Lightning Guidance for Outdoor Events

plasa

1st Edition - June 2019

PLASA

PLASA is proud to issue this guidance on lightning and outdoor events to help raise awareness of health & safety throughout the live entertainment industry.

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The association supports its members across business, legal, HR, skills and technical and offers a range of professional pathways from the widely recognised National Rigging Certificate (NRC) to the new National Event Lifting Training (NELT) programme. Furthermore, the association works closely with experts to produce free, downloadable guidance documents which can be found on our website. Each service is developed and provided in response to the industry's evolving needs, ensuring our members can set the bar high and support quality, safety and standards across the industry.

Our commercial divisions play a crucial role in supporting membership initiatives and services: our market-leading LSi and LSA magazines provide intelligent cover of the latest projects and products, while our highly regarded annual PLASA Show and PLASA Focus events continue to be key dates in the global industry calendar.

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Acknowledgements

PLASA would like to thank the following organisations and individuals who have contributed to this guidance:

Tim Roberts | The Event Safety Shop

Roger Barrett SFIIRSM, Eng Tech, TIStructE, MIoD | Star Events Ltd

James Eade BEng (Hons) CEng MIET | Electrical Safety Consultant | Chair of BSI CPW/4 Committee

Zoe Davies | IMG

Tom Goode CMIOSH MIIRSM | Safety Advisor/Production Manager

Matthew Waldram | Omega Red Group | Chair of BSI GEL81 Lightning Protection Committee

Bill Egan | Aggreko

Ken Law | Ken Law Safety Ltd.

Stuart Page MSc MIET Grad IOSH | BBC Safety

Eric Stuart | Emergency Planning College/Gentian Events

Howard Eaton | Howard Eaton Lighting

Mike Anderson | Anderson Bradshaw Ltd

Andrew Grove | National Outdoor Events Association | Local Authority Events Organiser Group

Matthew Wells | Lee Valley Leisure Trust | Lee Valley Regional Park Authority

Ron Bonner | CMIOSH CSP MIIRSM

Special thanks to:

Professor R. Giles Harrison |Department of Meteorology, University of Reading

PLASA would like to thank the following companies for sponsoring this document:

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Index

1. Introduction

1.1 About this guidance

Lightning is a regular, naturally occurring phenomena, and everyone is aware that it may present a severe life-safety risk. However, the level of threat presented at events where people are gathered together, or how temporary event structures may affect the chance of being struck, is less clear.

Whilst changes in weather patterns may have an effect, the increase in the number of festivals and outdoor events may also lead to an increase in risk at such events, purely due to increased numbers of people exposed.

This guidance has been produced to assist all those who are involved with the production and management of outside live events to make informed decisions regarding how to react to any imminent threats from possible lightning strikes. This is only one part of a much broader Adverse Weather Plan, which for most outdoor events should also include the effects of wind, heavy rain and hot, dry weather. While the risk may be low, it is foreseeable and events have experienced lightning strikes to structures in the UK.

1.2 Scope

This guide provides practical advice on the management of lightning risk at outside entertainment or leisure events, and the mitigation of risk to life-safety and equipment damage. It considers crowd safety, the protection of temporary structures, and the protection of critical electrical equipment and power systems used on the site. It does not contain advice on general event health and safety management, although elements of the advice given here will undoubtedly form part of an event's plans. Advice on these subjects can be obtained from other publications. This guidance was produced by members of the safety community within live entertainment production, crowd movement specialists and technical and meteorological experts.

Each section is structured in the common framework of Plan – Do – Check – Act, providing a balance between the systems and behavioural aspects of management, as well as treating safety management as an integral part of good management generally, rather than an additional necessity.

1.3 Definitions

Throughout this guidance various terms are used. To assist the reader a glossary is provided in the next section.

When reading this guidance, it is important to keep in mind the distinction between Hazard and Risk. These two terms are often interchangeable in normal speech, but when quantifying the danger presented by an unpredictable natural phenomenon, it is critical that they are not confused.

The Health and Safety Executive (HSE) defines HAZARD and RISK as follows:

- a hazard is anything that may cause harm, such as chemicals, electricity, working from ladders etc.
- the risk is the chance, high or low, that somebody could be harmed by these and other hazards, together with an indication of how serious the harm could be.

In the context of lightning, the hazard may vary as well as the risk. Thus, if your business includes handling pyrotechnics or running a refinery, the potential of lightning to cause fire or explosion presents a significant additional hazard, just as the construction of large wind turbines leads to an enhanced likelihood of lightning occurring in the workplace arising from the tall structures.

Nationally, the UK has a relatively low lightning frequency when compared to parts of Continental Europe and the US. Frequency varies with both geography and season, and for the most part normal event activities (even those outdoors) can be considered at low risk from lightning.

1. Introduction

This does NOT mean however, that lightning can be ignored or dismissed as irrelevant - when storms threaten, the organiser really needs a practical plan.

