# IEC 62305-4 : Protection Against Lightning – Part 4: Electrical and Electronic Systems within Structures

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## What are Transient Overvoltages (surges)?

"A transient overvoltage is a short duration increase in voltage measured between two or more conductors"

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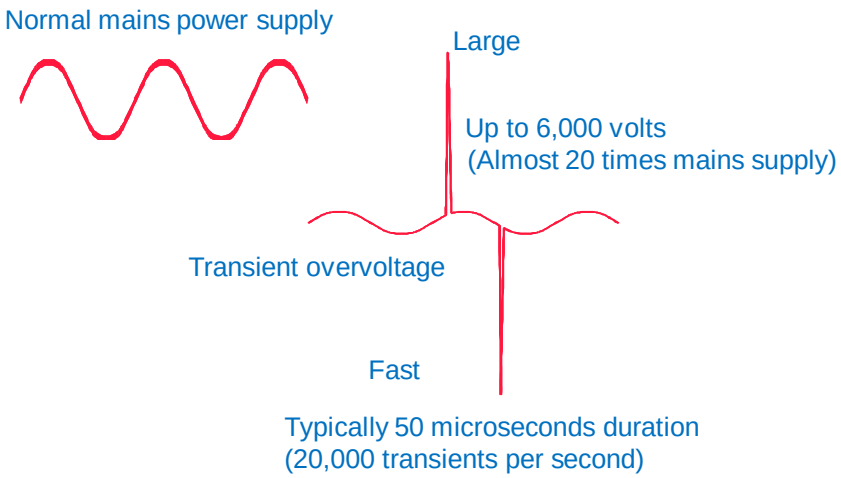
## What are Transient Overvoltages (surges)?

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## Surge Protective Devices
## For what purpose?

- SPD: Needs to be Quick!
  - Response times to a surge
    - Surge duration is between: 20 – 350 µs (millionths of a second)
    - Breaker response time: 10 – 60 ms (thousandth of a second)
    - **SPD** response time: **3-100 ns** (**billionths** of a second)

    - Some facts for comparison:

      - The human eye takes 50 – 80 ms to blink
      - A fly's wing takes 5ms to flap

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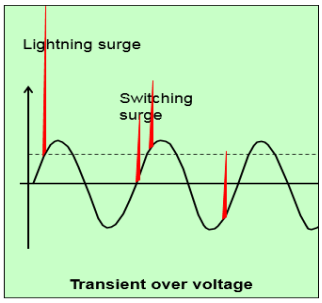
## How transient overvoltages are caused?

Two main causes:

- Lightning (also referred to as “Overvoltages of Atmospheric origin” within IET BS 7671)
- Switching Events

**External**
**35% of all transients originate outside the facility**




**Internal**
**65% of all transients originate inside the facility**

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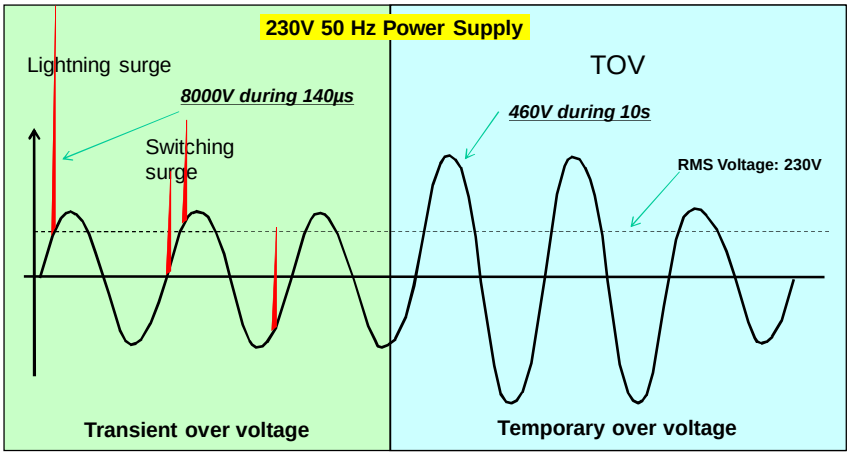
## Surge Protective Devices
## SPD Targets




**Purpose of SPD**

**Enemy of SPD**

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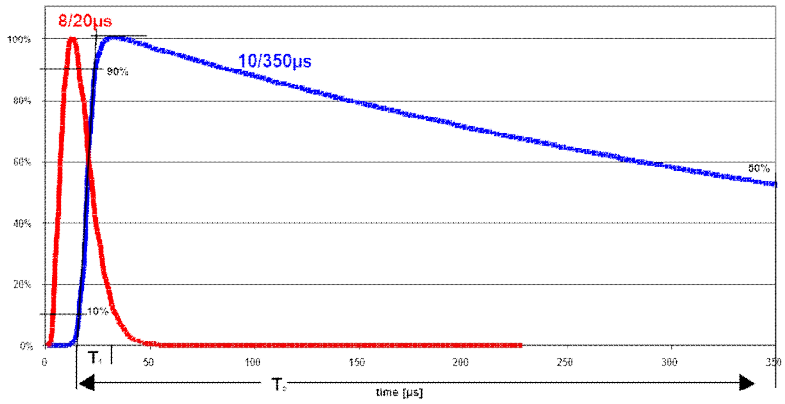
# Lightning and Transient Overvoltage Waveforms




- **10/350µs waveform :** **10/350µs:**
  The first number corresponds to the time from 10% to 90% of its peak value (10µs)
  The second number corresponds to the time taken for the wave to descend to 50% of its peak value (350µs).
- **8/20µs waveform :** **8/20µs:**
  The first number corresponds to the time from 10% to 90% of its peak value (8µs).
  The second number corresponds to the time taken for the wave to descend to 50% of its peak value (20µs).

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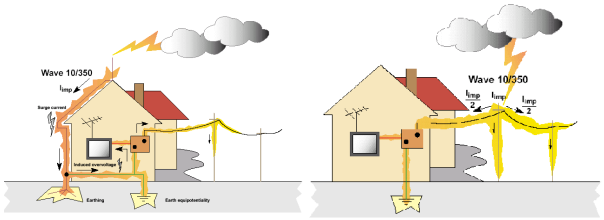
7

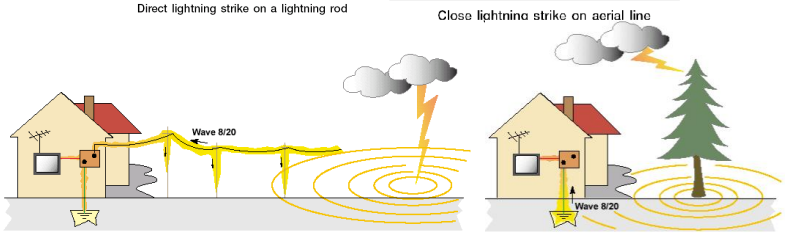
# How transient overvoltages are caused?

External sources:




Direct lightning strike on a lightning rod

Close lightning strike on aerial line




Indirect lightning strike

Indirect lightning strike

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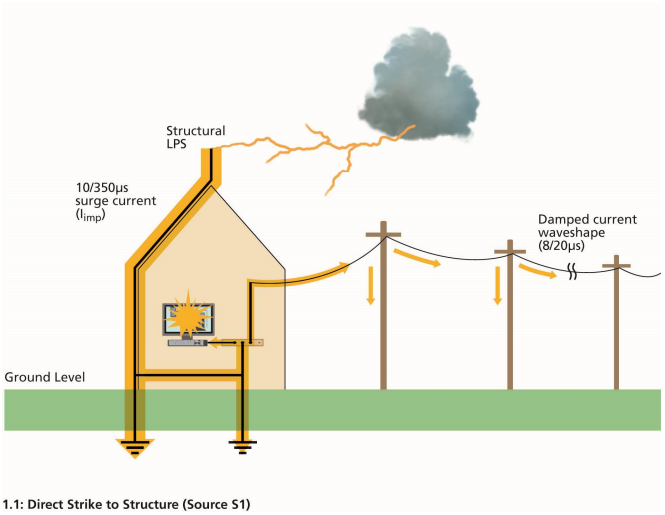


1.1: Direct Strike to Structure (Source S1)

