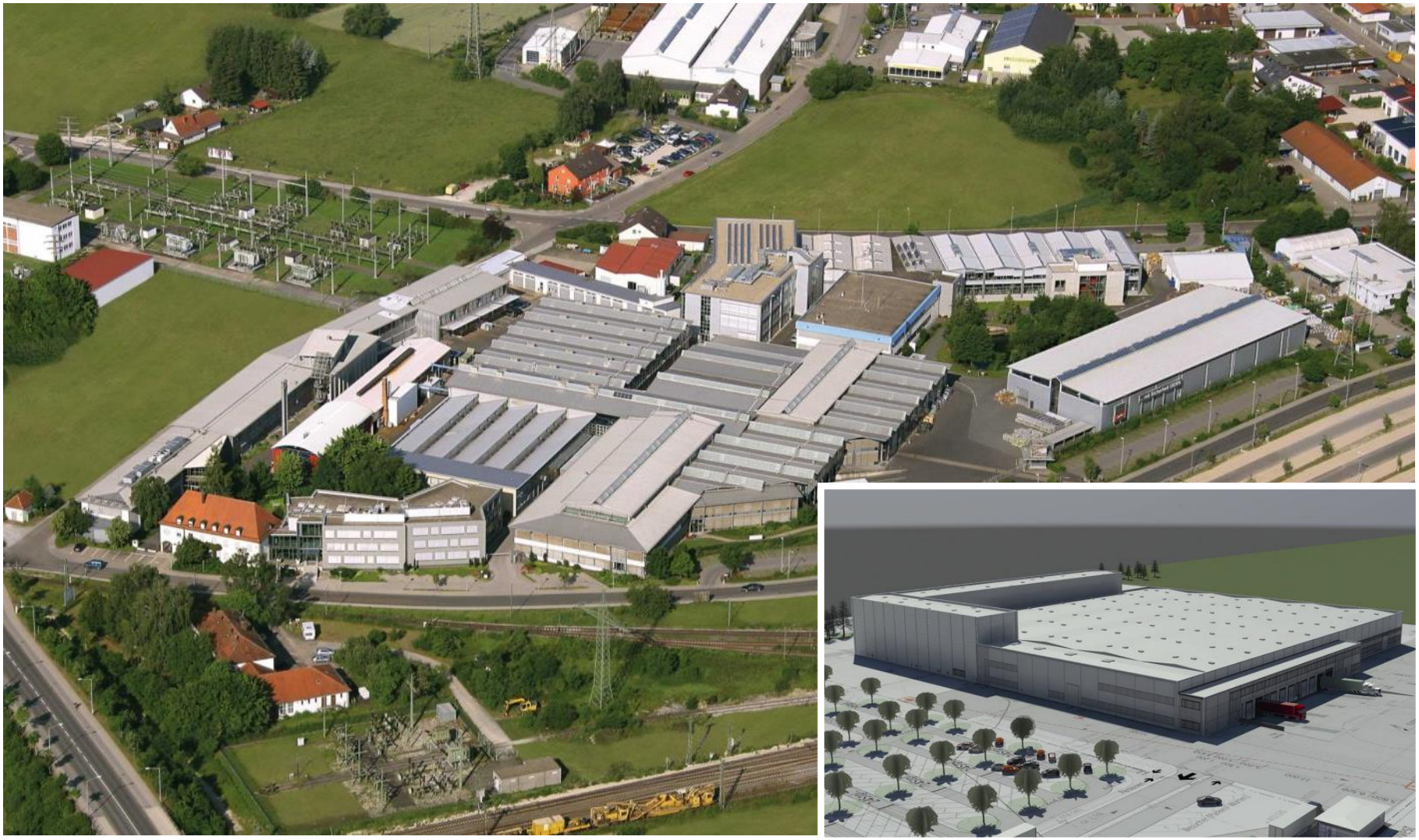
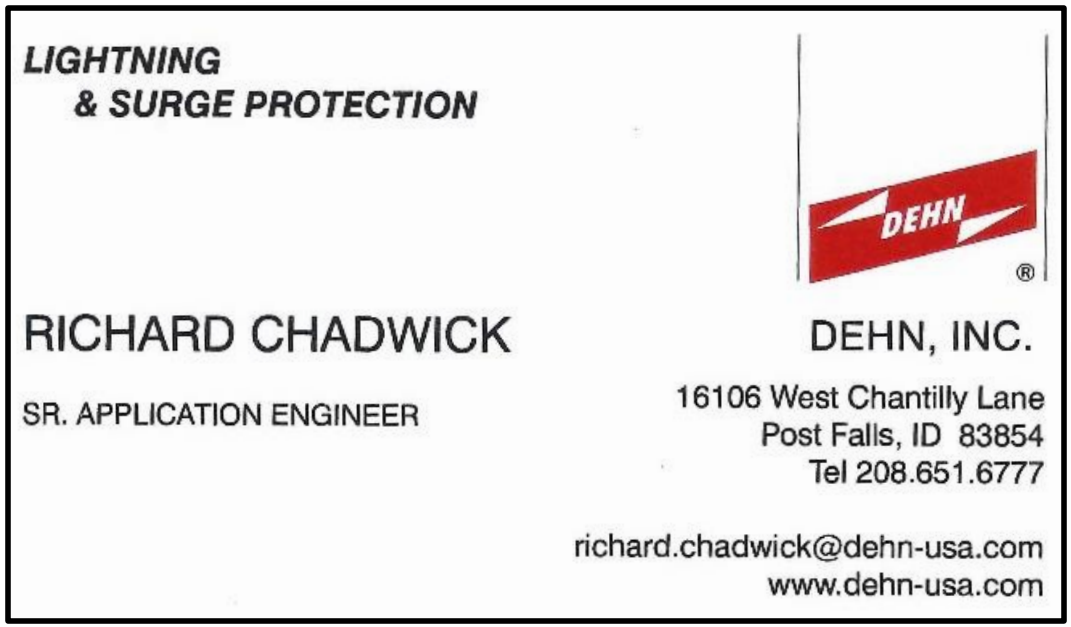
RRH Protection Considerations
- Richard Chadwick, DEHN Inc.