1.4 Lightning safety and the law

An event organiser has a responsibility to ensure that staff and participants attending an event are not placed at undue risk. They should take reasonable steps to avoid reasonably foreseeable risks. Context is critical in determining what is reasonable; organising a midsummer south-coast cliff-top family kite-flying competition brings a greater onus on organisers to consider lightning than a mid-winter ice rink in the centre of Aberdeen. This is partly because the frequency of lightning varies significantly through geographic regions of the UK. Not only is lightning far more likely during the former, but the activity itself increases both the possibility of a strike (by flying kites on a cliff-top in summer), and the potential severity of outcome (by having families clustered at the bottom of each kite string).

Neither criminal or civil law changes in their application – it is the test of foreseeability and what is considered reasonable action required to meet the duty of care that varies.

Maps depicting average lightning frequency geographically across the UK are currently contained in BSI Published Document PD 62305-2 Flash density map 2014. Supplement to BS EN 62305-2:2012. Protection against lightning. Risk management. They are also available in the IET Wiring Regulations BS 7671:2018.

Throughout this guide, reference will be made back to legal duties, and where helpful, examples given of proportionate responses as well as responses that may be considered either excessive, or insufficient.

1.5 Glossary

Cloud to Cloud
A lightning stroke between thunderclouds. Typically, cloud to cloud lightning precedes cloud to ground lightning.

Cloud to Ground
A lightning stroke between cloud and ground.

Contact Voltage
This can occur if a person is in contact with a structure's metal frame or if the person is inadvertently conducting the lightning strike to ground via the structure itself.

Faraday Cage
A conductive metal structure which is able to safely convey electrical energy by taking the charge around the occupants. The effectiveness of any given structure will depend on its resistance to current, ground connection and the distance between parts of the mesh. Stage roofs may provide a degree of protection to those within them, and the bodywork of enclosed vehicles can be effective in protecting the occupants.

Flash to Bang
An expression used to describe the time that elapses between seeing the visual lightning stroke and hearing the sound that goes with it. As sound travels much slower than light through air, the further the viewer is from the lightning, the longer the gap between the flash and the bang.

Induced Current
Electrical energy that flows in wires or other metallic conductors arising from the intense magnetic field created near the lightning stroke, or objects that have been struck, such as a lightning conductor.

Lightning Action Plan
A documented set of procedures which are followed if a thunderstorm takes place at or near an event, or is forecast to do so.

1. Introduction

Lightning Safe
A structure which has sufficient protection to ensure it is not significantly damaged or puts the occupants at risk in the event of a direct lightning strike.

Lightning Strike
The point at which cloud to ground lightning hits. Typically this would be buildings or trees which are then hence described as being 'struck by lightning'.

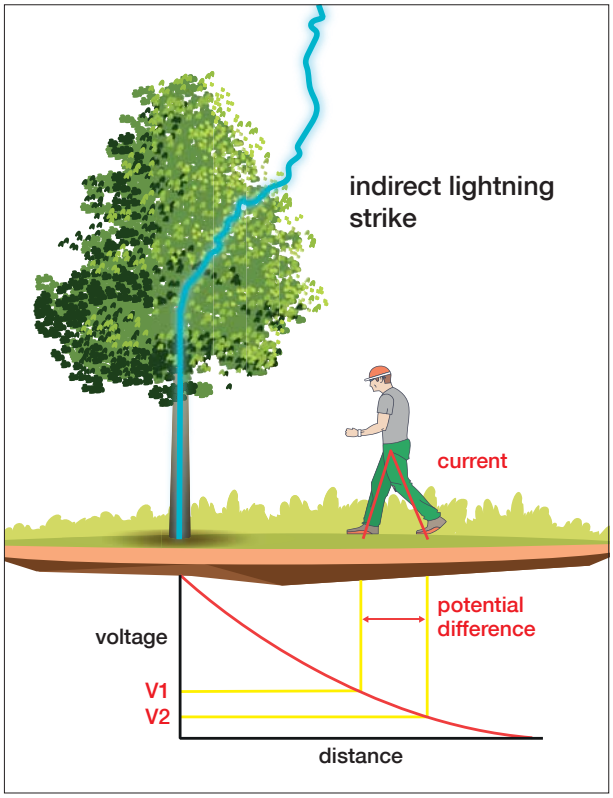
Lightning Stroke
This is the actual discharge of energy (the 'lightning flash'), usually appearing as a massive spark between clouds or clouds and ground. For simplicity in the main body of this document only the word strike has been used.

Lightning Unsafe
A structure which does not have sufficient protection against a direct lightning strike and may become significantly damaged or put the occupants at risk.

Safe Refuge
A physical location that provides a substantial degree of protection from lightning, by virtue of its design or because it is lightning protected in accordance with BS EN 62305.

Side Flash
The high voltages from lightning can arc across air gaps between metallic parts. It can flashover to a person giving them a shock, or the person might suffer physical injuries and burns from an explosion of components. Burns can occur at the point of entry/exit, and along the internal path the current takes though the body.

Step Potential (Step Voltage)



If lightning strikes nearby, the voltage dissipates with increasing distance from the point of the strike.

It is possible for there to be a significant potential difference between the feet (the 'step potential') as shown in the diagram.

This can give rise to significant injury and animals that have legs a long way apart and a heart in the middle (horses, cattle, deer) are more vulnerable to step potential.

