Raycap

Corporate Presentation

Raycap at a Glance

Our Company

- Founded in 1987, privately owned
- Global leader in electrical surge protection
- Strong in-house R&D capabilities and IP creation
- State-of-the-art manufacturing facilities
- B2B model, serving industrial OEM customers
- Strong organic growth, augmented by M&A

Markets

Telecom

Renewable Energy

Industrial

Power & Utilities *Transportation* *EV Charging*

Facts & Figures

Revenues (2022)	Global Headcount	Countries Served
€485 M	2,100	75+
R&D Investment	**Issued Patents**	**Presence in Countries**
4% of revenues	400+	8

Customers

T··· OTE at&t verizon

vodafone dish ERICSSON NOKIA

Vestas SMA SNCF HUAWEI

GE PORSCHE ALSTOM ABB

Global Operations

Kearny, NJ, USA

Paris, France

% of sales (FY2022)

Europe 23%

Munich, Germany

Ljubljana, Slovenia

Bucharest, Romania

Post Falls, ID, USA

Athens, Greece

Drama, Greece

Charleston, SC, USA

Nicosia, Cyprus

Suzhou, China

North America 75%

% of sales (FY2022)

Rest of the World 2%

% of sales (FY2022)

World Class Laboratories and VDE Testing

Raycap operates Labs in: **Drama Greece, Post Falls Idaho USA, Ljubljana Slovenia**

High Current Generators

- Lightning impulse current test (8/20 us impulse up to 200 kA peak),
- Lightning impulse current test (10/350 us impulse up to 100 kA),
- Low Current - Long duration impulse test (2000 us square wave up to 1000A)
- Milliamp test under AC and DC voltage

Other testing equipment

- Environmental chambers
- Isolation measurements
- Various voltage and surge pulse generators

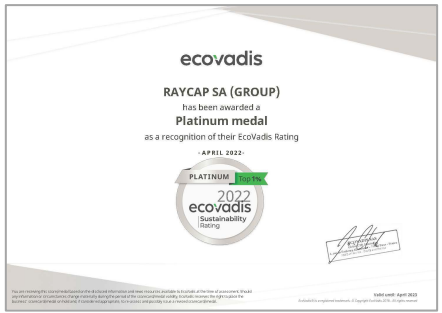
Power supplies

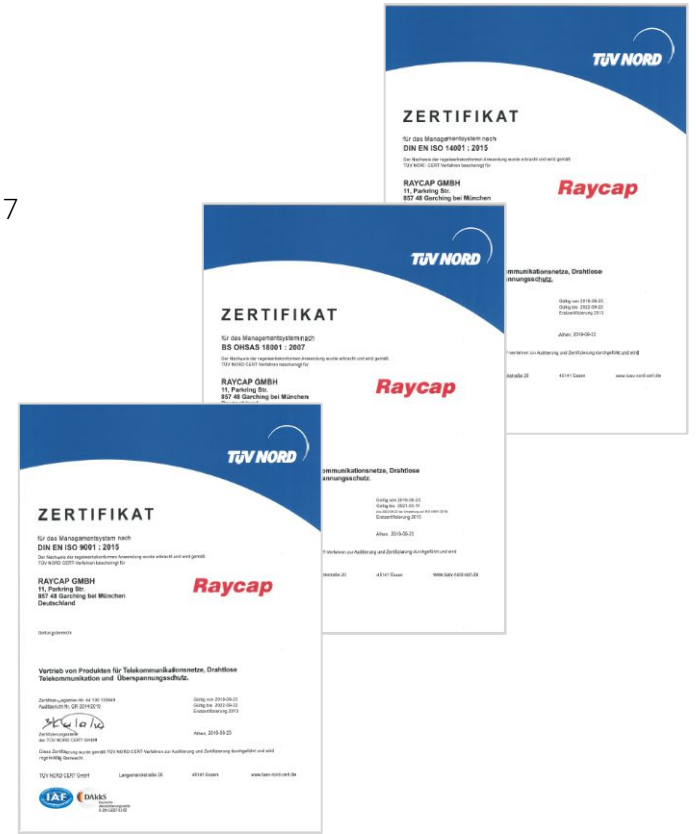
- AC and DC programmable power supplies
- Output power of up to 1MW
- Current limiting resistor
- Power factor adjustment

Labs are approved by UL and VDE for certification testing

Certifications

- Certified **Quality** Management System according to ISO 9001
- Certified **Environmental** Management System according to ISO 14001
- Certified Occupational **Health & Safety** system according to OHSAS 18001
- Accredited Testing Laboratory for Fiber-Optics under the terms of ISO 17025:2017
- Certified Information Security Management System ISO 27001:2013
- Certified by GSB International as Approved Coated Aluminum manufacturer
- **Ecovadis** Platinum Recognition Level **(top 1% globally)**
- Certified by **UL** LLC for Participation in the **Client Test Data Program** (CTDP)
- Certified for Participation in **IECEE** MTL's/CTF's testing programs