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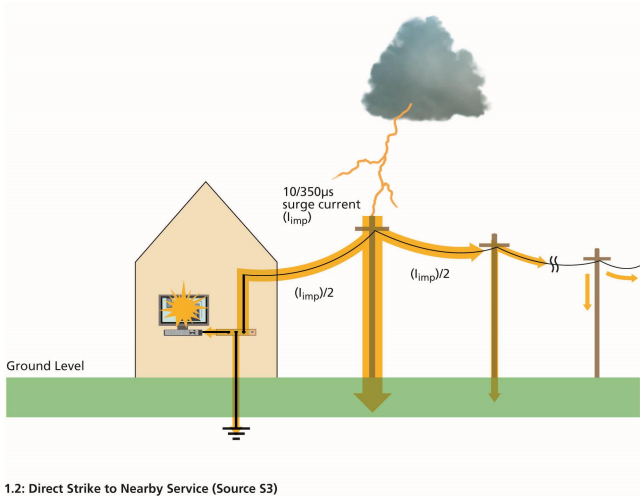


1.2: Direct Strike to Nearby Service (Source S3)

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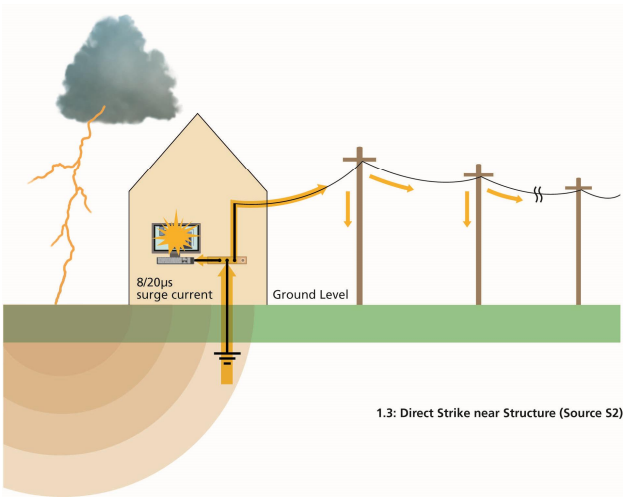


1.3: Direct Strike near Structure (Source S2)

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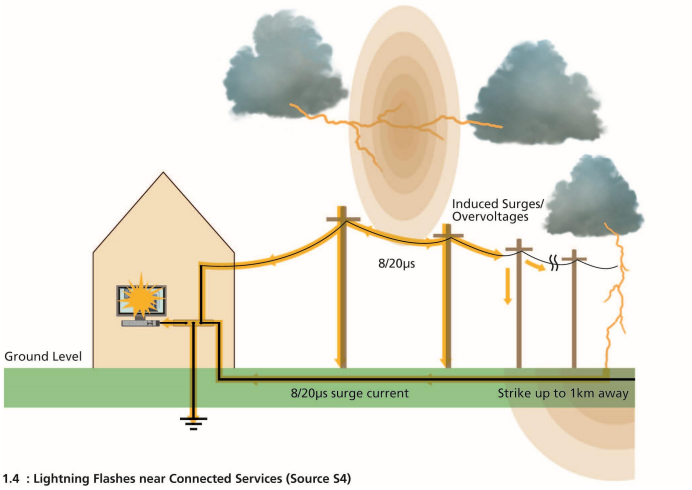


1.4 : Lightning Flashes near Connected Services (Source S4)

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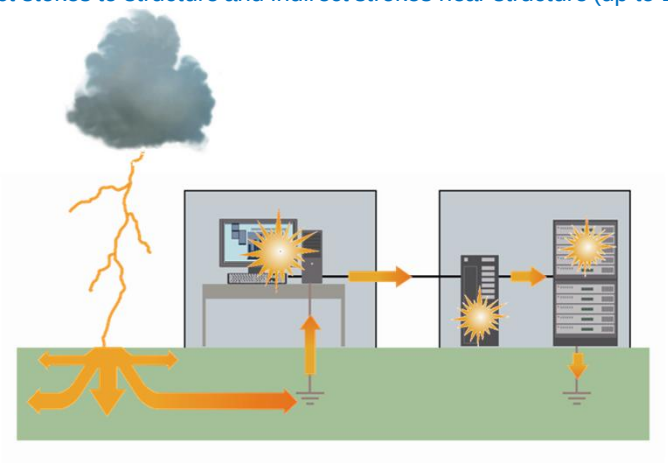
## Causes of Transient Overvoltages

External - atmospheric over-voltage (lightning)

Both direct stokes to structure and indirect strokes near structure (up to 1km away)



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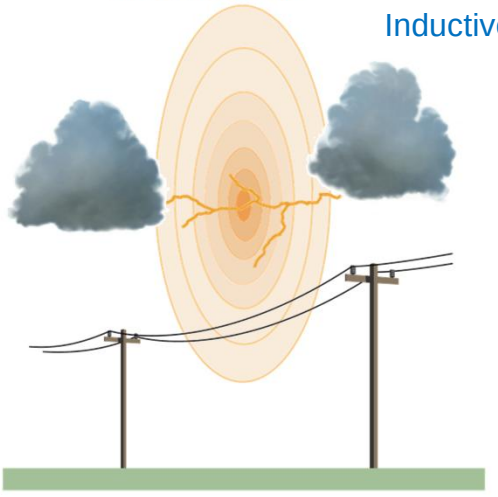
## Causes of Transient Overvoltages

External - atmospheric over-voltage (lightning)

Inductive coupling



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## Causes of transient overvoltages

Internal - from switching surges (inductive loads)

Equipment that cause switching transients

- Motors – lifts, air-con
- Transformers
- Welding equipment

Internal transients as a result of fault initiations

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## Why Protect?

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## Why Protect?

- **Risk of Loss of Life**
  - Fire and electric shock hazards through flashover
  - Health and safety hazards caused by plant instability, after loss of control
- **Consider the cost for**
  - Replacing damaged equipment
  - Repair work, for remote or unmanned installations
  - Lost or destroyed data
- **The financial implications of extended stoppages**
  - Sales lost to competitors
  - Lost production

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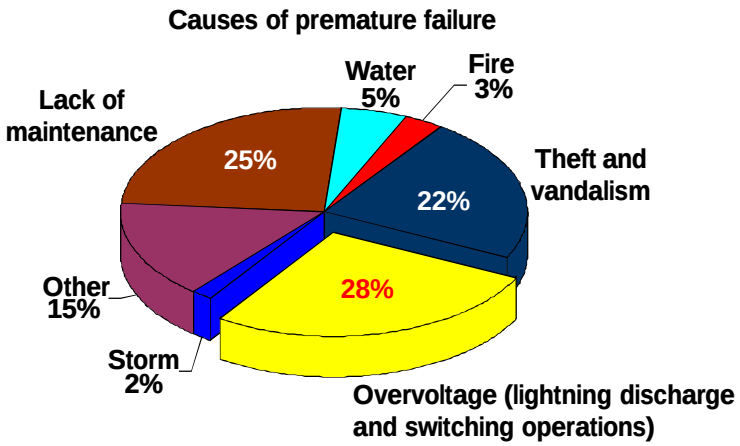
## Failure Analysis – industrial equipment




Damage to electronics: Analysis of approx. 7,750 damages
NOTE – transients can also cause damage via metallic data, signal & telecommunications lines

Ref: Contingency planning insurance data

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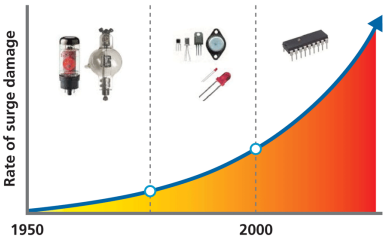
# IEC/BS EN 62305 to address increasing problem




Increased use of electronics, less able to withstand surges

*"Lightning as a source of harm is a very high-energy phenomenon. Lightning flashes release many hundreds of mega-joules of energy. When compared with the milli-joules of energy that may be sufficient to cause damage to sensitive electronic equipment in electrical and electronic systems within a structure, it is clear that additional protection measures will be necessary to protect some of this equipment.*

*The need for this International Standard {BS EN62305-4} has arisen due to the increasing cost of failures of electrical and electronic systems, caused by electromagnetic effects of lightning. Of particular importance are electronic systems used in data processing and storage as well as process control and safety for plants of considerable capital cost, size and complexity (for which plant outages are very undesirable for cost and safety reasons)."* BS EN 62305-4