Surge Protection Device (SPD)
A device designed to protect electrical apparatus from high transient voltage and to limit the duration and the amplitude of induced currents.

2. Event Management

2.1 Plan

During the planning phase for any kind of outdoor event, the organisers must consider the hazards that may arise from adverse weather, including rain, wind and extreme heat. The threat from lightning should be included in this assessment process. Lightning storms in the summer months of the UK are reasonably foreseeable and it is therefore reasonable for an organiser to give the threat due consideration. Once the level of risk has been determined, plans should be drawn up to take appropriate levels of precaution, which may include some form of protection systems and critically, a clear and proportionate response plan if storms are forecast.

The lightning assessment should consider risks to production and event staff as well as visitors to the event, therefore it is important to have plans that are appropriate for each phase of site activity. The lightning safety plan should reflect when different construction activities are underway and that a varying number of contractors and people may be on site. The phases may include:

- Set-up and mark-out before structures are erected
- Building of temporary structures (that may include cranes or high-level working)
- Installation of production through to sound check and rehearsal
- Public opening phase
- Production load-out
- Dismantling

Consideration of weather risk through these phases does not require a significant duplication of work.

Uppermost in these considerations should be the ability to safely manage crowds, perhaps tens of thousands, perhaps in a green field site and possibly with little or no safe refuge. In some instances, the dangers arising from an uncontrolled or unplanned mass movement of crowds in response to a storm may outweigh the actual threat from the weather itself. There is no single solution or simple answer. The best course of action will depend on the event location, the type of structures available, the numbers present, the availability of safe refuge and the likely behaviour of those present.

The organiser needs to consider factors that may affect public and worker safety; achieving a balance between risks arising from each possible course of action, and the practicality of implementing control measures.

Before determining an appropriate course of action if lightning threatens, it is essential to recognise the risks associated with moving large numbers of people. Simply stating “we will evacuate all temporary structures” is unhelpful if there is nowhere safe to send people, or if there aren’t resources to actually carry out an evacuation; especially if people are reluctant to move. Sending people out of tents, only to find that they shelter under trees, or are simply stood in the open is not a sensible plan. It may be that the balance of risk means it is safer to stay in a temporary structure - even if that structure is not itself lightning-protected.

On other occasions it may be quite reasonable to evacuate people from event structures to a safe refuge, or send them home, or back to the (relative) safety of their vehicles. The organiser needs to take account of the particular circumstances of their event and come to a considered conclusion on how best to protect the welfare of those present.

Before embarking on their risk assessment, the organiser is reminded of the dangers that may arise from the abrupt or uncontrolled movement of crowds. In May 1999, 54 young people died trying to enter a metro underpass to escape a sudden thunderstorm at an event in Minsk. No-one was killed by the weather. Fundamental to any crowd plan is a design that allows people to move to safety and includes the ability to communicate effectively

2. Event Management

with the public. Decisions need to be made in advance of the storm's arrival - giving staff and the public time to respond in a calm and measured way.

An example of the lightning assessment process (with specific crowd safety considerations) is shown in the list below:

- What is the overall risk from lightning?
- When is the event, and where? Months from May through September are higher risk periods, but storms can occur at any time.
- Are there particular risk factors such as events on elevated or exposed terrain?
- Are the public accommodated in (or on) structures that are more likely to be at risk from a lightning strike, such as a tall grandstand at a sporting event for example?
- How many people are attending the event?
- What is the event duration? Something that holds people on site for many days has a higher risk than something of short duration in the same location.
- Does the profile of the crowd give rise to particular considerations? Mobility, likely reaction to a storm, reluctance to move etc.
- Is a safe refuge available and if so, how is it accessed and what proportion of the public can be accommodated?
- Vehicles may offer a reasonable place of safety if they are metallic enclosed vehicles (i.e. no soft-tops or fibreglass shells) and the windows are closed. Occupants need to be advised not to touch the internal metalwork of the vehicle itself. Other considerations include the ease of moving people to parking areas. How much notice would this require? Will people have immediate access to their keys? What would you advise people who came on public transport?
- How long would it take for the public to reach a relatively safe refuge or disperse into the general urban environment? This should be added to the timeline for decision-making. For example, if an event is to be held on an exposed location with temporary grandstand seating, and the only place of safety is customer's own cars, then the organiser should consider how long it may take to reach the car park. If it is a 20-minute walk, then this needs to be factored into the monitoring, warning and evacuation process.

Clearly, the longer the "time to safety" journey is, the earlier the organiser needs to make a cancellation/suspension/evacuation decision. For larger or high-risk events, this lead time for decision-making may be hours ahead, and so reliable forecasting (including lightning) is fundamental.

If no place of safety is available, then consider if it is appropriate to allow people to remain in situ, or whether they should be dispersed and the event site closed.

Compared to simply being in the open, marquees and stages may afford a degree of protection (if they are well constructed and earthed - see sections on Electrical Safety and Temporary Structures), and are almost certainly preferable to sheltering under trees.

If the event has limited cover and a large crowd is expected to attend, then consideration should be given to the means of mitigating overcrowding if structures are not going to be evacuated.