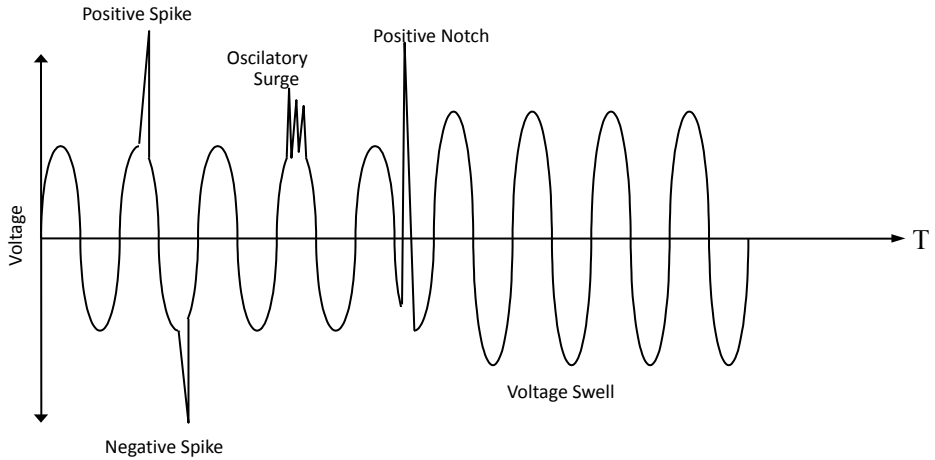
Raycap

Topics to be addressed

- The problem (surge)
- The solution – Surge Protective Device (SPD)
- Selection of SPD
  - Technology
  - Characteristics
  - Installation

Power Surges

- In theory, the voltage is described as a pure sinewave
- In reality, the voltage is subject to sudden fluctuations, generated either by internal or external factors



Power Surges

Sudden changes in the electrical conditions of a circuit will cause power surges. Surges are very short time high voltage amplitude disturbances (high dv/dt).

External Sources

- **Lightning**
- Power line disconnection & re-connection
- Transformer switching on/off
- Electrostatic discharges
- Load switching

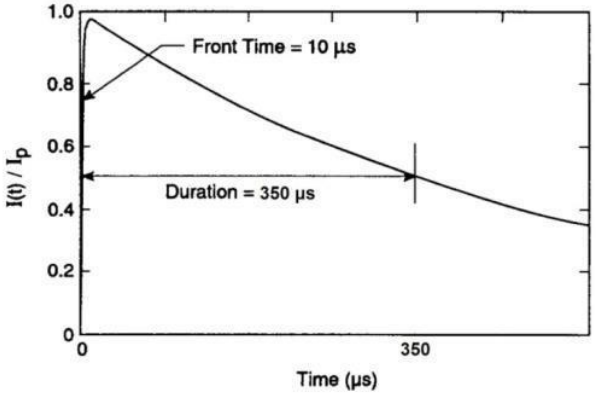
Internal Sources

- Operation of circuit breakers or fuses
- Operation of elevators, air-conditioners and generators
- Operation of electrical motors

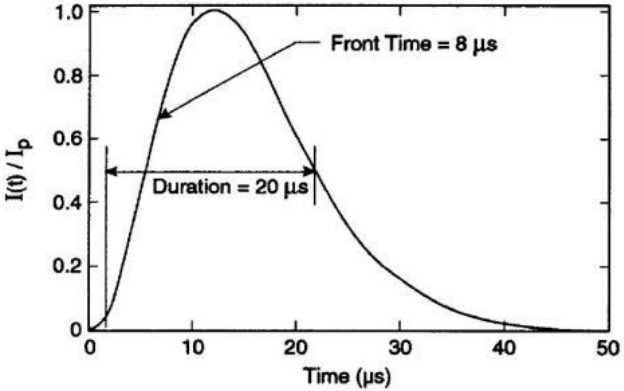
The majority of surges come through the power lines

