New European Standards Regarding Lightning and Surge Protection

Joe Ellwood
New European Standards Regarding
Lightning and Surge Protection

• Lightning facts and characteristics
  • Direct effects and damage

• Secondary lightning effects - surges/transient overvoltages
  • How do they damage equipment?
  • The problems transients cause and why protection is required

• Recognised protection measures
  • BS 6651/BS EN 62305 - comparisons

• Where to apply protection

• Key requirements for a protector

• Questions & Answers
Lightning Characteristics

- Lightning strikes the earth 100 times a second
- Discharges in excess of 200,000 amps
  - Can energize half a million 100 watt light bulbs!

- Direct damage is obvious and immediately apparent
  - Damaged buildings, trees, fires
  - Personal injuries, death

- Tendency to strike taller structures and objects

- However ground strikes are common where distance between structures is greater than twice their individual height
Physical damage (fire, explosion, mechanical destruction etc) due to lightning current effects
Direct Lightning Damage

Injuries/death to living beings due to high voltages
(step and touch voltage)
Secondary effects of lightning

• The secondary effects of lightning causes surges or transient overvoltages

“A transient overvoltage (surge) is a short duration increase in voltage measured between two or more conductors”

• Resistive coupling is the most common form of damage
• Inductive coupling can also occur
What are Transient Overvoltages (surges)?

Normal mains power supply

Transient overvoltage

Big
• Up to 6,000 volts (Almost 20 times mains supply)

Fast
• Typically 50 microseconds duration (20,000 transients per second)
Resistive coupling
Inductive coupling
Lightning Transients

- Direct strike to building NOT required
- Direct strike to line NOT required
- Transients can pass through HV network
Equipment that cause switching transients

• Motors – lifts, air con

• Transformers

• Welding equipment
The problems transients cause

- Disruption – loss of data, RCD’s tripping
- Degradation – reduced equipment lifespan
- Damage – loss of equipment
The problems that transients cause

- Damage
- Degradation
- Disruption

No effect

Size of transient overvoltage

6000V

0V

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• Losses due to downtime often far exceed hardware losses
• Typical hidden costs of system downtime
  • Lost business
  • Delays to customers
  • Lost productivity
  • Staff Overtime

Downtime – the biggest cost!
Equipment typically vulnerable to transient overvoltages

- Computers
- Fire and Burglar Alarms
- PABX telephone exchange
- Telecom base stations
- Data communication network
- CCTV equipment
Critical equipment for vital services

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Home of Manchester United

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Losses due to direct strikes

Losses due to transient overvoltages

Comparison of losses due to direct strikes against losses due to transient overvoltages

Increase in transient losses due to electronics becoming

• Cheaper - more utilised
• Smaller - more sensitive

Transients - the growing threat!
Why protection is required

Effective transient overvoltage protection can prevent:

• lost or destroyed data
• equipment damage
• repair work for remote and unmanned stations
• sales lost to competitors
• loss of production
• health and safety hazards caused by plant instability, after loss of control
• LOSS OF LIFE
British standards: Protection of structures against lightning

(BS) CP1  1947
(BS) CP326  1965
BS6651  1985
BS6651  1992
Appendix C – equipment protection added
BS6651  1999
BS6651  2000 Corrigendum No 1
BS6651  2005 Amendment No 1
Main body of standard covers protection of structures
- Need for protection determined by simple risk assessment
- Protection measures consist of “Faraday cage” principles

Protection of electronic equipment covered separately
- Guidance given in Informative Annex C
- Separate risk assessment to structural protection
- Protection measures consist of transient/surge protection
Risk Assessment – consider direct strike to structure
Collection area for a direct strike to structure
A lightning strike up to 1 km away can have devastating consequences.

Both buried and overhead cables are vulnerable.

Need to additionally allow for:
- surrounding ground
- associated buildings
- lines between buildings
- lines leaving the site

Collection area MUCH bigger than for a direct strike
- risk to equipment therefore MUCH bigger!
Risk Assessment – threat from transient overvoltages
Collection area for transient overvoltages/surges
Protection measures - realities

• BS 6651’s risk assessment for protection of equipment not utilised in practice

COMMON MISCONCEPTION –

“I have a structural Lightning Protection System (LPS) fitted – I do not need transient protection for my equipment”

• Fitting structural LP system protects the structure NOT the equipment!
Direct strike to building – with NO LPS fitted

Physical damage to structure through mechanical forces and heat

Inductive coupling can still cause transient problems for equipment
LPS provides safe low resistance path but surges have higher energy. Structure is SAFE, equipment is NOT!

Fit transient protection on all cables that enter/leave buildings and critical external equipment (CCTV). Fit protection local to critical equipment within building.
INDIRECT STRIKES
Most common cause of lightning transient problems

Indirect strike as far as 1km away cause transient problems irrespective of whether structural LPS fitted or not!
From BS 6651 to BS EN 62305 - CENELEC

- Harmonisation of European standards has led to new industry standards
- BS EN62305 series “Protection against lightning” published in September 2006
- Over 15 years of work by world experts including 28 European member states
- Over 4 times more information than BS 6651
- CENELEC standards have priority over “conflicting” National Standards
- Both the BS 6651 and BS EN62305 series will run in parallel for 24 months
- BS 6651 will be withdrawn in August 2008
### Key changes: BS 6651 and BS EN 62305

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<th>BS 6651</th>
<th>BS EN 62305</th>
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<td>Simple Risk Assessment (structural damage)</td>
<td>Comprehensive Risk Management Calculation based on four type of risk (R1-R4)</td>
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<tr>
<td>Two levels of lightning protection – ordinary and high risk</td>
<td>Four levels of Lightning Protection System (LPS) I-IV</td>
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<tr>
<td>Transient Overvoltage (Surge) protection in Appendix C (informative)</td>
<td>Transient Overvoltage (Surge) protection incorporated in main standard – detailed in BS EN 62305-4</td>
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BS EN 62305 - four parts

BS EN 62305-1 General Principles

BS EN 62305-2 Risk

BS EN 62305-3 Physical damage & life hazard

BS EN 62305-4 Electrical & electronic systems
Scope – BS EN 62305 - 1

Provides general principles for protection against lightning of:
• structures, their installations, contents and persons
• services connected to a structure
• Complex document embracing many more factors than the BS 6651 risk assessment.