2.2 Do

Create a Lightning Action Plan, tailored to the specific circumstances of the event, which clearly sets out trigger points and what will be done in response. Like any contingency plan, it must be proportionate to the risk. There is little benefit in producing highly detailed Action Plans if the overall threat from lightning is very low and the public can easily be made safe.

2. Event Management

As an illustration, let's consider an acoustic busker on the street:

- Do they have a duty of care to the public with regard to lightning? *No*
- Do they have a duty to protect workers? *No*
- Do they have a duty to protect themselves? *Yes*

What is the lightning plan?

1. Check the weather forecast before going out.
2. Take a waterproof jacket and guitar case.
3. Stop playing and head for shelter if lightning is seen or thunder heard.

At the other end of the scale, the organiser of a large-scale outdoor event with camping will have a different response to the same hazard. Their duty of care extends to the public and staff, which may mean close-monitoring of weather fronts, setting of threshold distances at which activity may be stopped or people moved to safety. For example:

1. Storm in the area – alert to all staff.
2. Lightning detected at 10km (6 miles) distance and closing (30 seconds Flash to Bang) – all staff down from high workplaces & towers. Prepare for show-stop and evacuation.
3. Lightning detected at 6km (3.6 miles) distance (18 seconds Flash to Bang)– stop show and evacuate.

Specific actions on technical installations may need to be carried out, depending on the conclusions of the lightning risk assessment. Decision-makers and event management staff need to understand their role, and the basis on which they are making choices.

The key thing is to produce a practical plan before action is required. A key part of any such plan is to identify decision-makers. When and how will they make a decision regarding lightning action? How will they let everyone know? It seems simple, but it is often the case that slow decision-making, or failure of the command and control framework, makes the situation worse or even directly contributes to serious injury.

2.3 Check

Before site activity starts, be sure that contractors and crew are aware of the lightning action plan and the procedure to follow if lightning is observed or forecast. Many pre-event lightning checks should already be part of established routines for verifying an event is ready to open to the public, such as:

- Are communications systems working?
- Have staff been properly briefed on emergency action?
- Are access, circulation & egress routes adequate, free of obstruction and identifiable?
- Have electrical safety measures been put in place on structures as required?

These are all part of normal preparation and are equally applicable to a range of threats and contingencies.

Depending on the level of risk, there may be lightning-specific controls to verify such as surge protection, completion (sign-off) of lightning conductors, checking of detector systems and so on.

Whatever the event, there must be a reliable means of monitoring the weather. Depending on the scale and risk-level, this may simply mean close attention to websites and services such as the Met Office, or it may mean the engagement of professional services and advanced detection technology. For larger events, reliance on a free phone-app may not meet the test of a 'reasonable' level of precaution.

Ensure your communications with staff and the public are functioning and effective. Remember that

2. Event Management

social media may play a valuable part in providing warning to people who can't be reached by PA systems or other warning systems.

Finally, be sure that everyone who may be involved in making a lightning safety decision is aware of their responsibility and are able to act swiftly in the event of threat.

2.4 Act

With something as unpredictable as lightning, action needs to be taken before it is certain that the event will be struck; because it is only certain when the strike happens. An organiser following the guidance above will have already thought about what to do, will have a means of determining the likelihood of a strike and a means of advising staff that action is required. So, when a trigger point is met, it is 'simply' an issue of activating the plan – rather than trying to work out what to do from scratch.

- Pre-warn staff. They may need time to prepare for announcements, evacuation etc. Even if your plan is to rest-in-place, warnings to staff and a re-brief on policy are valuable.
- Make physical preparations for crowd movement, which may mean a re-deployment of stewarding or security staff, and warn stakeholders (police, fire, ambulance, local authority) of impending action.
- Act swiftly and decisively when weather thresholds are met. Don't be tempted to wait a few minutes to see if it clears up.
- Record your actions and closely monitor both crowd and weather conditions.
- Continue to monitor weather until an all-clear given.

The 30:30 Rule

This is a simplistic rule of thumb developed in the USA following incidents where strikes have killed & injured people at sports and other events. The first '30' is about judging how far away lightning might be. The flash of light travels pretty much instantaneously from the lightning to the viewer, but the boom of the thunder progresses more slowly through the air (at the speed of sound, around 340 metres per second). If you are right under the lightning strike, there wouldn't be much opportunity for these travel speeds to make much difference and you'd see & hear the lightning/ thunder simultaneously. As you get further away, there will be more delay to the sound.

Counting the gap between the lightning flash and the time it takes for the noise to arrive (flash & bang) can be a simple way of estimating how far away a strike was. If there is a gap of 10 seconds; the strike was around 3.5 kilometres away.

So, why '30'? Well, the answer stems from the large distance over which lightning can reach. Storms produce lightning strikes across a very wide area and anything under 30 seconds between flash & bang means you are in the danger zone. The storm won't neatly count down where it puts the lightning; the next strike could be right on top of you. Under 30 seconds = Danger - Activate your action plan!