10/350µs vs 8/20µs

30x Energy of 8/20 Impulse

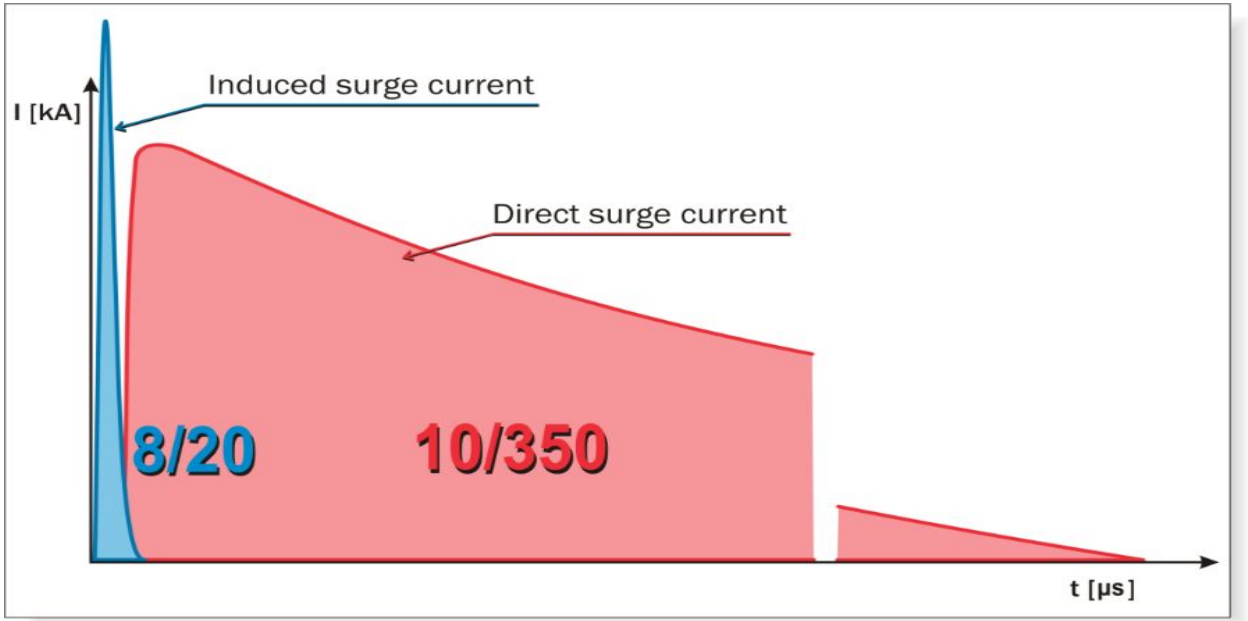


10/350µs



8/20µs

Type 1 and Type 2 impulse comparison

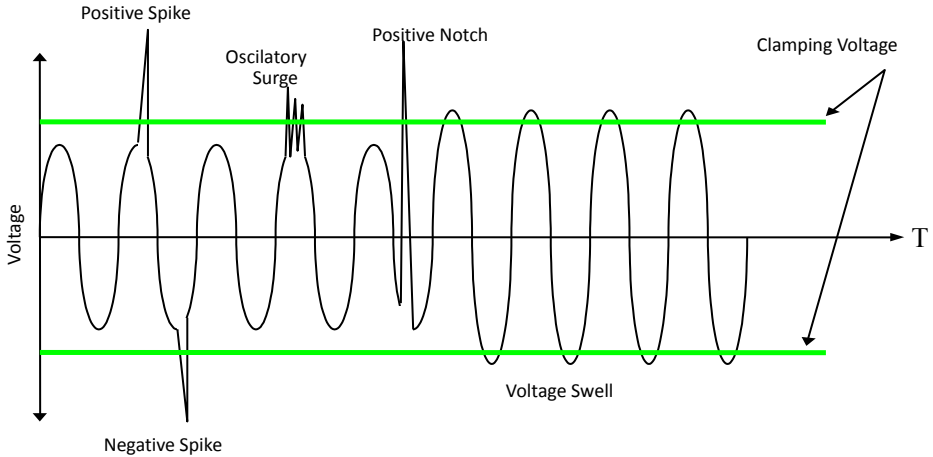


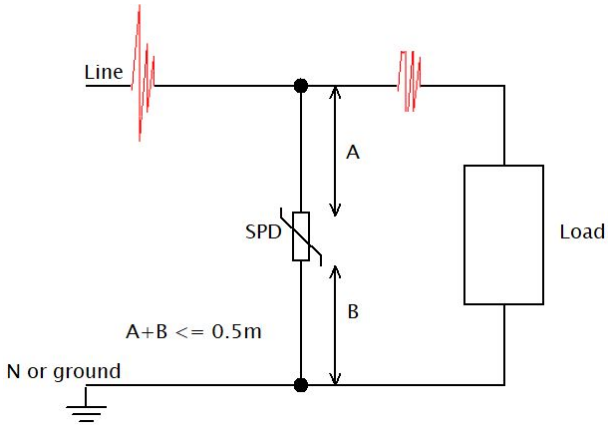
Due to longer duration Type 1 impulse (10/350) carries up to 20 times more energy at the same impulse amplitude as Type 2 impulse (8/20)

Surge Protective Devices – Description

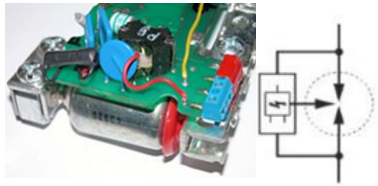
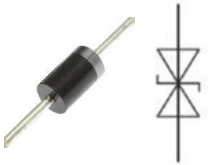
The Surge Protective Devices (SPDs) protect the sensitive electronic equipment from power surges.

When the amplitude of the voltage is over a specific level, the SPD will be activated. A current will flow through the SPD and the voltage on the SPD terminals will be limited to a specific value (Clamping Voltage, Residual Voltage or Let Through Voltage).

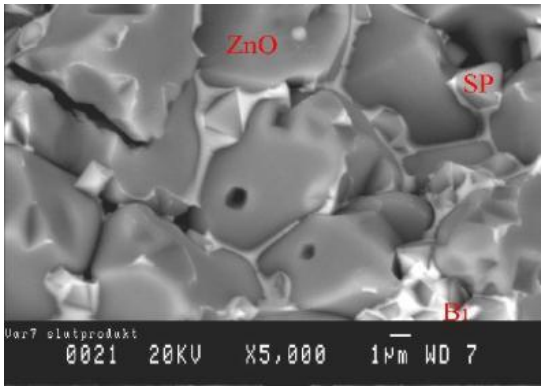




Technology comparison

	Triggered SG [Spark Gap]	GDTs [Gas Discharge Tube]	MOVs [Metal Oxide Varistor]	TVSs [Transient Voltage Suppressor Diode]
				
Pros	High current capability	High current capability	Low clamping voltage and high current capability	Lowest clamping voltage
Cons	Medium clamping voltage and follow on current	High clamping voltage (used only N-PE)	Significant overheating during conduction	Very low energy absorbing capability