About the Presenter

Richard Chadwick

- 35 years in Surge Protection Industry
- DEHN, Inc.
  - Sr. Application Engineer
- Joslyn Electronic Systems
  - Manufacturing Supervisor
  - Project Engineer
  - Sr. Applications Engineer
  - Product Manager
- Raycap / AC Data Systems
  - Senior Applications Engineer
  - Product Manager
- Protection Engineers Group ATIS/PEG: Former Chair and Lifetime Board Member

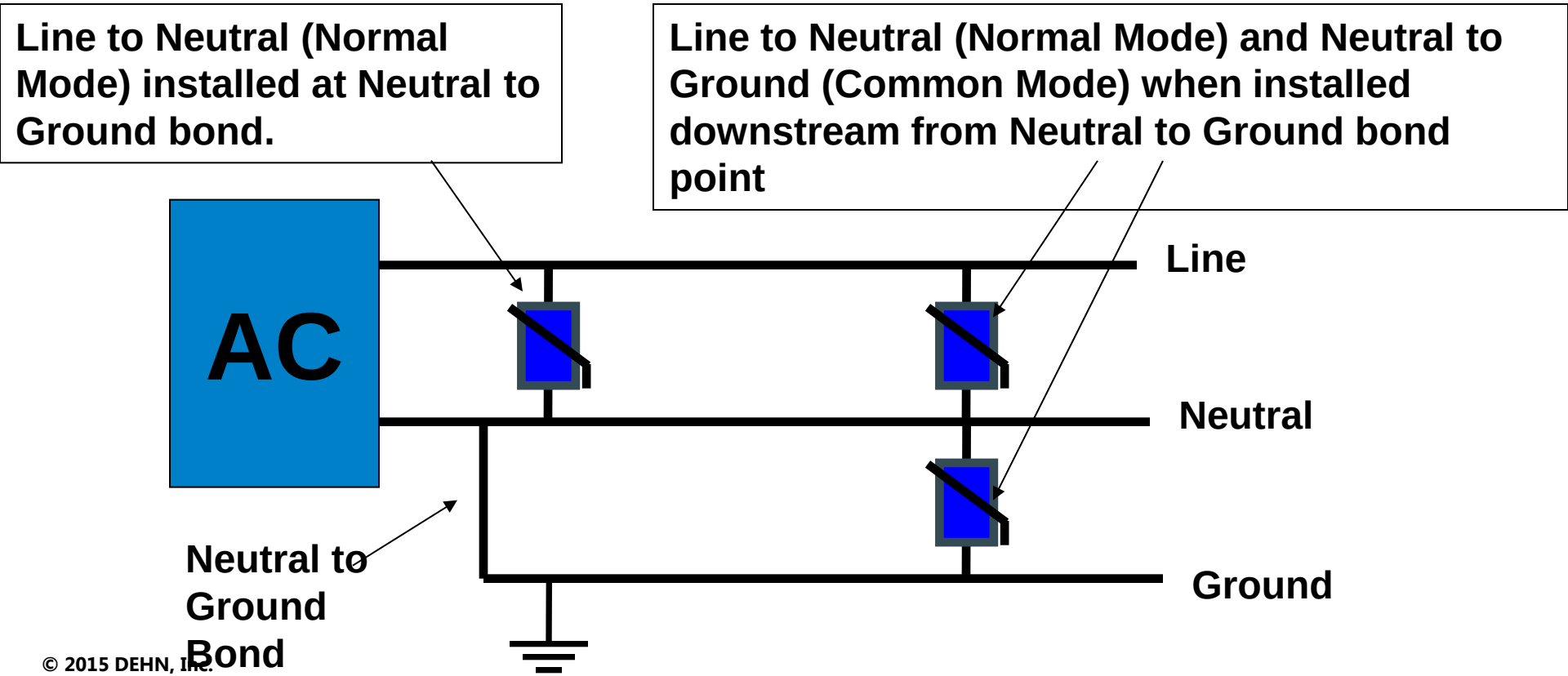


RRH Protection Considerations - Agenda

- **Modes, Surges, Let Through Voltage, Coordination Issues, and Use of Modern Sparkgaps for Coordination**
- Installation Locations and Isolated Down Conductors

Modes of Protection: Type TN AC system, Return bonded to Ground.

In a North American TNC-S AC power system, neither surges from the grid, nor from GPR place much stress on the N-G protection elements. In many AC SPDs the N-G element is not failure monitored.