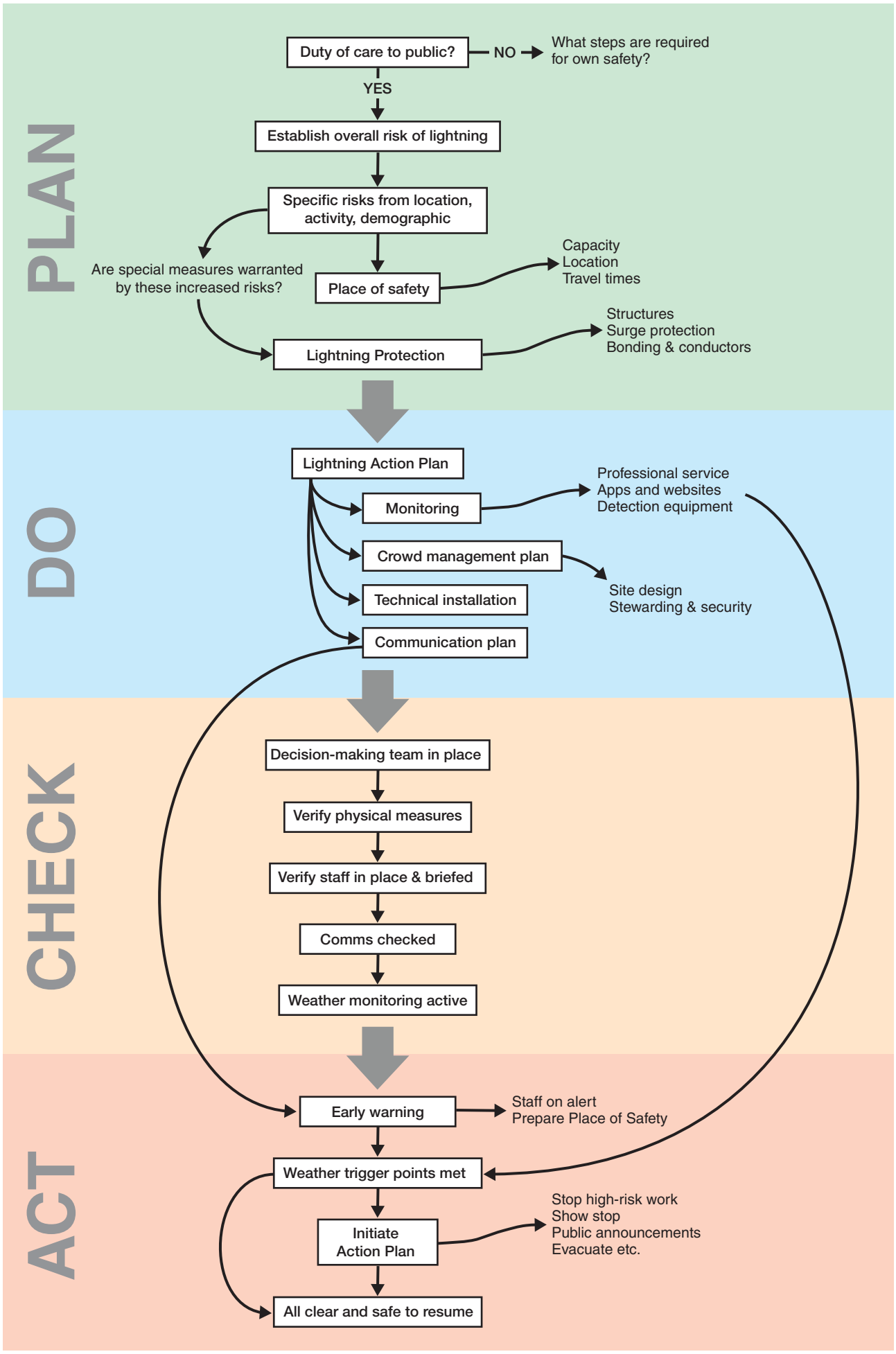
The second '30' refers to safety once the storm has passed. Throughout the period when there is less than 30 seconds between flash & bang there is a risk of a strike, but once the gap goes back above 30 seconds this is an indication the storm may be passing. You have to wait 30 minutes after the last sub-30 second flash-to-bang to be sure the storm is far enough away. If you are counting the time & another sub-30 second strike happens; reset your clock & wait the full 30 minutes.

If you have more sophisticated tools at your disposal your lightning action plan can be set on the specific range away from your site of detected strikes. It is up to the organiser to determine what is appropriate, depending on the level of risk & the speed at which they can respond; however range-rings of 10km and 6km are common.

2. Event Management

The example below is an illustration of how the 30:30 Rule can be applied.

Activity	Action
Organiser checks forecast for the few hours ahead. There is a threat of thunderstorms.	Advise all crew/contractors/participants to be alert and aware. Remind them of the policy. Step up frequency of weather monitoring.
Lightning detected within 10km (**<30 seconds** Flash to Bang)	**Amber Alert** High level working stopped and people return to ground (security watchtowers, follow-spot operators, construction & scaffolding etc.) Tall rides or activities such as Ferris Wheels stopped and cleared of public. Exposed seating or tribunes evacuated. Crew prepare for bad weather (wind & rain, hail etc.)
Lightning detected within 6km	**Red Alert** Evacuation of at-risk areas. Dispersal of public to safe shelter (if possible). Crew switch off and secure vulnerable technical systems which are critical to event operation. Activate preparations for bad weather.
Last strike within 10km	**After 30 minutes** activity can be recommenced. Public messaging and crew communication can obviously continue during the storm to provide updates and assurance. Re-starting an event is not necessarily a quick or simple process, and crew may require some time to get ready. These preparations may begin before the full 30 minutes, but the re-start needs to wait until there is a clear margin of safety.