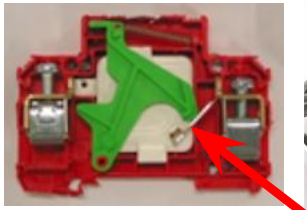
Main Issues with Conventional SPDs

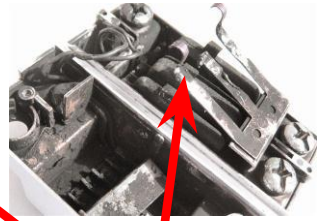


Aging &
Thermal Load Management

Spark-gaps

Life-End-Modus





Use of
internal
thermal fuses

Surge Protection Devices – Characteristics

- **Voltage Protection Level (U_p)**: The voltage between the SPD terminals when the SPD is activated. The Up values derive from the IEC 61643-11 test procedures.
- **Partial Lightning Current** (I_{imp}): The peak value of the lightning current (10/350μs waveform) flowing through the SPD.
- **Surge Current** (I_{max}): The peak value of the surge current (8/20μs waveform) flowing through the SPD.
- **Nominal Voltage** (U_n)
- **Response Time** (T_n)
- **Voltage Protection Level (U_p) :** It is the most important parameter. Higher U_p than the U_{wth} of the equipment under protection, will lead to equipment failure, sometimes in a catastrophic way.

Equipment Withstand Voltage

Equipment Withstand Voltage

Category I: Electronic Devices

Category II: Residential Devices (home equipment)

Category III: Devices Permanently Connected On the Grid (MCBs, etc.)

Category IV: Electric Accessories (cables, fuses, breakers etc.)

For 230/400V operational voltage (IEC 60664-1)

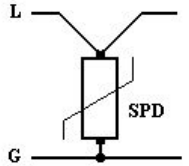
Equipment Category	I	II	III	IV
Withstand Voltage	1.5KV	2.5KV	4KV	6KV

According to IEC, the SPD should have a protection level less than 80% of the above

Surge Protective Devices – Connections

In Line or Kelvin Connection

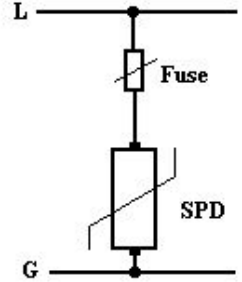
The SPDs are connected directly on the power conductors



Parallel or T-connection

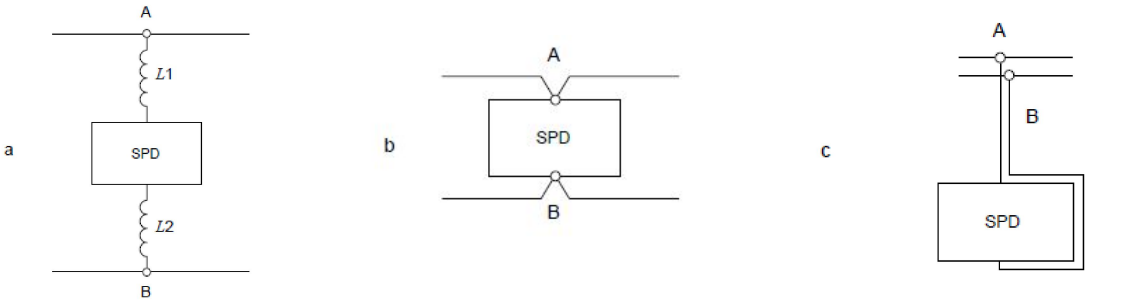
The SPDs are connected to the power conductors using extra cables.

In order to secure the extra cables, additional fuses are required.



Available connection methods

IEC 61643-12 / Paragraph 6.1.3



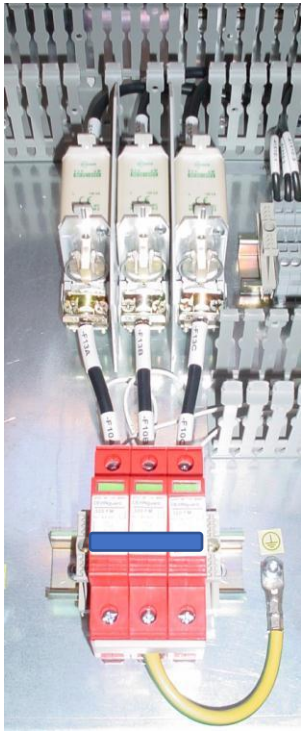
a) THIS SCHEME IS TO BE AVOIDED WHEN POSSIBLE, ESPECIALLY WHEN EITHER *L*1 OR *L*2 IS LARGE

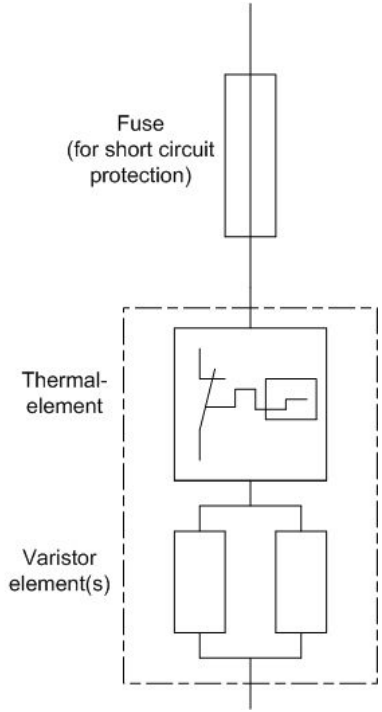
b) THIS SCHEME IS TO BE PREFERRED

c) THIS SCHEME IS ACCEPTABLE WHERE SCHEME b IS NOT POSSIBLE

Conventional SPD’s Issues - Fusing

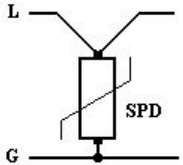
Conventional SPD’s use internal fuses and in most cases also require external fuses to meet the safety standards (UL - IEC)