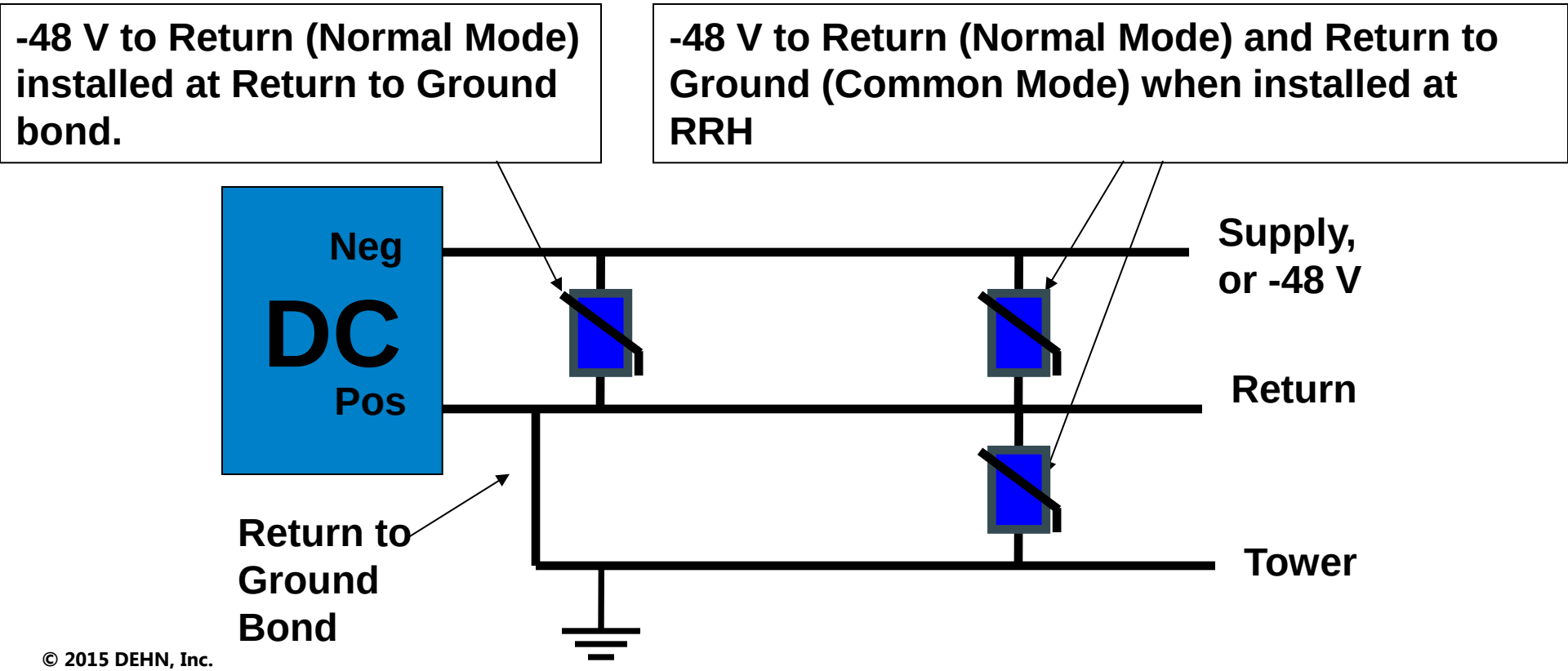


Standard RRH DC system with 1+1 (-48 V to RTN and RTN to GND) SPDs at RRH

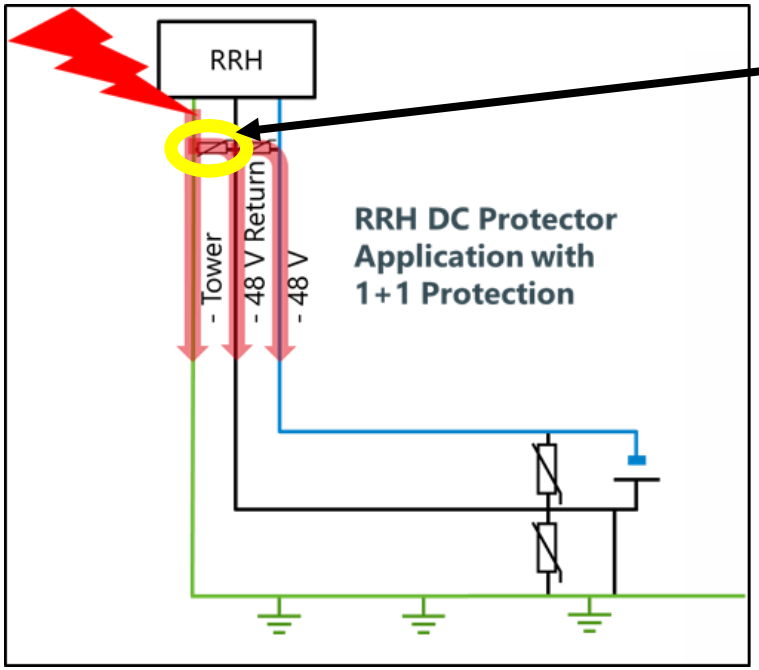
In a DC RRH power system, the surge comes from the tower, through the RTN to GND SPD, then through the -48 V to RTN SPD.