PLAN
Duty of care to public?
NO
What steps are required for own safety?
YES
Establish overall risk of lightning
Specific risks from location, activity, demographic
Are special measures warranted by these increased risks?
Place of safety
Capacity
Location
Travel times
Lightning Protection
Structures
Surge protection
Bonding & conductors
DO
Lightning Action Plan
Monitoring
Professional service
Apps and websites
Detection equipment
Crowd management plan
Site design
Stewarding & security
Technical installation
Communication plan
CHECK
Decision-making team in place
Verify physical measures
Verify staff in place & briefed
Comms checked
Weather monitoring active
ACT
Early warning
Staff on alert
Prepare Place of Safety
Weather trigger points met
Initiate Action Plan
Stop high-risk work
Show stop
Public announcements
Evacuate etc.
All clear and safe to resume

3. Electrical Safety

Lightning can affect electrical systems in a variety of ways. As well as containing a huge amount of electrical energy, a strike creates magnetic pulses which can be picked up by cables even if they are well insulated. These magnetic pulses are so strong they can create an induced current in cabling and other electrical systems – even if there isn't a direct transfer of the lightning's electrical charge. It can cause problems if there is:

- a direct lightning strike to, or in close proximity to, a structure (such as a tent, stage, platform, tower, building etc);
- a strike to, or close to, a cable such as power, data, RF or video signal.

The hazard is not just one of electric shock, but also that of burns and fire risk. A lightning strike to a structure will result in arcing across joints which may result in rapid heating and burning metal being discharged. The area of ground around the structure will also be subject to a rise in earth potential (voltage), increasing the risk of 'step-potentials' which can give rise to the risk of shock even if the person is not touching the structure itself.

The induced currents arising from a strike to, or near, cables can be considerable and can give rise to high voltages on metallic structures and interconnected equipment. The damage that this can cause can be exceptional – it only takes a strike to a delay tower to send damaging voltages back to the generator and throughout the rest of a distribution system. In many events, signal and power cables are ubiquitous and often systems are interconnected, such as data or power feeds between lighting and video. A strike to a remote structure is likely to have ramifications for event continuity if these things are not taken into consideration. With good planning and effective control of electrical risk, a thunderstorm might only result in an unscheduled break in proceedings, not the cancellation of an event.

In practice traditional methods of lightning protection may involve considerable work for an unquantifiable level of protection. Installation of a lightning protection system would usually include site surveys to ascertain the electrical characteristics of the soil, electrode network design, ground excavations to lay the electrodes and then specialist conductors installed to structure(s) as necessary. This may need to be repeated for multiple structures on a large site and the cost could be considerable for a protection measure where the statistical risk is still very low. Unless an event is held at the same venue with the same (or similar) infrastructure on a regular basis, such measures may exceed the requirements of 'reasonable' controls to manage the risk.

Despite this, certain measures can be put in place to minimise damage to equipment and to help protect the crew and audience. It is important to realise that all contractors/suppliers play a part to some degree. Any contractor constructing, or installing equipment on temporary structures such as WiFi points, site lighting, delay towers, camera platforms, mobile phone networks, security cameras and so on all need to consider how their equipment may be affected and what they will do to minimise the chance of a strike and mitigate the impact. It is not just the power provider's problem to resolve on their own. It needs co-ordinated planning commensurate with the scale of the event.

It is important to note that operating electrical systems will not attract or increase the risk of being hit by lightning. However, if everything is left operational, the consequential damage arising from a lightning strike will be greater as a result.
A pragmatic balance needs to be achieved between what remains live, and what gets shut down.

3. Electrical Safety

3.1 Plan

As noted previously, planning is key to any successful lightning protection strategy. The temporary power Standard BS 7909 requires the event organiser to appoint an electrically competent person to oversee, co-ordinate and manage the temporary electrical systems across all suppliers, including the design as required. This person would need to consider the following electrical aspects in conjunction with the production:

- Identify systems without which it may be hard for an event to proceed safely. For example, the stage audio systems or video walls may be used for evacuation messages, or radio base-stations might be crucial for communicating with stewards.
- Separate out critical systems and consider backup plans. Install extra protection for critical circuits such as additional surge protective devices (SPDs) and ensure supplies will be resilient. For example, a generator feeding non-critical site lighting and critical audio supplies may be rendered inoperable following a strike to a lighting tower, thereby taking the audio system with it.
- Minimise step potentials around structures by fencing-off areas around the base of metal masts such as stage legs or big-top supports for example. A distance of 3m radius is a desirable minimum for lightning safety, but the actual safe distance depends on how well earthed the structure is in practice. This distance must also be balanced against the potentially negative impact on available space for the public and flow. If staff are working within fenced areas at the base of big-top masts etc. they should be withdrawn when lightning threatens.
- Ensure crews are evacuated from sub-stage areas and also smaller scaffolding structures such as front-of-house towers.
- If event-continuity is required, such as for broadcast purposes, design a segregated safe system electrically isolated from others systems as far as practicable. Such a measure might include an independent generator to a studio and fibre signal connections to other parts of the site.