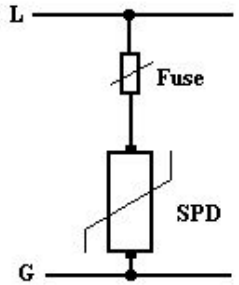




Surge Protective Devices – Connections

Recommended Connection Method





In-Line connection:
$U(L\text{-}G) = U_p$

Parallel connection:
$U(L\text{-}G) = Up + U_{fuse} + U_{cable}$

U_{cable}=1,2kV residual voltage

(When 10kA surge current pass through 0,5m cable of 25mm² cross section)

Main outcomes – Summary

- Based on MOV for fast response, low residual voltage and no follow currents
- Capable to be connected in line
- Capable to withstand at the same time lightning currents
- Maintenance free
- Fail safe operation

Strikesorb technology

Strikesorb Technology vs. conventional SPD Technology

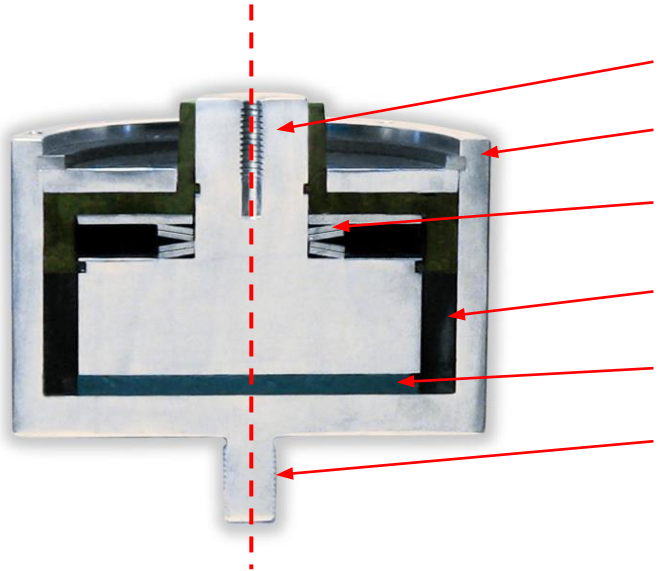
All conventional SPD types have one thing in common: They are in a “hurry” to disconnect from power lines in every instance for self-protection, leaving the equipment unprotected.
This design approach is the main reason for all the issues of conventional technologies SPDs.

Strikesorb is the first and only SPD technology that differentiates from this fundamental design direction, giving a new meaning to the words safety and performance in the SPD industry.

Strikesorb technology was developed several years ago to address the main issues conventional SPD technologies might have:

- Complicated designs (unreliable operation)
- Leave the equipment unprotected
- Catastrophic end of life
- Frequent maintenance
- Limited warranties

Strikesorb Technology



- **Large Thermal Capacity Electrodes**
  Absorb heat generated during surges & decelerate the MOV aging
- **Strong Aluminum Housing**
  Prevents explosions
- **System under 1500+ pounds of pressure**
  Results in very low dynamic resistance and higher conductivity
- **No Fuel to Burn**
  Prevents fire and smoke emission
- **Single, Distribution-Grade Varistor**
  Contributes to reliability, long lifetime
- **Coaxial symmetry & uniform surge current distribution**
- **Eliminates the aging problem**
  Due to its heat dissipation capabilities

- Protects sensitive, high-value equipment without sacrificing itself
- Withstands multiple lightning strikes with no need of replacement or maintenance
- Raycap provides a 10-year warranty; no failure in the field since 2000
- UL and IEC approved, conforms with US and European regulations

Patented proprietary technology that provides a clear competitive advantage

Strikesorb – Catalog Modules

AC Protection




Nominal AC Voltage	Strikesorb 30 / DRM	Strikesorb 40	Strikesorb 80
60V	Strikesorb 30-V1	Strikesorb 40-V1	
120V	Strikesorb 30-A	Strikesorb 40-A	Strikesorb 80-A
240V	Strikesorb 30-B	Strikesorb 40-B	Strikesorb 80-B
277V	Strikesorb 30-C	Strikesorb 40-C	Strikesorb 80-C
400V	Strikesorb 30-D	Strikesorb 40-D	Strikesorb 80-D
480V		Strikesorb 40-E	Strikesorb 80-E
600V		Strikesorb 40-F	Strikesorb 80-F
1000V		Strikesorb 40-G	

DC Protection

Maximum DC Voltage	Strikesorb 35
650V	Strikesorb 35-D-HV
800V	Strikesorb 35-E-HV
1100V	Strikesorb 35-F-HV
1500V	Strikesorb 35-G-HV
1500V	Strikesorb 35-G-HGV

To date Strikesorb 35 is the only UL 1449 (5th edition) certified SPD at voltage >500V DC for non-PV applications, fulfilling the Supplement SB – Direct Current (DC) SPDs.