• By working through series of formulae the process allows the user to decide on what protection is required to reduce the actual Risk (R) below the tolerable level (R{T}).

• Protection may be the installation of an LPS system or transient/surge protection or both – a significant deviation from BS 6651.
Need to assess each relevant risk ($R$) according to corresponding types of loss ($L$)

$R_1$ – risk of loss of human life ($L_1$)

$R_2$ – risk of loss of service to the public ($L_2$)

$R_3$ – risk of loss of cultural heritage ($L_3$)

$R_4$ – risk of loss of economic value ($L_4$)
Protection against lightning is required if the calculated risk $R_n$ (whether $R_1$ or $R_2$ or $R_3$) is greater than the tolerable level of risk $R_T$

$\text{ie } R_n > R_T$

<table>
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<th>Types of loss</th>
<th>$R_T$ / annum</th>
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<td>Loss of human life or permanent injuries</td>
<td>$1 \times 10^{-5}$</td>
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<tr>
<td>Loss of service to the public</td>
<td>$1 \times 10^{-4}$</td>
</tr>
<tr>
<td>Loss of cultural heritage</td>
<td>$1 \times 10^{-4}$</td>
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</table>
• LPS (Lightning Protection System) – BS EN 62305-3
  - complete system used to reduce physical damages to a structure.

  Consists of external and internal lightning protection systems.
• BS EN 62305-4 Protection of electronic systems
- LPMS (LEMP Protection Measures System)
- complete system of protection measures for internal systems against LEMP.
• LPZ (Lightning Protection Zone)
  - zone (area) where lightning electromagnetic environment is defined

  $0_A$ Full current, full magnetic field, $0_B$ Partial/induced current full magnetic field

  1 Limited induced current damped magnetic field

  2 Limited induced current, further damped magnetic field
Basic Lightning Protection Zone LPZ concept – BS EN 62305-4

LPZ 0 - most severe
Cross bond metallic services
Transient protection (SPDs) installed on services entering each zone

SPD (Surge Protection Device)
- device which limits transient overvoltages and diverts surge currents.
Zoned concept or “Location Categories” – BS 6651 Appendix C

- **CATEGORY A**
  - 6 KV
  - 500A

- **CATEGORY B**
  - 6 KV
  - 3 KA

- **CATEGORY C**
  - 20 KV
  - 10 KA

[Diagram showing various electrical components and connections]
Where to Protect

• Transients enter buildings via metallic conductors
  – Through both underground and overhead cables

• Protect all cables which enter or the leave building
  – Different systems require different protectors

• Protect critical equipment locally
  – Examples include Fire Alarm Panels, PLCs, Computers, Servers

• Comprehensive product range required to protect all systems
  – Mains protectors cannot protect a telephone line
Where to apply protection
Where to apply protection

Where to protect

- All cables that enter or leave the building:
  - Mains power
Where to apply protection

Mains protectors
Where to apply protection

Mains protectors
Where to apply protection

Where to protect

- All cables that enter or leave the building:
  - Mains power
  - Data communication and local area network cables
Where to apply protection

Data communication and local area network cables
Where to apply protection

Where to protect

• All cables that enter or leave the building:
  - Mains power
  - Data communication and local area network cables
  - Telephone lines
Where to apply protection

Telephone lines
Where to apply protection

Where to protect

• All cables that enter or leave the building:
  - Mains power
  - Data communication and local area network cables
  - Telephone lines
  - CCTV, Satellite, TV and antenna cables
Where to apply protection

CCTV protectors
(Mains power, CCTV video & telemetry lines)
Where to apply protection

RF protectors
Where to protect

- All cables that enter or leave the building:
  - Mains power
  - Data communication and local area network cables
  - Telephone lines
  - CCTV, Satellite, TV, and antenna cables
- The power supply local to important equipment
Where to apply protection

The power supply local to important equipment
Where to protect

- All cables that enter or leave the building:
  - Mains power
  - Data communication and local area network cables
  - Telephone lines
  - CCTV, Satellite TV and antenna cables
- The power supply local to important equipment
- **Electronic equipment outside the main buildings**
Where to apply protection

Protect electronic equipment
outside the building
Key requirements for a protector

For effective protection, a transient overvoltage protector should:

- be compatible with the system it is protecting
- survive repeatedly
- be properly installed
- not leave the user unprotected, as a result of failure
- have a low let-through voltage for all combinations of conductors
  - Lower let-through voltage = better equipment protection
Low let-through voltage

6,000V

600V

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Summary

• Transient overvoltages present a growing threat
  • Most modern systems are affected
• Structural LP systems do not protect equipment
  • LP systems need to be complemented with surge protection to protect both the structure and equipment
  • Recognised in new BS EN 62305 standard
  • Risk and protection measures now include both LPS and SPDs
• All incoming/outgoing cables should be protected
  • Also provide local protection to critical equipment
  • Choose protectors that have a low let-through voltage in all modes
Questions & Answers