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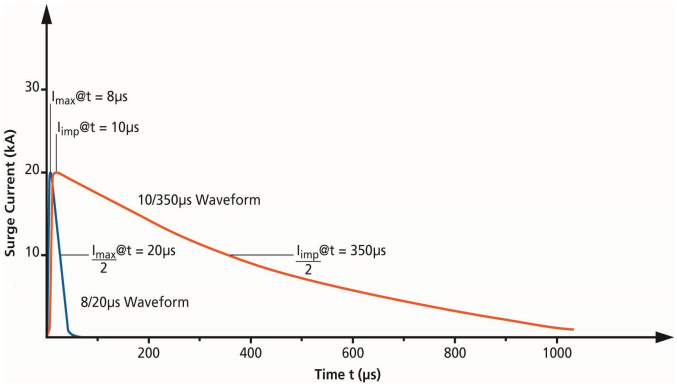
# Surge current waveforms to IEC/BS EN 61643

Surges characterised by standardized waveforms (approx time in µs to peak/half peak)

- **Direct or partial lightning currents are represented by 10/350 waveform (high energy)**
- **Indirect or induced lightning currents are represented by 8/20 waveform**
- **Type 1 SPDs are tested with 10/350, Type 2 and 3 are tested with 8/20**
- **Surge voltage waveforms (e.g. 1.2/50) are characterized similarly**

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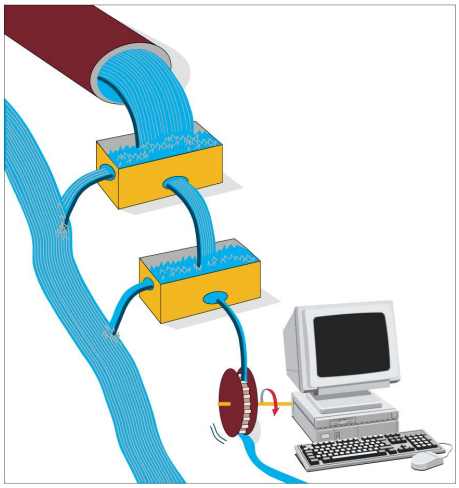
## Surge Protective Device SPD - basic principle



The SPD will control the flow to respect the equipment's withstand level

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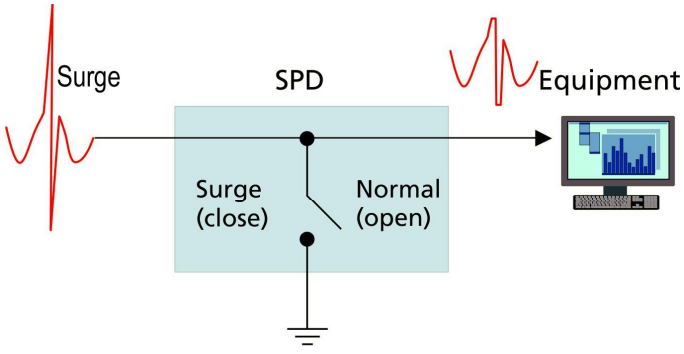
## Surge Protective Device SPD - basic principle






Divert surge currents and limit over-voltages, survive and repeatedly protect personnel, buildings and equipment

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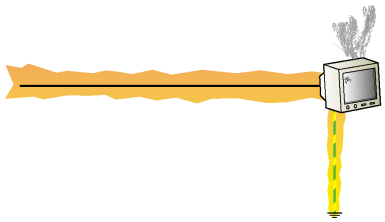
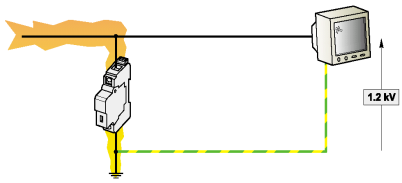
## Surge Protective Device SPD - basic principle

**Purpose and operation of SPD**



Possible effects on equipment
if it's not properly protected by SPD




If the equipment is protected by SPD, the SPD will limit transient surges and divert them to ground.

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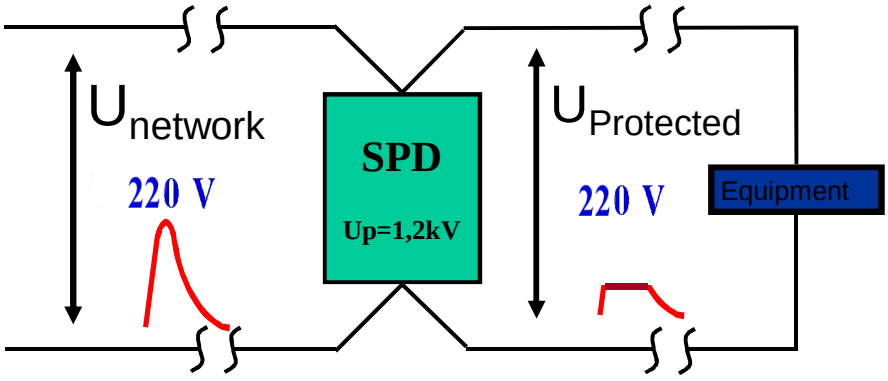
## Surge Protective Device SPD - basic principle

**Purpose and operation of SPD**




**Level of protection = Up**

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## Surge Protective Devices
## Withstand Voltage of the device to be protected

These 4 categories are indicated in the following table, according to IEC 60364-4-44, IEC 60664-1 and IEC 60730-1.

| Category | $U_n$ | | | | Examples |
|---|---|---|---|---|---|
| | 120-220 V | 230-400 V | 400-690 V | 1 000 V | |
| I | 800 V | 1 500 V | 2 500 V | 4 000 V | Equipment containing particularly sensitive electronic circuits:<br>– Servers, computers, TVs, HiFis, videos, alarms etc.<br>– Household appliances with electronic programs etc. |
| II | 1 500 V | 2 500 V | 4 000 V | 6 000 V | Non-electronic household appliances, devices etc. |
| III | 2 500 V | 4 000 V | 6 000 V | 8 000 V | Distribution switchboards, switching devices (switches and circuit breakers, sockets, insulators etc.), conduits and accessories (wires, bars, junction boxes etc.) |
| IV | 4 000 V | 6 000 V | 8 000 V | 12 000 V | Industrial equipment and equipment such as, for example, fixed motors connected permanently to fixed systems, electricity meters, transformers etc. |

The SPD's level of protection Uprot (Up under In) must always be less than the impulse withstand voltage Uw of the equipment to be protected.

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## Surge Protective Devices
### Major SPD Types, Technologies and Characteristics

- **2 major types of SPDs**
  - Type 1 (10/350µs)
  - Type 2 (8/20µs)
- **2 major Technologies**
  - Spark gap / Gas Tube
  - Varistors (MOVs)

**4 major characteristics**
Iimp for Type 1
Imax for Type 2
Uc: Maximum Operating voltage
Up: Voltage protection level

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# Surge Protective Devices

## Major SPD Characteristics

**4 major characteristics**

**Iimp:** (Impulse current for class I testing)
ค่ากระแสสูงสุดที่อุปกรณ์ป้องกันแรงดันเกินชั่วขณะสามารถทนได้ เป็นค่าที่ใช้กับ **SPD Type1 (10/350)**

**Imax:** (Maximum discharge current for class II testing)
ค่ากระแสสูงสุดที่อุปกรณ์ป้องกันแรงดันเกินชั่วขณะสามารถทนได้ เป็นค่าที่ใช้กับ **SPD Type2 (8/20)**

**Up:** (Voltage protection level)
ค่าแรงดันป้องกันที่ถูกจำกัดไว้ที่อุปกรณ์ป้องกันขณะเกิดแรงดันเกินชั่วขณะ

**Uc:** (Maximum continuous operating voltage)
ค่าแรงดัน r.m.s หรือ d.c. สูงสุดแบบต่อเนื่อง ที่อุปกรณ์ป้องกันแรงดันเกินชั่วขณะสามารถทนได้

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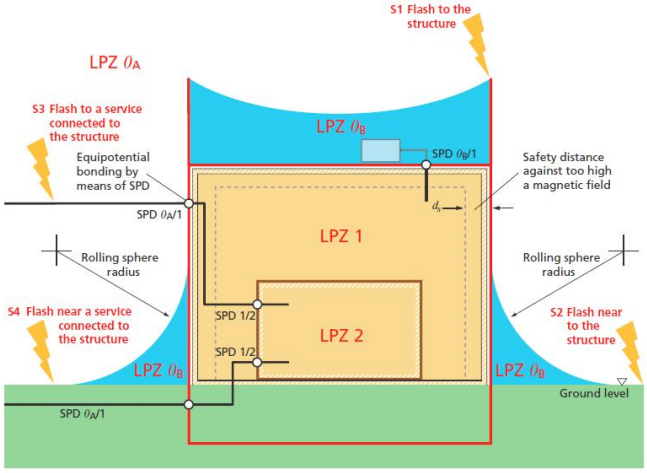
27