Reliability Study/Test: Lifetime performance

Is Strikesorb able to perform in a wind turbine for 20 years without service?

1 lifetime cycle = 20 years in the field

6 x 5,00kA (10/350µs)
\+ 9 x 3,75kA (10/350µs)
\+ 24 x 2,50kA (10/350µs)
\+ 21 x 1,25kA (10/350µs)

One lifetime cycle test reflects 20 years in a standard lightning environment.

Strikesorb 40 was tested to a total of ten lifetime cycles. This represents 200 years of lightning exposure. These results show that Strikesorb not only survives but it also does NOT change significantly in performance. It does not age per accepted industry requirements.

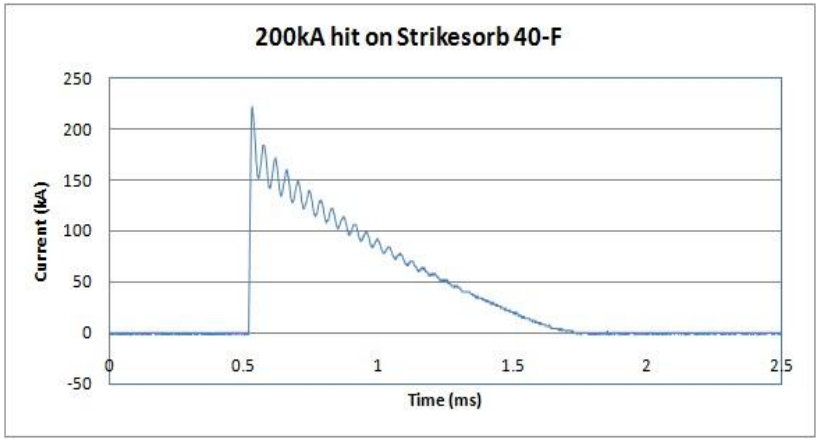
Conventional SPDs are designed to withstand only one lightning hit, they afterwards disconnect and need replacements.

Lifetime test results on Strikesorb		
Initial Measurements	Residual Voltage @ 10kA (8/20µs) (V)	RC of Leakage Current @ Uc (mAdc)
	1750	0.167
Lifetime test cycle #	Change (%)	RC of Leakage Current @ Uc (mAdc)
1	2.86	0.234
2	3.2	0.237
3	3.54	0.252
4	3.94	0.267
5	4.28	0.267
6	4.63	0.31
7	4.63	0.306
8	3.54	0.372
9	3.54	0.384
10	4.29	0.444

Reliability Study/Test: Overcharge behavior

Is Strikesorb able to withstand a direct lightning hit much higher than the rated impulse current?

- I_{IMP} = 200 kA (10/350µs)
- Test performed at an independent test lab in Denmark
- Strikesorb didn't explode, didn't catch fire, didn't emit smoke



Conventional SPDs are designed to withstand only one lightning hit of rated current, they explode catastrophically if charged with higher currents. There is a high risk of causing fire.

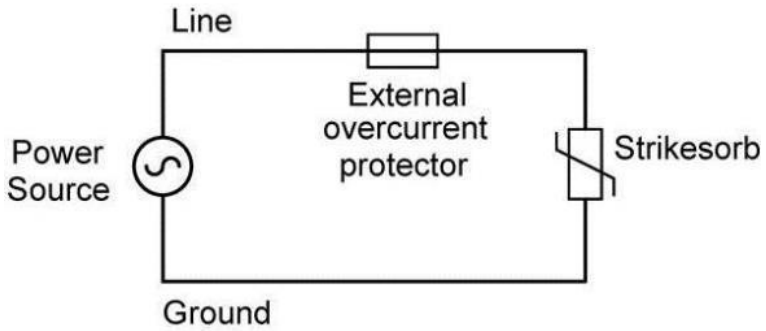
Strikesorb Technology UL safety benefits

Certified by UL – unlimited short circuit test, for 3 cycles (= 50 ms @ 60 Hz)

The 3-cycle test is done by connecting the module to a power source of a specified available short circuit current without an external fuse or breaker. The module safely sustain this short circuit current for a **period of three cycles**.

Results:

Strikesorb module	Power system available short circuit current
30mm	42kA
40mm	85kA
80mm	65kA



Strikesorb Technology – Installation rule

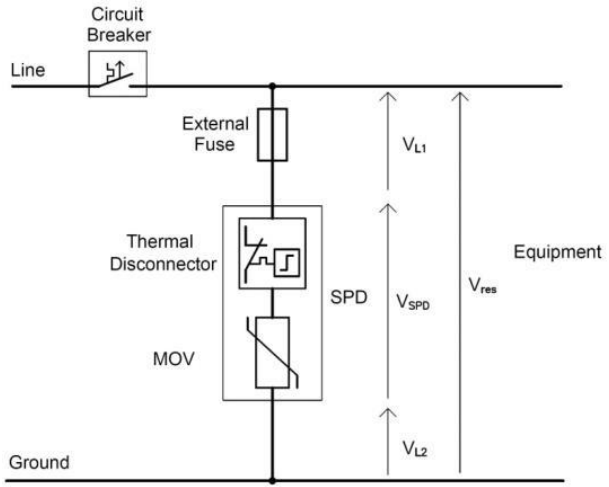
Strikesorb modules require an external overcurrent protector for the safe disconnection of the module from the power system in case of failure.

