at least 1 m preferably 3 m from each other.

6.4 Hazardous situation in a car

A metallic car constitutes good protection (Faraday-like shield) if windows are wound up. As a good electrical conductor, a car keeps the passengers protected against lightning (see Figure 12). Nevertheless, it is advisable to drive carefully (at a moderate speed) in a thunderstorm. Vehicles with fibreglass bodywork (e.g. mobile homes) as well as convertibles without roof metallic framework or roll bar offer a far lower protection.

IEC 822/13

Figure 12 – Generally, a car acts as a Faraday cage

Dangers associated with driving a car in a thunderstorm include:

– the vehicle can be damaged through the tyres due to the transfer of heat and puncturing caused by the lightning current; tyres have no protecting effect;
– metallic parts should not be touched while sitting in the car as they may obtain a high voltage;
– electronics can be perturbed by the electromagnetic field accompanying the lightning current (check the functionality of the car electronics after a thunderstorm!);
– bright flashes and simultaneous loud thunder may cause fatal driving errors and heavy rain obstructs the view;
– traffic lights and signals may not be working properly.

You should delay your journey for the duration of an intense thunderstorm.

6.5 What to do when camping

In a camping tent or trailer, be sure that a metallic conductor surrounding the whole volume to be protected is correctly earthed.

Caravans and mobile homes with an outer metallic skin offer the same safe protection as cars with metallic bodywork. However, persons inside vehicles with fibreglass bodywork are endangered.

Recommendations:

– never put up tents or position vehicles or their trailers used as living accommodation in prominent sites, on hilltops, at the edge of the forest or under isolated trees;
– stay at least 3 m from neighbouring tents and camping cars;
– don't install metallic wires between tents and camping cars.

During a storm:

– where a protected structure or metallic skin vehicle is not available, stay inside the tent in the crouching down position, keeping distance from metallic tent poles;
– unplug all cables from site supply points;
– remove or take down external antennas;
– don't forget that metallic feet, connected to the bodywork of mobile homes generally act as lightning conductors.

6.6 Thunderstorms in mountainous regions

In the mountains, lightning is extremely dangerous for hikers and mountaineers. The weather can change very quickly. Move promptly and safely away from peaks and ridges and avoid cliffs, cracks, crevices, edges, protuberances and trees if storms can be seen forming or if you feel hair starting to stand up on arms or the back of the neck. Remove metallic objects, such as jewellery and watches, from close contact with the body. It is better to crouch down in order to decrease the body surface and to protect yourself against diverted currents.

Don't touch a rock face with hands or feet; a lightning current could flow through your body and throw you several metres away.

Stop climbing up the mountain when a thunderstorm is approaching and try to reach a safe mountain hut (preferably with a lightning protection system) or remain in accommodation in the valley before the outbreak of the thunderstorm.

If this is not possible, metal bivouac boxes offer a certain protection on fixed rope routes. You are also relatively safe in caves under ledges or at the lower parts of rock faces. There, try to keep 1 m away from the wall.

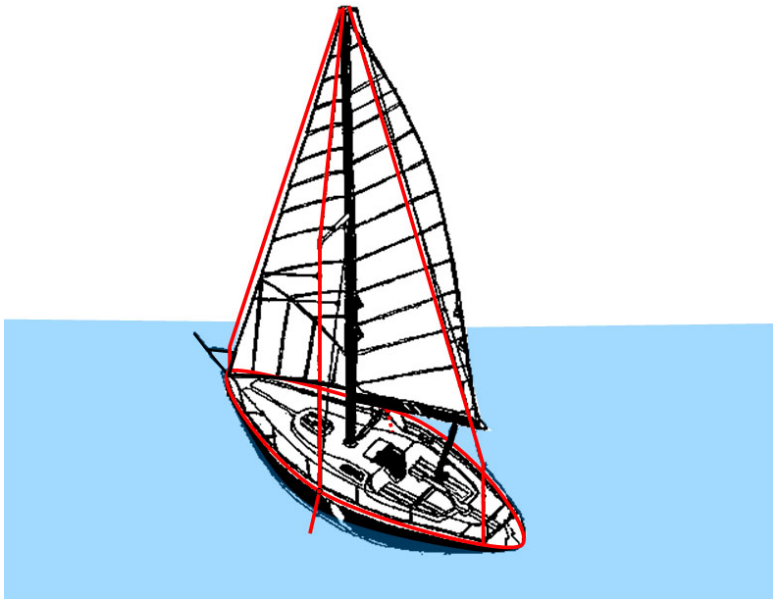
Metallic ropes, wet climbing ropes, ladders and bars as well as damp rock faces should not be touched.

Thunderstorms can initiate rock falls and dangerous avalanches.

6.7 What to do on water

At the approach of a thunderstorm, leave the water and the shore zone and proceed to a protected area. If you are caught off-shore in a watercraft, stop fishing or other activity and move below deck if possible. Squat with closed legs as deeply as possible into the boat and avoid touching the rigging or other metallic parts. In the water, the lightning current is spread over large areas; at 100 m from the strike point the current is still hazardous. Figure 13 shows a sailing boat protected by a lightning protective system.

Be cautious when scuba-diving. Although the danger of a direct lightning strike is low underwater, some vaporizing of the water can be triggered by lightning, generating a shock-wave. Possible injuries extend from a ruptured eardrum to an embolism and loss of consciousness. People are endangered when leaving the water.



IEC 823/13

Figure 13 – Example of a lightning protection system on a sailing boat

6.8 What to do at open air festivals

The same elementary rules apply to open air events as for other outdoors activities. In principle, spectators sitting or standing on open platforms are endangered; when a thunderstorm approaches, they should move to lightning protected areas. Platforms equipped with a lightning protection system or covered with a roof made of metal or reinforced concrete are regarded as protected areas.

No metallic parts, columns, walls, crowd barriers should be touched. Keep at least 1 m and preferably 3 m away from all these and other conductive parts.

You should place your feet close together to avoid a possible surface voltage gradient.

Before any event with many spectators attending, a good weather forecast should be obtained.

6.9 What to do when playing outdoor sports

People involved in outdoor sports activities should seek a safe location at the first sign of lightning or thunder in the area. Coaches and/or game officials should terminate games or practices at the first sign of thunder or sighting of lightning. Players and coaches should seek shelter in buildings with lightning protection systems or in closed metallic vehicles. Play may be resumed 30 mins after the last thunder is heard or lightning flash is seen.

If protected structures or closed vehicles are not available, the following areas should be considered as the second-best possibility:

– buildings without lightning protection systems;
– areas close to buildings or metallic masts but keeping a distance of at least 1 m, preferably 3 m, from walls and metallic parts; in order to reduce the surface voltage gradients, feet must be close together.

Golf courses are particularly dangerous places during thunderstorms, due to the area profile and the presence of isolated trees or clusters of trees as well as the golf equipment. Injuries and death by lightning strikes occur on golf courses when golfers try to continue playing as a storm approaches or seek shelter under isolated trees or at the edge of a group of trees.

Trees should never be considered trees as protected zones and standing in groups should be avoided; keeping a distance of at least 5 m from one another is highly recommended.

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