# Example of a complete LPMS




| | |
|---|---|
| LPZ $0_A$ | Direct flash, full lightning current, full magnetic field |
| LPZ $0_B$ | No direct flash, partial lightning or induced current, full magnetic field |
| LPZ 1 | No direct flash, partial lightning or induced current, damped magnetic field |
| LPZ 2 | No direct flash, induced currents, further damped magnetic field<br>Protected volumes inside LPZ 1 and LPZ 2 must respect safety distances $d_s$ |

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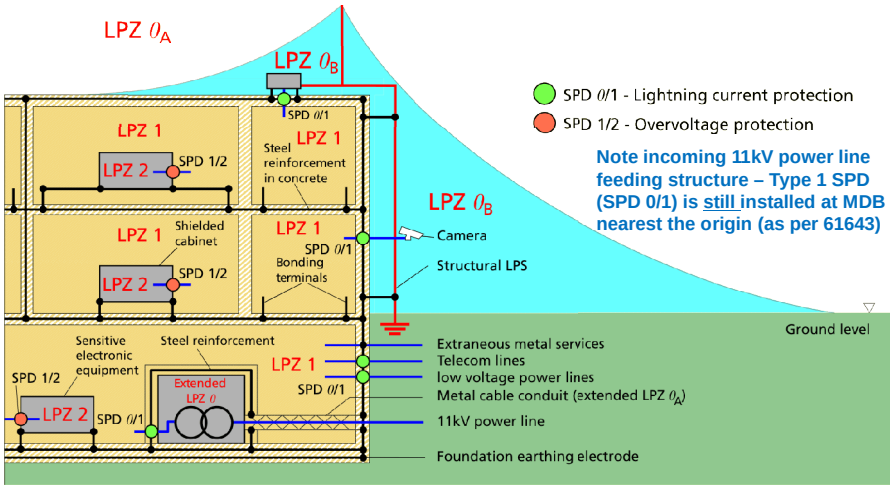
28

# Example of a complete LPMS



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# Type, test class/category and application of SPD's to IEC/BS EN 61643 series

| | SPD location/LPZ boundary | | |
|---|---|---|---|
| | LPZ 0/1 | LPZ 1/2 | LPZ 2/3 |
| Typical SPD installation point | Service Entrance (e.g. Main distribution board or telecom NTP) | Sub-distribution board or telecom PBX frame | Terminal Equipment (eg socket outlet) |
| Mains Test Class/SPD Type[1] | I/1 | II/2 | III/3 |
| Surge test waveform | 10/350 current | 8/20 current | Combination 8/20 current and 1.2/50 voltage |
| Typical peak test current (per mode) | 25kA[2] | 40kA | 3kA (with 6kV) |
| Signal/Telecom Test Category[1] | D1[3] | C2[3] | C1 |
| Surge test waveform | 10/350 current | Combination 8/20 current and 1.2/50 voltage | Combination 8/20 current and 1.2/50 voltage |
| Typical peak test current (per mode) | 2.5kA | 2kA (with 4kV) | 0.5kA (with 1kV) |

[1] Tests to BS EN 61643 series
[2] Peak current (per mode) for a 3 phase SPD to protect a TNS system
[3] Test category B2 10/700 voltage waveform (also within ITU-T standards) up to 4kV peak also permissible

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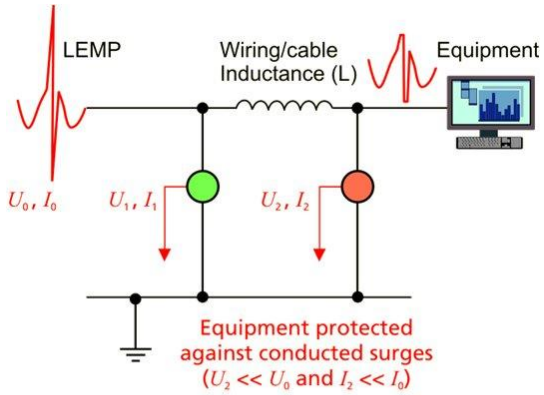
## Principle of co-ordinated SPDs




SPD 0/1 - Lightning current protection

SPD 1/2 - Overvoltage protection



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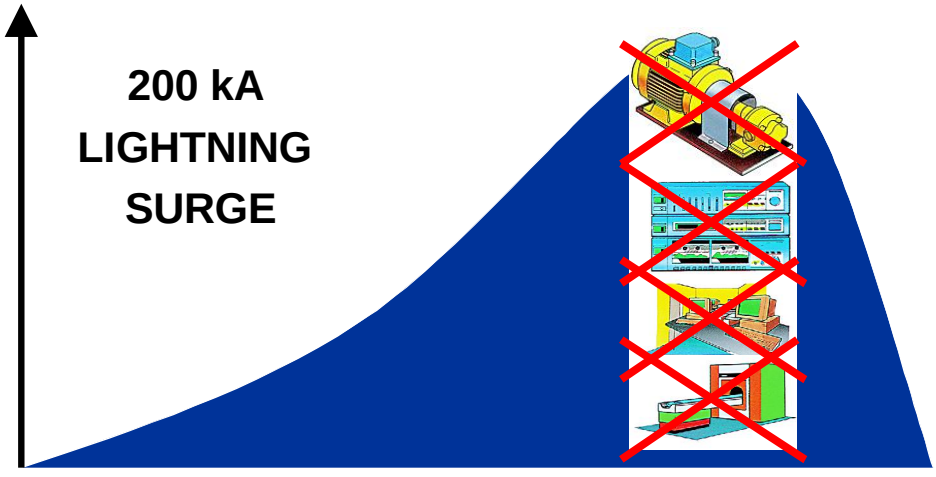
31

## Surge Protective Devices
## How does the SPD operates?

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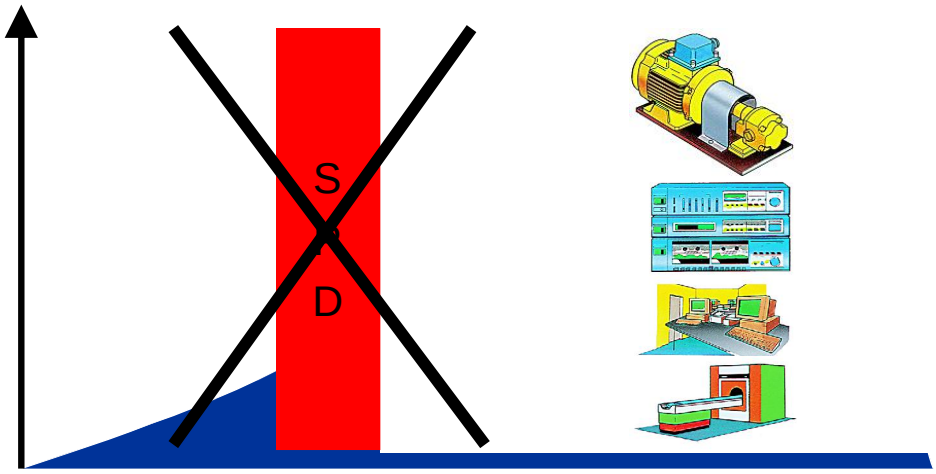
32

## Surge Protective Devices
## How does the SPD operates?

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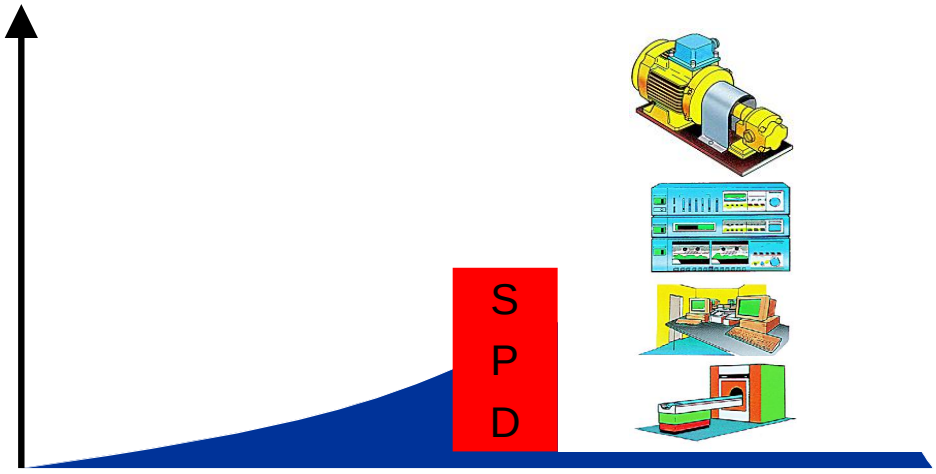
## Surge Protective Devices
## How does the SPD operates?