- Strikesorb modules are VDE tested to be safely installed directly behind high rated circuit breakers, unique for SPD products.
- This confirmed VDE ratings help integrators to minimize engineering effort for standard applications (up to 50kA SCCR).

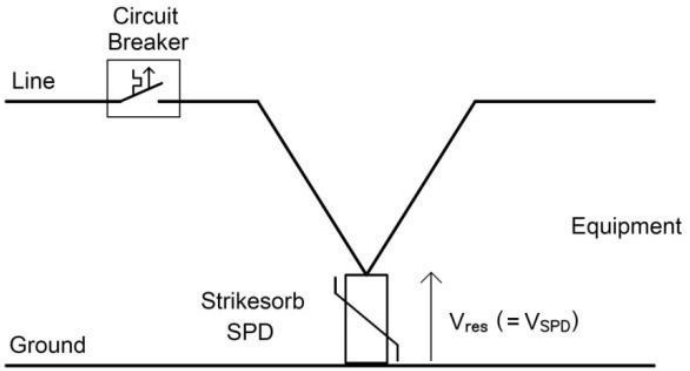
Model	Max. CB rating
Strikesorb 80	1600A
Strikesorb 40	1600A
Strikesorb 30	630A
Strikesorb 30 DRM	Inline: 125A T-connection: 630A

Strikesorb – Installation benefits

SPD typical installation

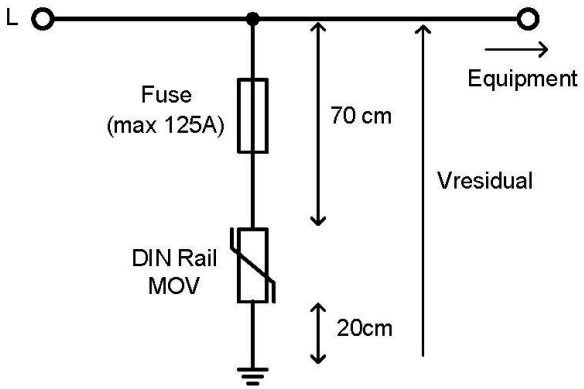


Strikesorb installation

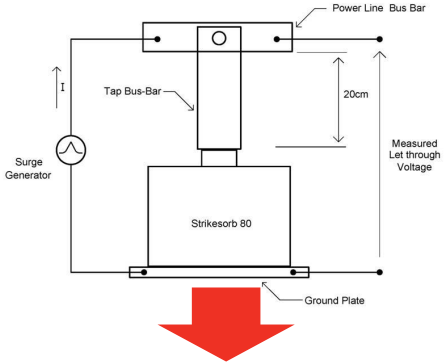


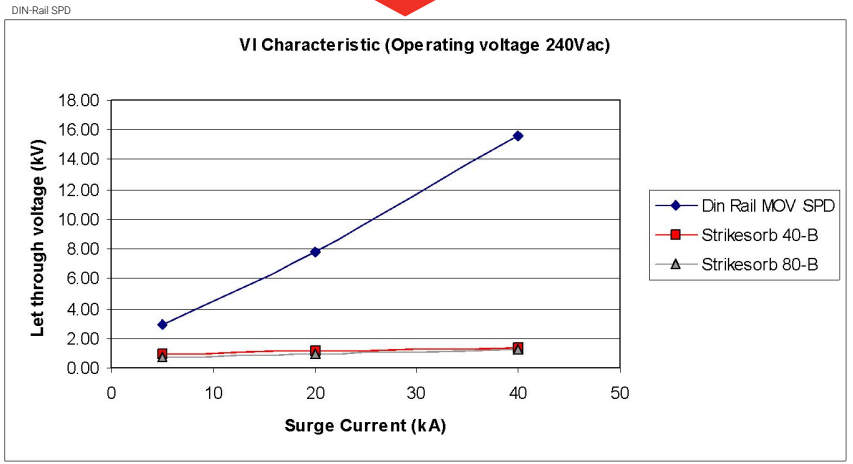
Fuseless operation – Lower Residual Voltage

Conventional protection design



Replaced by a direct Strikesorb integration





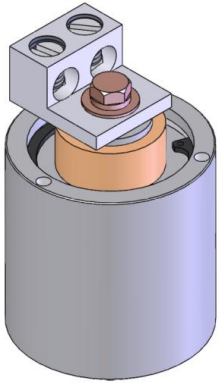
Clear and positive result:

Due to shorter parallel path and lower residual voltage across the Strikesorb module, the overall Let Through voltage of a Strikesorb integration is significant lower. This reduces ageing stress at the electronic and extends the lifetime of your product.