The RTN to GND SPD sees twice the surge current and is the only element likely to fail.

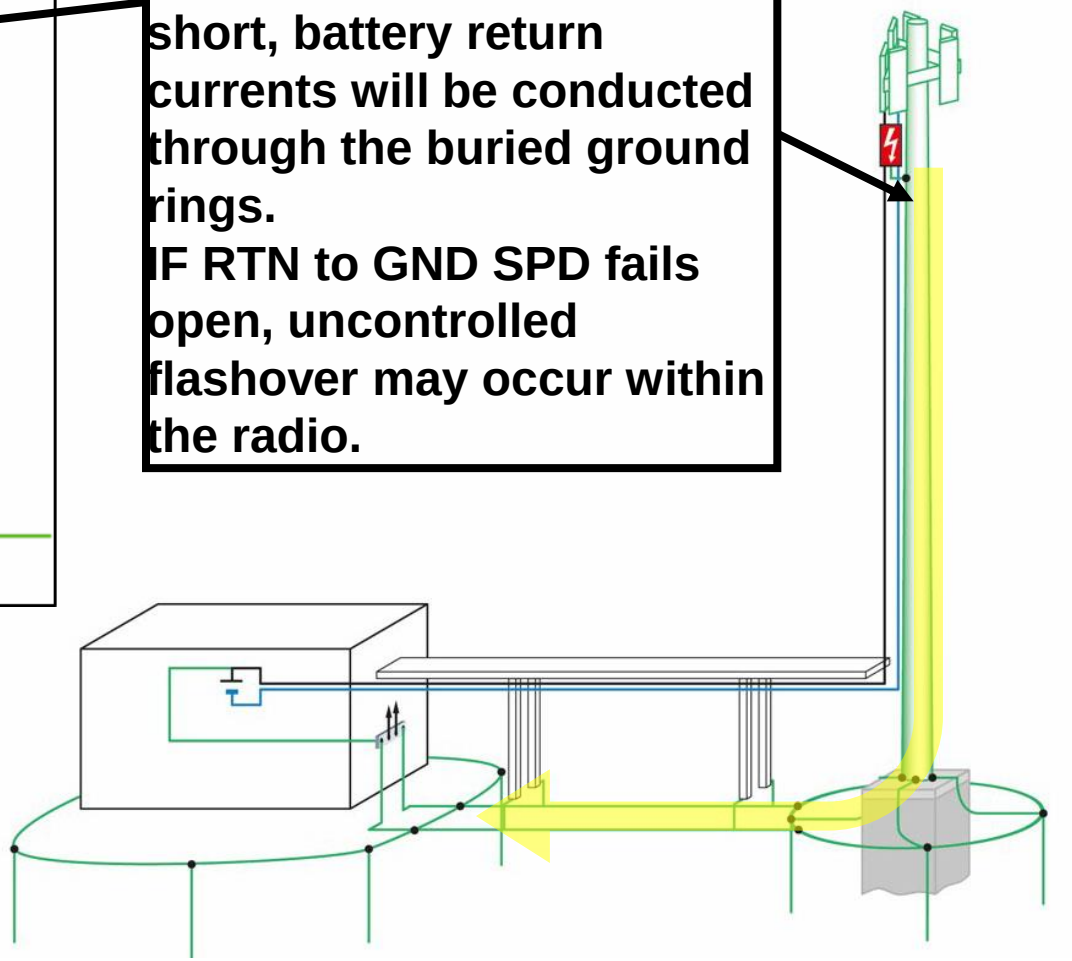
The RTN to GND SPD is **often NOT MONITERED**.