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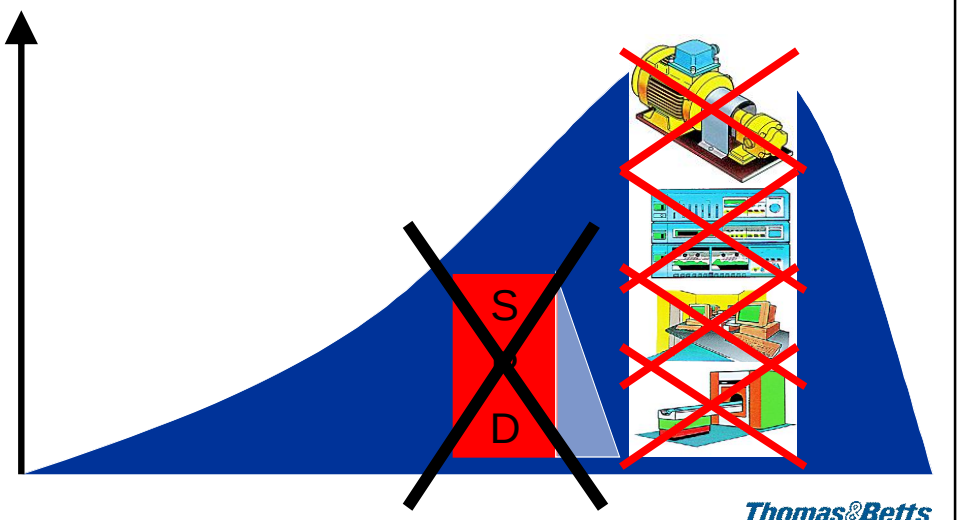
## Surge Protective Devices
## How does the SPD operates?

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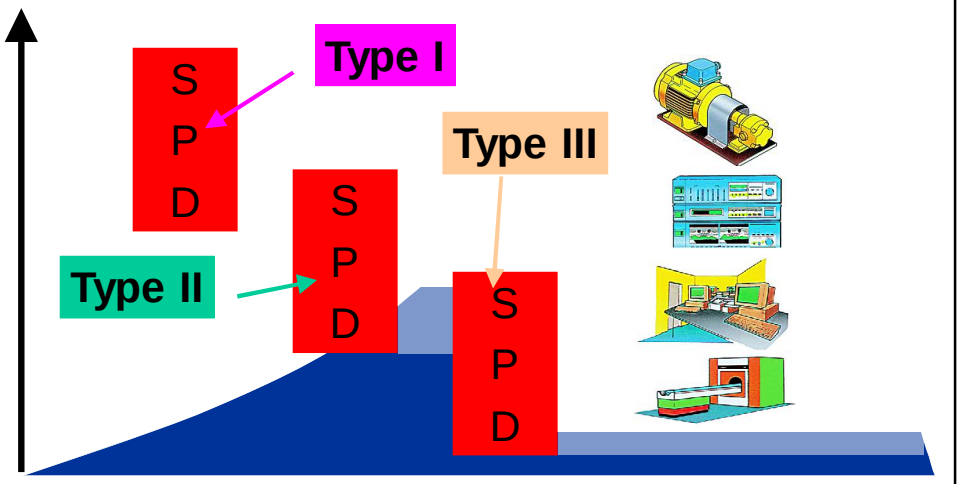
35

## Surge Protective Devices
## How does the SPD operates?

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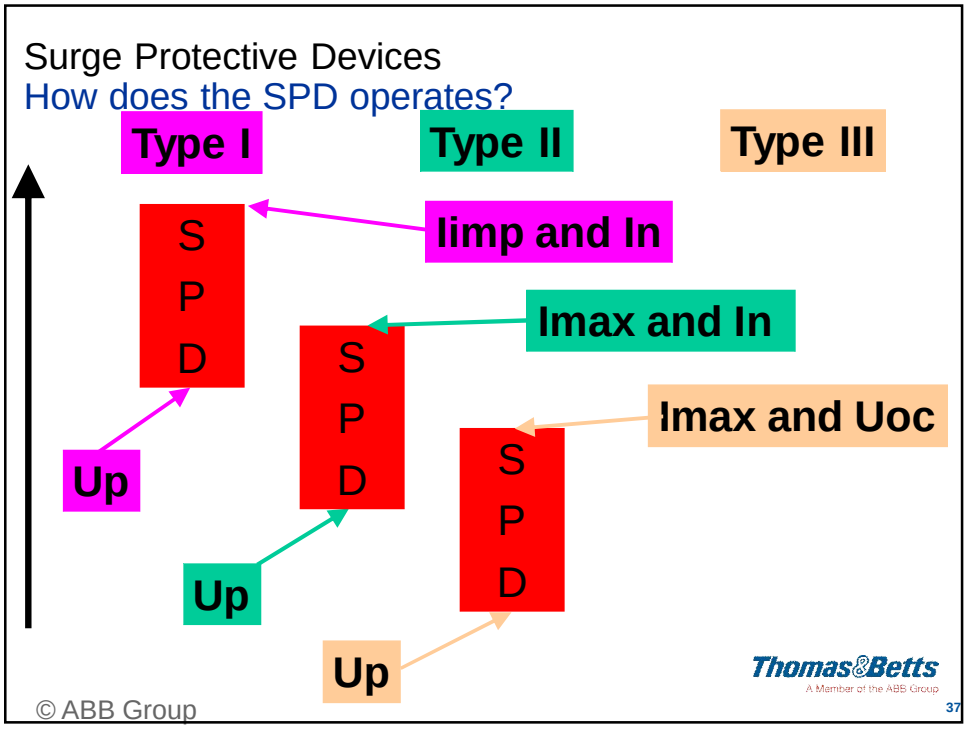
36


Surge Protective Devices
How does the SPD operates?
Type I
Type II
Type III
Iimp and In
Imax and In
Imax and Uoc
S P D
S P D
S P D
Up
Up
Up
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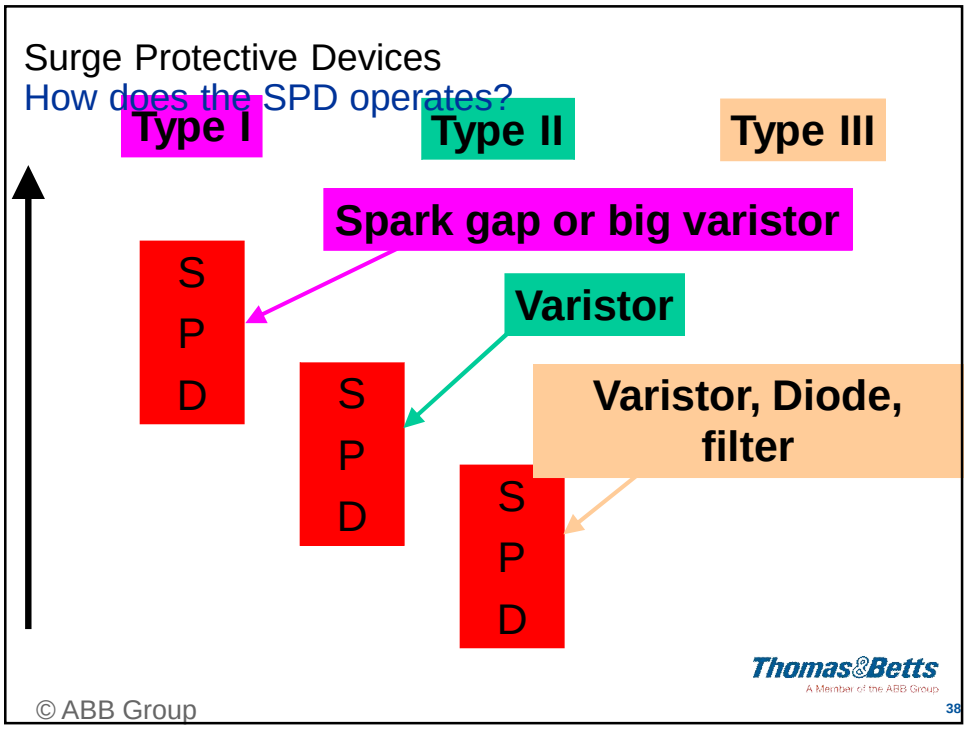
Surge Protective Devices
How does the SPD operates?
Type I
Type II
Type III
Spark gap or big varistor
Varistor
Varistor, Diode, filter
S P D
S P D
S P D
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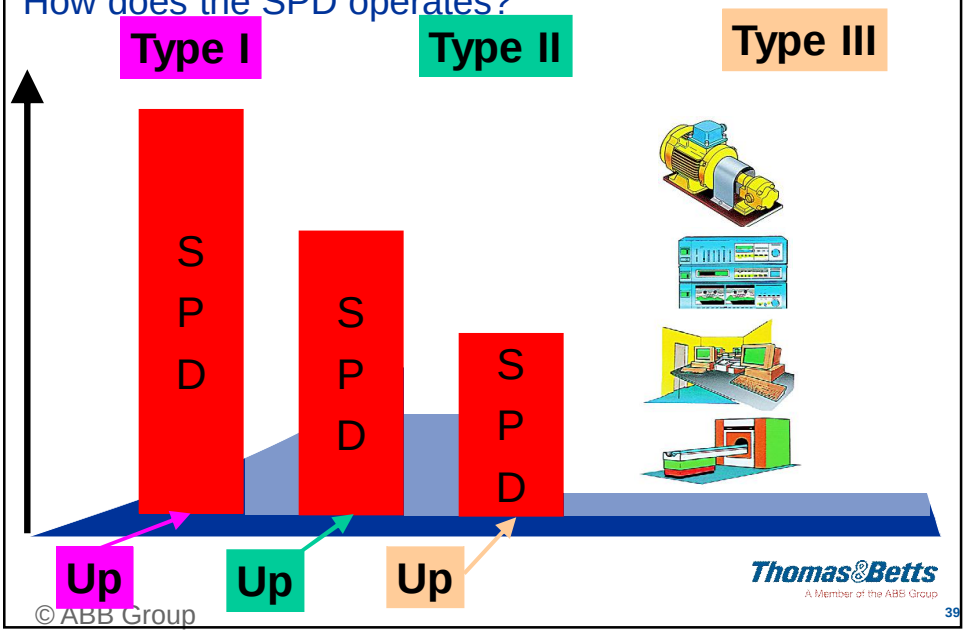
## Surge Protective Devices
### How does the SPD operates?