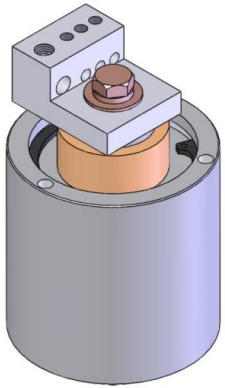
Strikesorb: Technical Characteristics

	Strikesorb 30-B	Strikesorb 40-B	Strikesorb 80-B
Iimp	7,5kA	12,5kA	25kA
Imax	50kA	140kA	200kA
Protection Level (IEC 61643-1)	1,2kV	1,2kV	1kV
Response Time	1ns		

Strikesorb – easy in-line installation

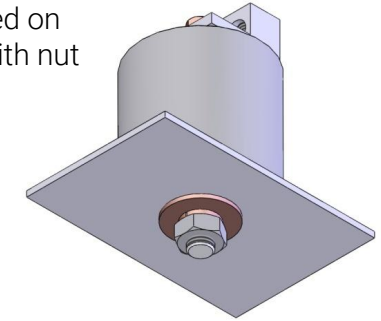


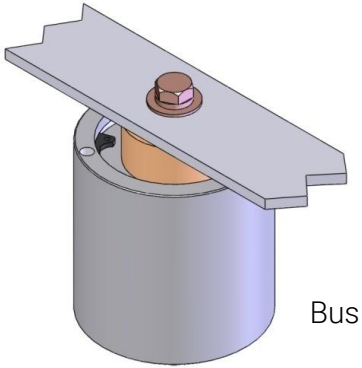
Burndy Lug Connector



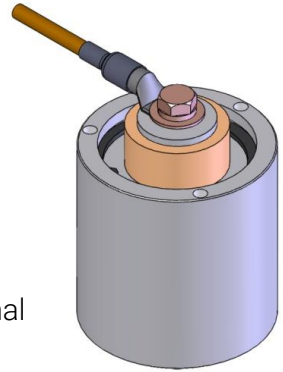
Raycap Lug Connector

Mounted on plate with nut

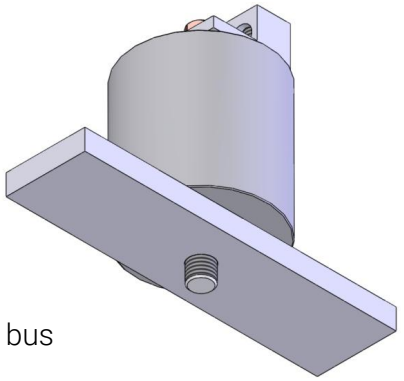




Bus Bar



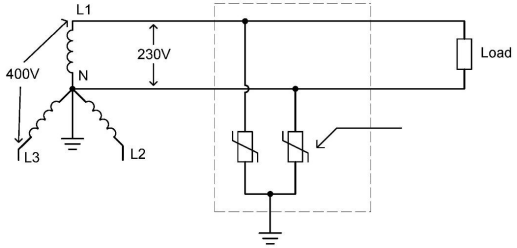
Crimp terminal



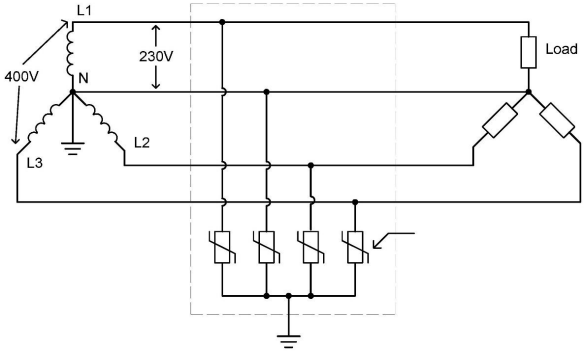
Mounted on bus bar

Strikesorb – easy installation

Rayvoss



Single Phase System



3-Phase Systems

With Strikesorb 80, 40 or 30 technology at their core, Rayvoss systems can be customized with a variety of operating voltages, configurations and cabinets and conform to industry standards and certifications.

RayDin – Strikesorb Technology on DIN-Rail

- Compact design ‘All in one’
- Din-rail mountable method provides fast installation
- Supports TN and TT 3 phase 400V L-L Systems
- VDE certification according to the latest versions of IEC 61643-11:2011 and EN 61643-11:2012
- Conform to UL 1449 4rd ed.
- Class I and Class II protection without internal coordination mechanism
- Provides very low protection level - unique for a Class I rated product
- No follow currents
- Reliable and field proven solution based on Strikesorb technology
- Maintenance free technology
- Uninterrupted protection of the equipment
- Supplied with 10 year warranty

Summary of benefits

- Maintenance-free
- High performance and high reliability
- Safe behaviour under lightning conditions
- Can withstand multiple higher energy surges without sacrificing itself
- Better overall protection of installation
- Fuse-less design allows optimum protection levels
- Suitable for direct installation with high surge currents

- Inherent immunity to temporary overvoltage (TOV)
- Easy integration, even in space constrained panels
- Tested and approved by internationally accredited bodies to the latest IEC & UL safety & performance standards
- 10-year warranty, 20+ year lifespan

  After more than 20 years of field deployment, with more than 20 million units installed worldwide, the Strikesorb failure rate is practically ZERO.

Applications of Strikesorb Technology

Mission critical applications:

- Renewable power generation and distribution (Wind turbines, PV installations, power plants)
- Communication (Telecom/Cell phone base stations, Internet providers and servers)
- Railway/aircraft operation
- E-chargers and Battery Energy storage Systems (BESS)

Basic SPD requirements on mission critical applications:

- High surge/impulse current rating and high energy withstand capability (TOVs etc).
- Low residual voltage to the equipment.
- Safe end of life.
- Coordination with upstream CB/fuse to reduce the size and cost of installation.
- Long lifetime, able to withstand the exposure to lightning over a period of at least 20 years in hash environments.
- Withstand the expected environmental conditions (vibrations etc)

Raycap's recommendation is to consider Strikesorb Technology for all or at least for critical SPD locations.