Impact of failed RTN to GND SPD at RRH



IF RTN to GND SPD fails short, battery return currents will be conducted through the buried ground rings.
IF RTN to GND SPD fails open, uncontrolled flashover may occur within the radio.



RTN to GND SPD is by far the most likely to fail.

Telcordia GR-3177 for RRH protection
All modes must be monitored + 2X surge current RTN-GND

All modes shall be monitored

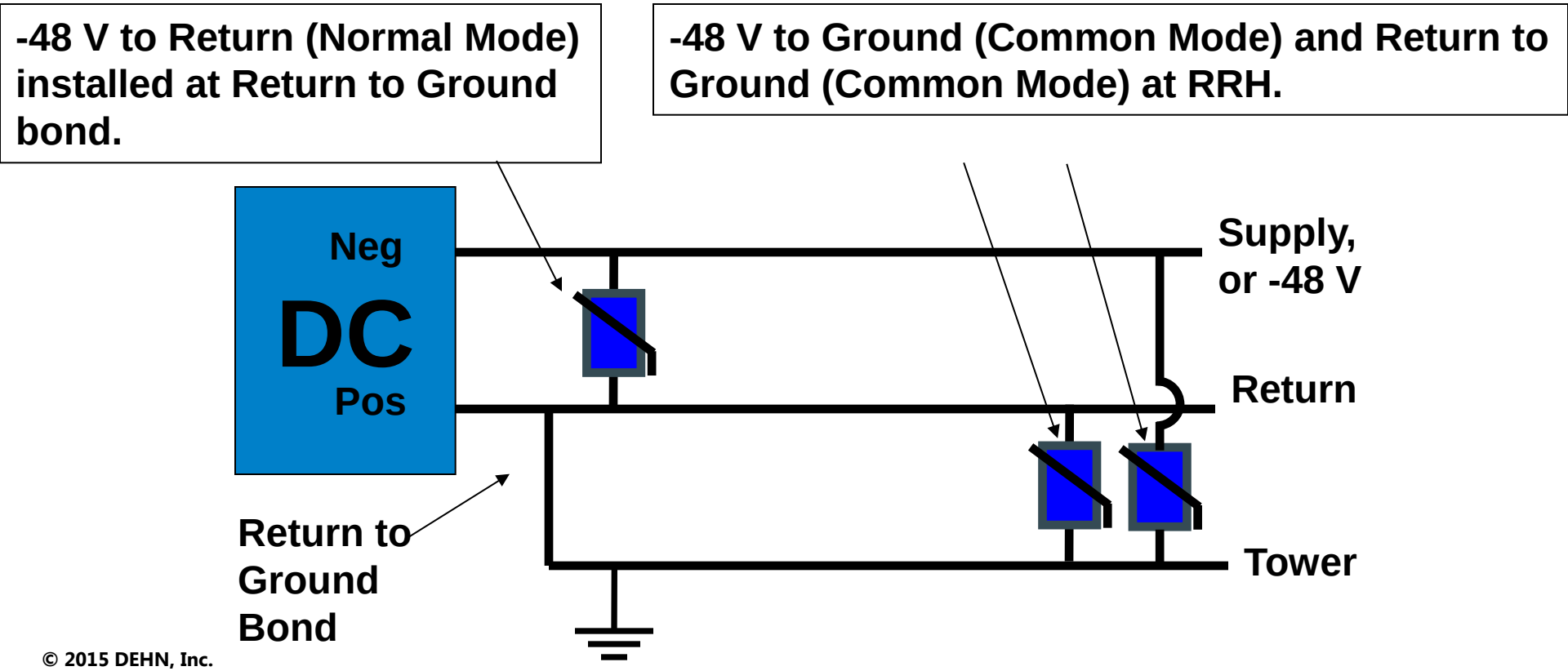
R4-61 **[91]** All modes of protection within the SPD shall be monitored. The SPD shall be provided with a visible indication means for indicating the protection status. Visual indication shall be provided from within the SPD closure indicating which specific SPD elements require service. This will allow for easy determination of which