3.2 Do

The following actions will help ensure the resilience of an electrical system:

- Co-ordinate protective bonding of structures and install appropriate SPDs in the supplies.
- Installing one or more earth electrodes on structures may help discharge lightning currents more effectively. It is important that structures are bonded back to the electrical system for electrical safety reasons, irrespective of any lightning plans, but additional earth electrodes are likely to be beneficial for lightning protection by increasing the effectiveness of the discharge path to earth.
- Ensure sections of the distribution can be readily isolated, for example by having non-critical circuit segregated from other show-critical ones. Turning something off at a distribution unit is not effective isolation in this context as circuit breakers usually only disconnect one conductor. Effective isolation is only achieved by unplugging circuits.
- Install appropriate SPDs in the distribution to mitigate damage to connected equipment.
- Brief crew on plans and ensure parts of the distribution requiring intervention in the event of a storm have a member of crew tasked with each role.
- Ensure that fireworks, pyrotechnics and other special effects crews (if present) are aware of the plan and can readily isolate all control systems from pyrotechnics or other discharge effects in the event of the Lightning Action Plan being activated.

3. Electrical Safety

3.3 Check

When the electrical system is installed and ready for operation, check the following:

- Are all electrical crew aware of the relevant aspects of the lightning management plan?
- Do they know their responsibilities and what they should do if the action plan is instigated?
- Make sure crew with no specific role are aware of where they should go for safety.
- Check that the SPDs are still serviceable, typically shown by a green indicator on the unit.
- Check protective bonding on structures (if required) is present and adequate.
- Check that zones designed to be electrically segregated for continuity have not been breached.

3.4 Act

When the lightning plan is instigated:

- Mobilise crew to their stations or safe zones.
- Disconnect non-critical signal and power cables connected to equipment in structures.
- Implement shut-down operation and disconnect generators running non-critical loads.
- Lower lighting towers, cherry-pickers and other mobile platforms or masts.

If a lightning strike is experienced at an event, both structures and electrical systems will need to be assessed for damage by a competent person. Electrical distribution equipment should be checked for insulation damage and the SPDs should also be inspected.

3.5 Guidance for individuals caught outside in a storm

If you are caught outside or the public are unable to reach shelter, everyone should adopt this position.

If caught in the open in a lightning storm, keep your feet together and crouch down with your hands over your ears/head. Keeping your heels together minimises the step potential and gives a route for the current to flow without affecting vital organs. Covering your ears helps because the thunder clap can be very loud.

4. Structures

4.1 Plan

Temporary structures across an event site may be the obvious choice to shelter from an incoming storm. However, whilst it may be unlikely that someone would experience a direct lightning strike when inside a temporary structure, they are still at risk from the following:

- Contact voltage – this can occur if a person is in contact with a structure's metal frame or if the person is inadvertently conducting the lightning strike to ground via the structure itself.
- Side flash – the high voltages from lightning can arc across air gaps between metallic parts. It can flashover to the person giving them a shock, or the person might suffer physical injuries and burns from an explosion of components.
- Step voltage – the high voltage from a lightning strike to the ground dissipates through the earth. A person stood inside a temporary structure near to the strike point can have a sufficient voltage difference between their legs to cause injury.

In order to develop the event's Lightning Action Plan, organisers should identify which structures on their site are lightning safe and which are lightning unsafe based on the information below. With this information, organisers will be able to identify structures which can provide protection of persons should the event be affected by lightning. These lightning safe structures should form part of the Lightning Action Plan.

Organisers must also consider wind loadings and capacities for any structure they may want to label as lightning safe. Whilst it may protect persons inside if struck by lightning, it may become structurally unsafe if the wind speeds increase. Capacities should be taken into account during the normal course of event planning and should be managed if a structure is used as a shelter.

The lightning unsafe structures may require evacuation and the lightning safe structures can be considered as part of a shelter plan for staff, contractors and visitors. This section of the guidance will also look at what other types of places can be used as shelter.

Lightning protection of structures

The features of a Lightning Protection System (LPS) used on a structure comprise the air terminal (the 'spike' at the top of the building), a down-conductor (usually a flat copper bar fixed down the outside of the building) and a buried ground terminal or earth electrode. These elements must form a continuous path with connections made by reliable mechanical joints. The purpose of the LPS is to direct lightning currents to ground. These can be very large currents, so the LPS must be able to safely conduct them. While a metallic structure could form part of a LPS, the installation of the earth electrode arrangements would usually be considered cost-prohibitive and too disruptive for most events in the UK.

Permanent structures

BS EN 62305 (based on the International Standard IEC 62305) is the Lightning Protection Standard. Part 3 'Physical damage to structures and life hazard' is of interest as it concerns protection in and around a structure and gives guidance on the design of an external LPS, as well as having requirements for the internal electrical system including equipotential bonding and electrical separation.