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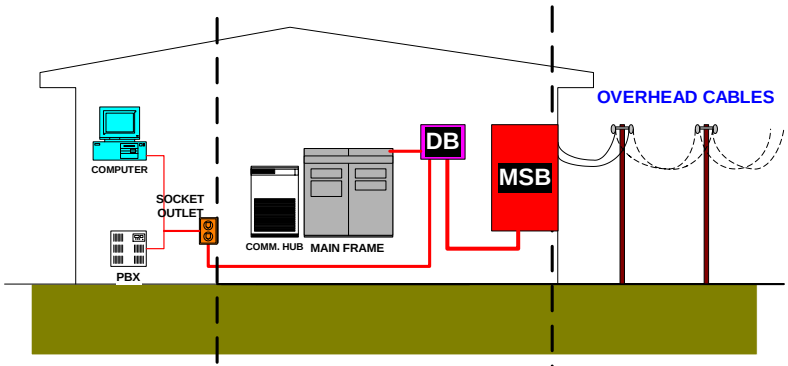
39

## SPD Location/ LPZ boundary for Main Power Supplies




LPZ 2/3 (Zone)
IEC 61643 – 11
Type 3: 3kA/mode 8/20㎲ current with 6KV voltage

LPZ 1/2 (Zone)
IEC 61643 – 11
Type 2: 40kA/mode 8/20㎲ current

LPZ 0/1 (Zone)
IEC 61643 – 11
Type 1: 25kA/mode 10/350㎲ current

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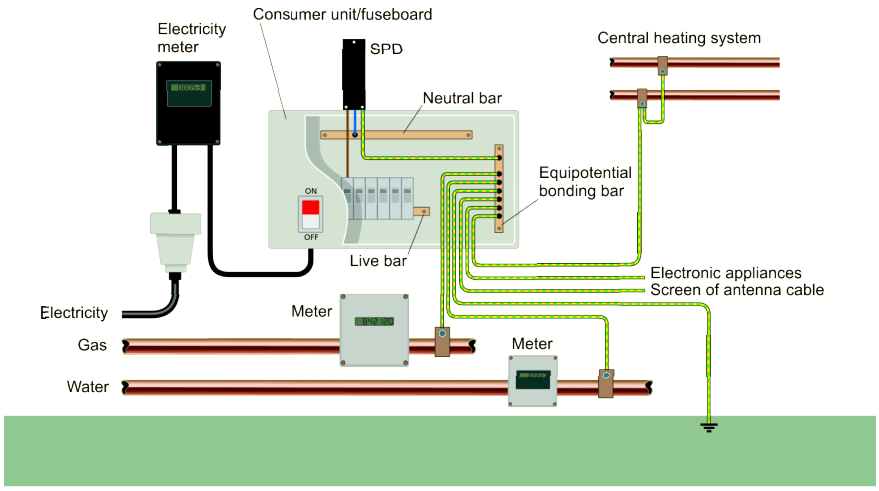
40

# Example of main equipotential bonding



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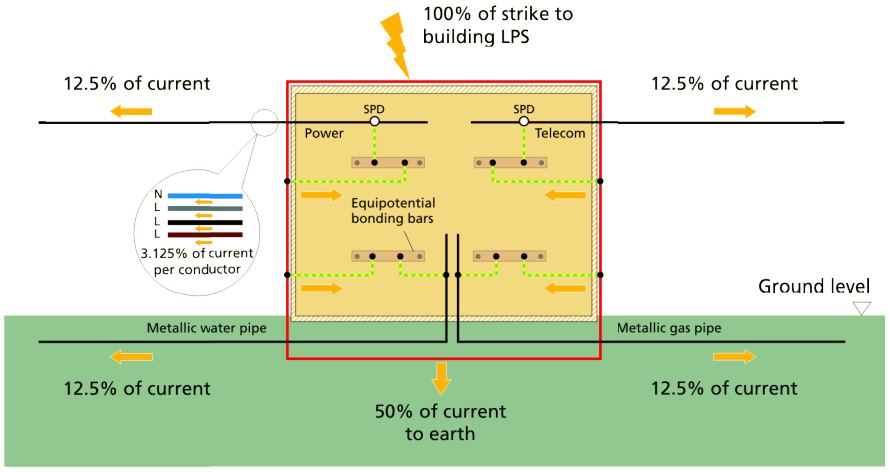
# 10/350 current division concept for multiple services (far more realistic in practice)



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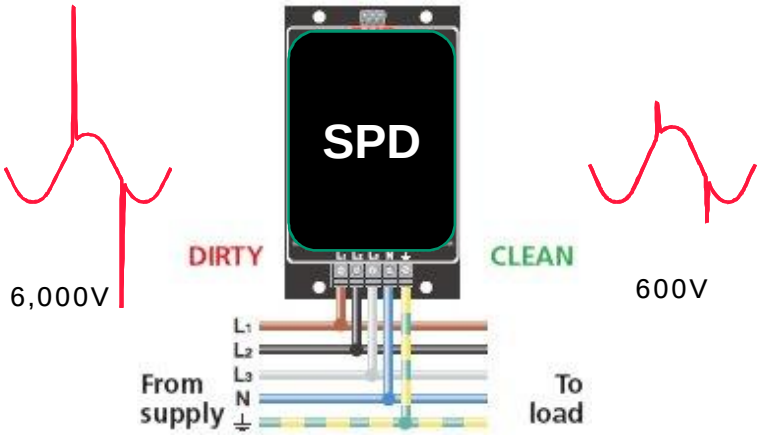
## Low let-through voltage/better protection level *Up*

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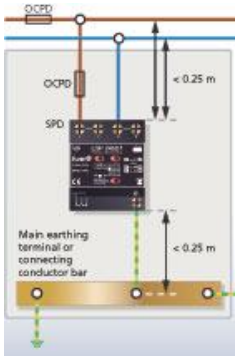
## Surge protection to BS EN 62305 / BS 7671 Amendment 1

- SPD installation – Parallel connection




OCPD Overcurrent protective device
SPD Surge protective device
E/I Equipment or installation to be protected against overvoltages

534 recommends connecting leads (*a* + *b*) should not preferably exceed 0.5m

Under no circumstances should leads exceed 1m

In practice, connecting leads should be kept as short as possible (0.25cm if practicable)

Minimum size of connecting leads copper (or equivalent):

- 16mm$^2$ for Type 1 SPDs
- 4mm$^2$ for Type 2, 3 SPDs

(Or equivalent size to line conductors if smaller)