2X Surge Current from RTN to GND

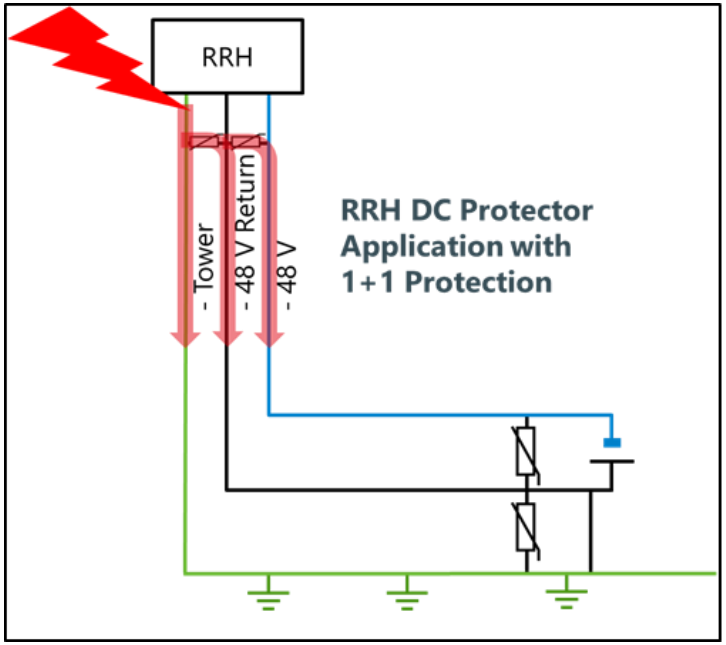
Note 2: When the protection configuration of Figure C-1 is used, the protection element connected between RTN and GND will conduct the current that will flow though both DC power cables (-48V and RTN). Therefore, the protection element connected between RTN and GND will conduct approximately twice the current than the protection element connected between -48V and RTN and as a result, adequate provisions should be made for the selection of the surge current capability of each protection element.

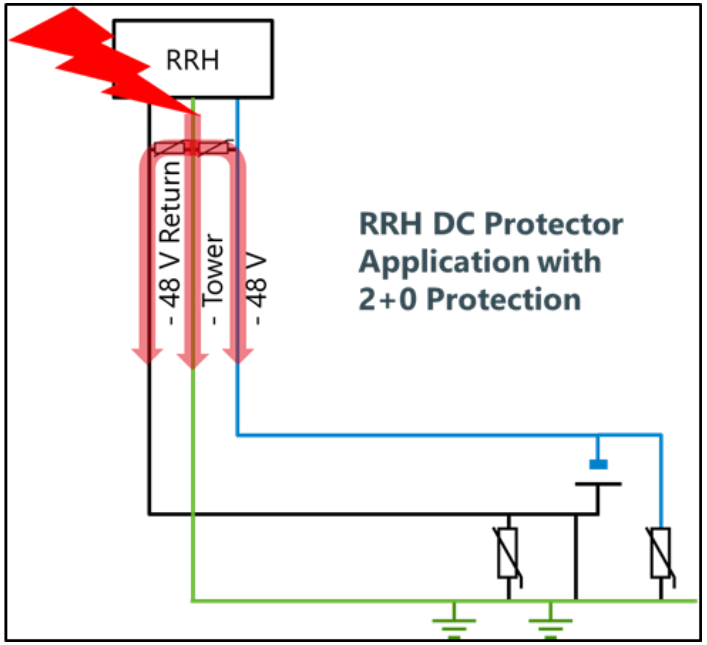
Standard RRH DC system with 2+0 (-48 V to RTN and -48 V to GND) SPDs at RRH

As surge is from the tower to RTN, and tower to -48, both SPDs see approximately the same size surge and neither is more likely to fail. The residual surge voltage at the RRH is the difference between the let through voltages of the two SPDs = Very Low