However, this standard typically applies to permanent buildings and the risk assessment model it uses is not appropriate for short-duration events. At an event site, the organiser should coordinate with the site owner to identify and list the permanent lightning safe shelters and their location.

4. Structures

The types of shelter at an event site that could be considered lightning safe include:

- Clubhouse
- Farmhouse
- Office building
- School building
- Church
- Shopping centre and high street shops

A vehicle can be used as a lightning safe shelter and a safe vehicle is one that is fully enclosed and metal-topped. Examples may include a bus, truck, car and minivan. Occupants need to be advised not to touch the internal metalwork of the vehicle itself, and ensure windows are closed.

Organisers should identify the location of the lightning safe structures and consider this when determining the evacuation times needed to allow people to get to a shelter. An event may have identified that the only lightning safe structures are cars and therefore need to allow reasonable time between notification of incoming storm and time taken to get to a shelter. There are several variables to this including size of event site, proximity of car parks (staff and public) to main event areas, proximity of any identified lightning safe structure and volume of people.

The requirement to identify and list lightning safe structures should also apply during the build and break phases of the event as part of the organiser's duty of care. This should include weather monitoring and response procedures; these can include stopping outdoor work, evacuating hazardous positions such as PA masts and stage roofs, and moving all employees to a designated safe place.

Temporary structures

Based on the information in Section 3 of this document, a temporary event structure can only be considered Lightning Safe if it meets the definition of a Faraday Cage and people can be kept more than 3m away from a potential conductive path to ground.

Structures likely to be lightning unsafe

- Grandstands (with the possible exception of those with a full roof)
- 'Underworld' production areas under concert stages
- Front of House structures
- Delay Towers
- Screen support goalposts
- Concessions tents

In all the above cases people must be kept at least 3m away from any metal parts of the above until the risk of lightning has passed.

Structures that could be lightning safe

- Large roofed stages where people can be kept on the wooden stage deck more than 3m away from metalwork
- Large enclosed tents where people can be kept more than 3m away from metalwork
- Shipping containers
- Production cabins

In all of the above cases effective earthing of the structure to ground will help, but it is important to understand that the 3m distance should be seen as a minimum. Step-potentials could exist beyond 3m if the structures are not earthed but as noted previously, the distances have to be balanced with the need to accommodate large crowds and ensure sufficient flows.

4. Structures

4.2 Do

The following actions will help ensure the correct use of temporary event structures in storm conditions:

- Based on the information in 4.1, draw up a list of all lightning safe structures at the event.
- Create an evacuation strategy for all lightning unsafe structures at the event.
- Installing one or more earth electrodes on structures may help discharge lightning currents more effectively.
- Brief crew on plans and ensure everyone is aware of which structures are lightning safe or unsafe, along with the relevant actions to be taken in the event of the Lightning Action Plan being activated.

4.3 Check

When the temporary structures are installed and ready for operation, check the following:

- Are all crew aware of the relevant aspects of the Lightning Action Plan?
- Do they know their responsibilities and what they should do if the action plan is instigated?
- Make sure crew with no specific role are aware of where they should go for safety.
- Check earth electrodes and the connection to structures are present (if required) and adequate.
- Check barriers are installed (or available and ready to be installed) around the legs or supports of structures as required.

4.4 Act

When the Lightning Action Plan is instigated:

- Mobilise crew to their stations or safe zones.
- Lower lighting towers, cherry-pickers and other mobile platforms or masts if safe to do so.

If a lightning strike is experienced at an event, all structures will need to be assessed for damage by a competent person. Particular attention should be paid to the likelihood of damage to structural connections close to ground level and/or adjacent to earthing points.

5. Further Reading

Royal Society for the Prevention of Accidents (RoSPA) – Lightning at Leisure
https://www.rospa.com/leisure-safety/advice/lightning/

Cobb Associates Lightning Research whitepaper (published in Total Production Magazine)
http://d2toxy35xg2aj.cloudfront.net/system/files/lightning.pdf

National Lightning Safety Institute (US) – Multiagency recommendations for lightning safety
http://lightningsafety.com/nlsi_pls/multi_recommendation.html

Health and Safety Executive

- Free publications concerning safety in events and entertainment:
  http://www.hse.gov.uk/pubns/entindex.htm
- HSE subsite covering events and entertainment
  http://www.hse.gov.uk/entertainment/index.htm

British Standards Institute PD 62305-2 Flash density map 2014:
Flash density map 2014. Supplement to BS EN 62305-2:2012. Protection against lightning. Risk management
https://shop.bsigroup.com/ProductDetail/?pid=000000000030312912

'When Thunder roars, go indoors' article, Festival Insights (US)
https://www.festivalinsights.com/2016/06/thunder-roars-indoors-lightning-safety-planning/

Events Industry Forum - The Purple Guide
https://www.thepurpleguide.co.uk/

PLASA
Redoubt House
Edward Road
Eastbourne
BN23 8AS

T: +44 (0)1323 524 120

www.plasa.org