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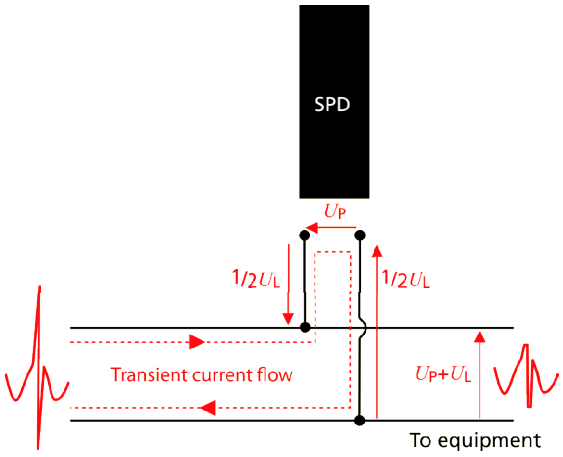
## Surge protection to BS EN 62305 / BS 7671 Amendment 1

- Installation effects – parallel protectors



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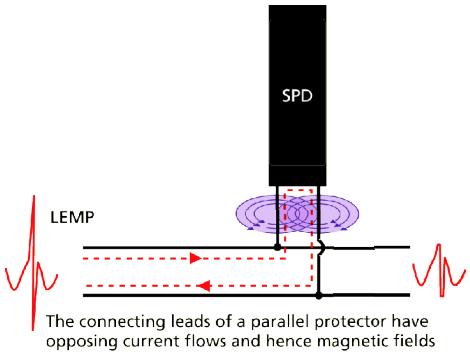
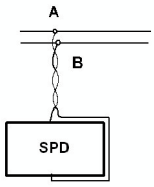
## Surge protection to BS EN 62305 / BS 7671 Amendment 1

- Installation effects – parallel protectors




Binding connecting leads cancels magnetic fields and hence inductive voltage



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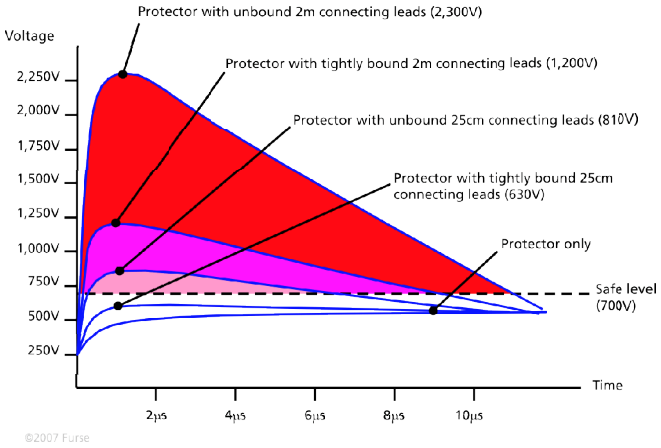
## Surge protection to BS EN 62305 / BS 7671 Amendment 1

- Installation effects – connecting leads

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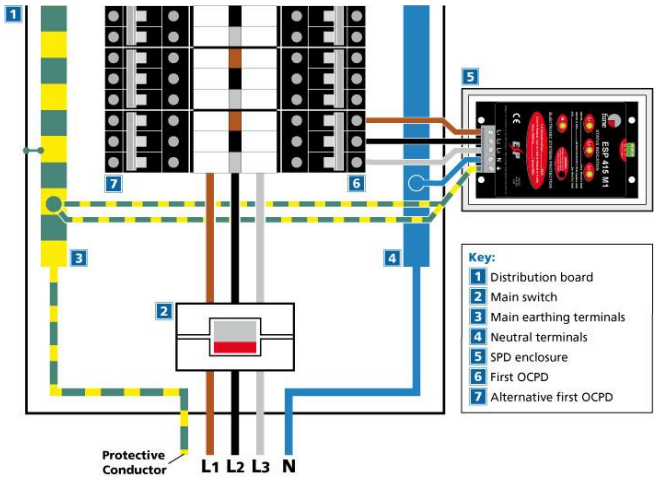
## SPD installation

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## SPDs Application – Power Line

Mains Protection

- Mains incomers
- Data/signal equipments
- In/Out mains protection DB
- Building control system
- **Sensitive sub and distribution**
- **UPS Data Centre**
- **Outdoor applications**

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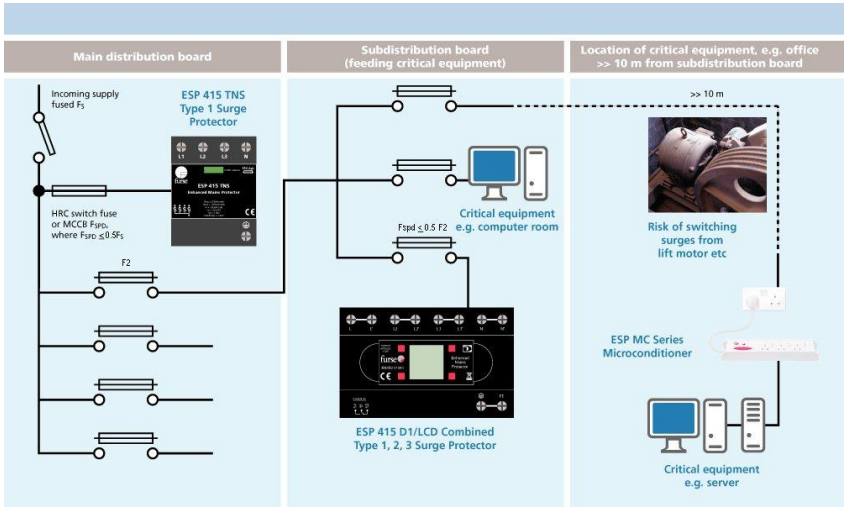
## Example of coordinated SPDs and location

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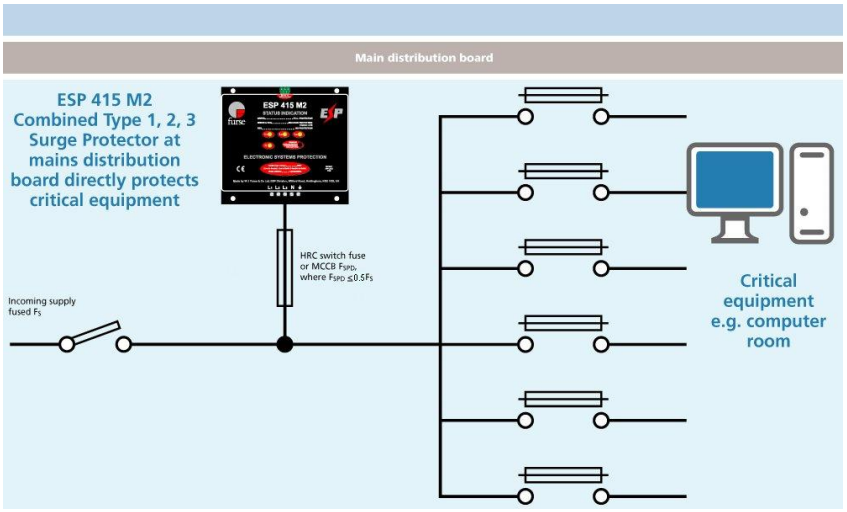
# Example for use of combined Type SPD

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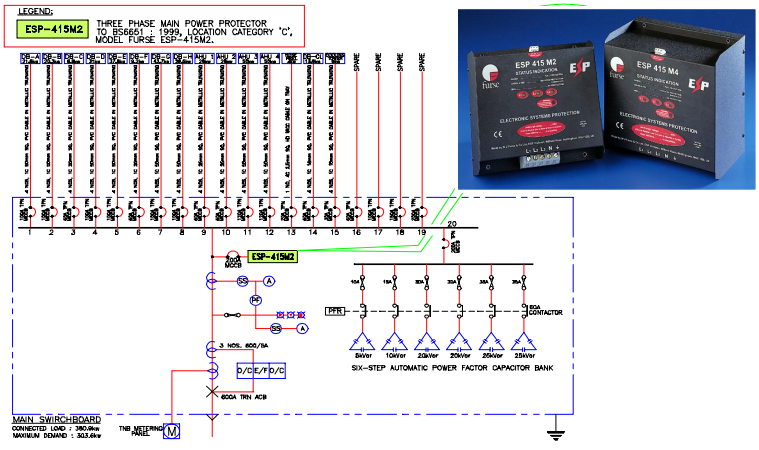
# SPDs Application – Power Line




Typical Mains ESP Design

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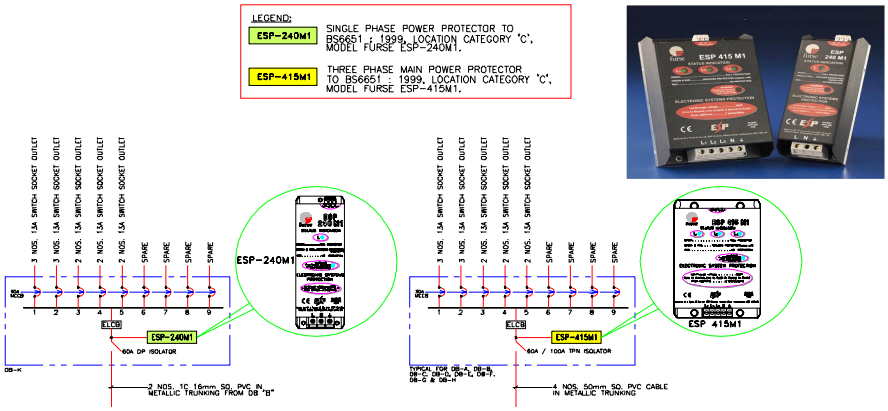
# SPDs Application – Power Line

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# Example to use with data and communication application

All cables that enter or leave the building:

Mains power

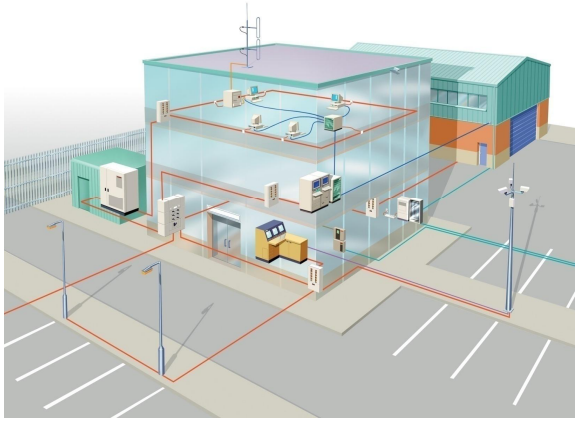
Data communication and local area network cables

Telephone lines

CCTV, Satellite, TV and antenna cables

Intercom System

Power supply local to important equipment



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## SPDs Application – Data and Communication

Signal / Data Protection

- Normal PSTN Tel
- ISDN, ASDL or DDN Lines
- CCTV Security System
- Computer Networking
- Programmable Logic Control
- Fire Alarm System
- RF or ELV applications

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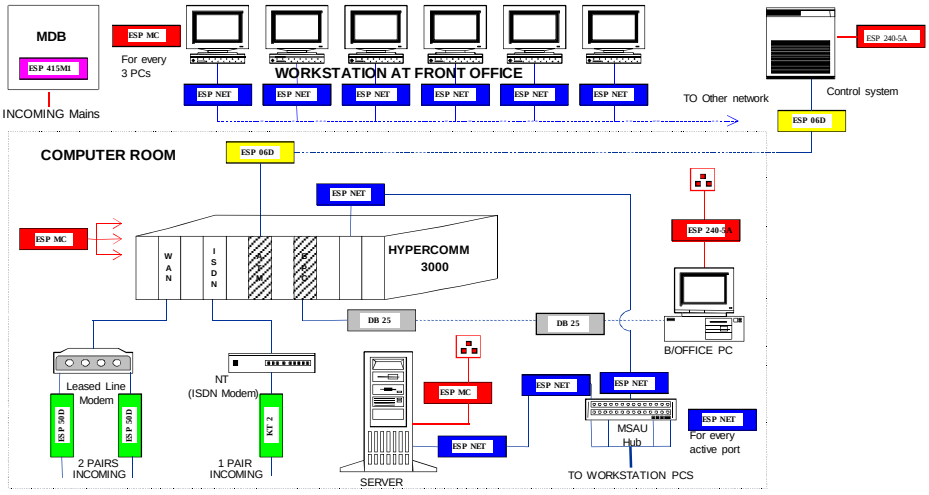
## SPDs Application – Data and Communication

### Typical Netwoking SPD Installation

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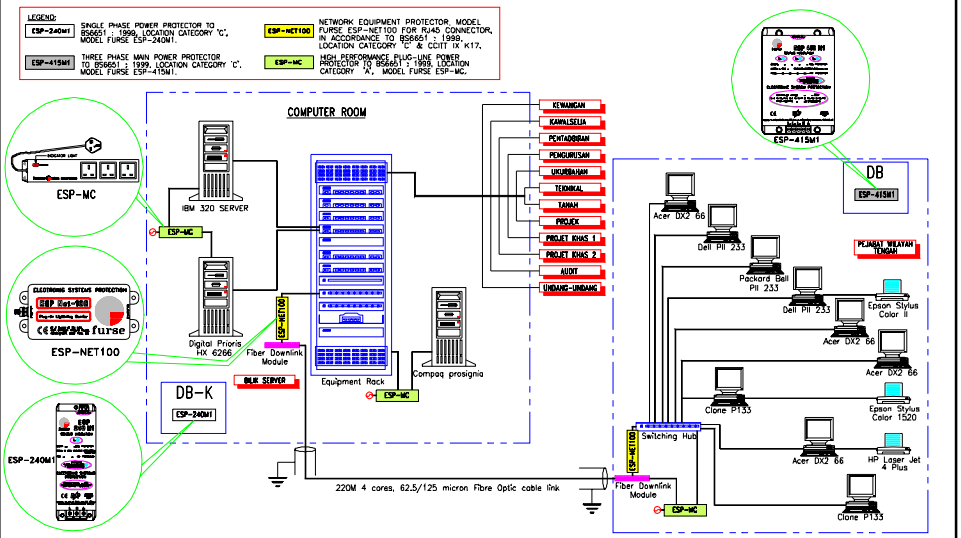
# SPDs Application – Data and Communication

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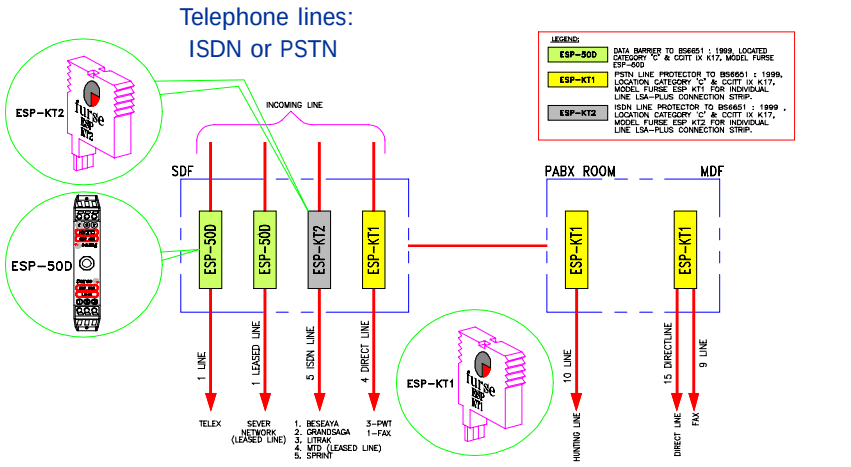
# SPDs Application – Data and Communication

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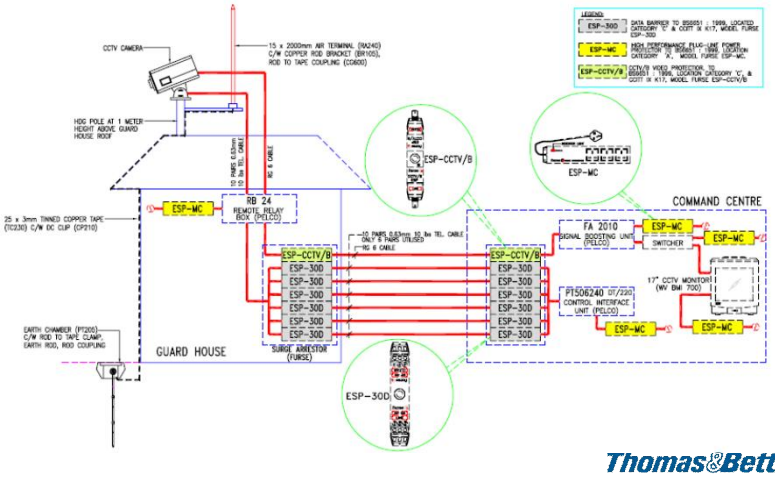
## SPDs Application – Data and Communication

EFFECTIVE PROTECTION FOR CCTV SYSTEM

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## End

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