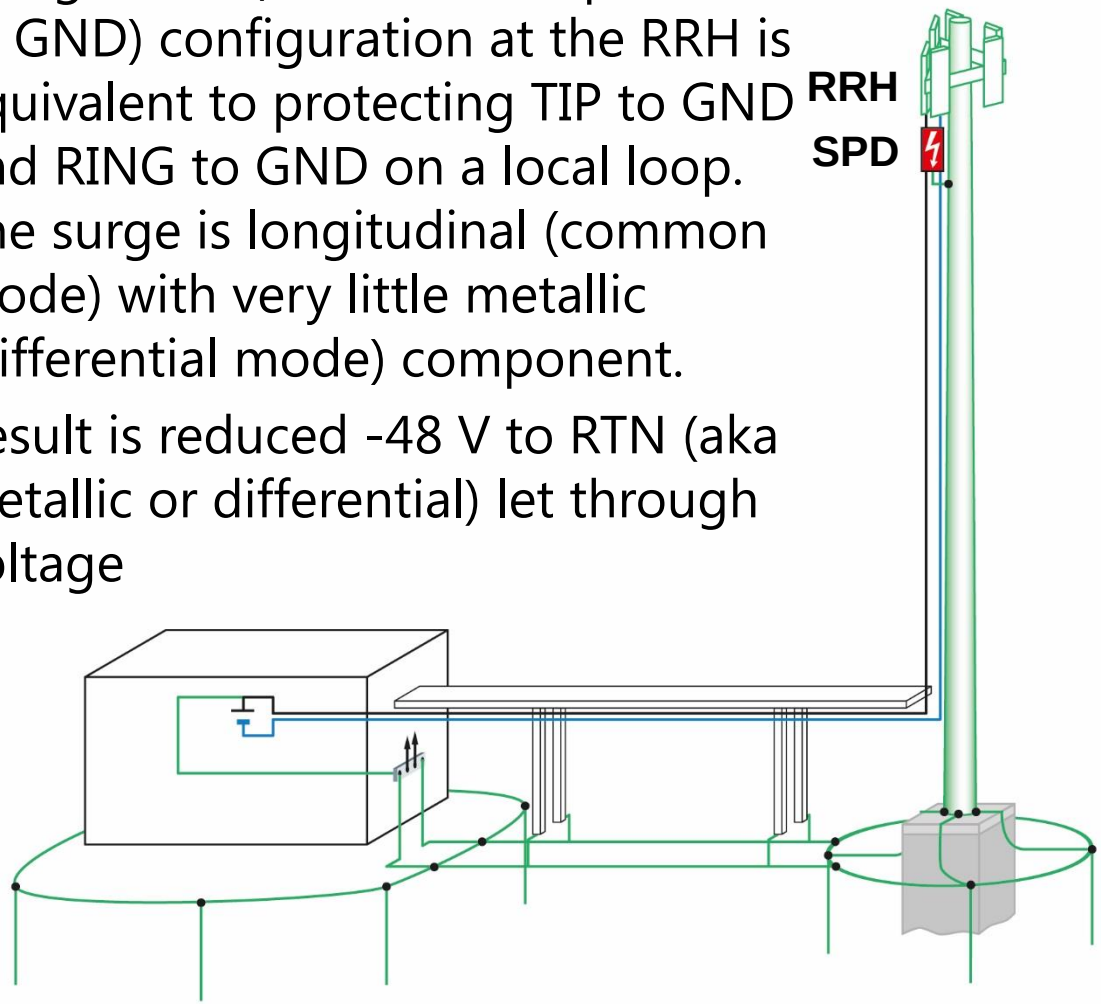
Using a 2+0 (-48 V to RTN plus -48 V to GND) configuration at the RRH is equivalent to protecting TIP to GND and RING to GND on a local loop. The surge is longitudinal (common mode) with very little metallic (differential mode) component.

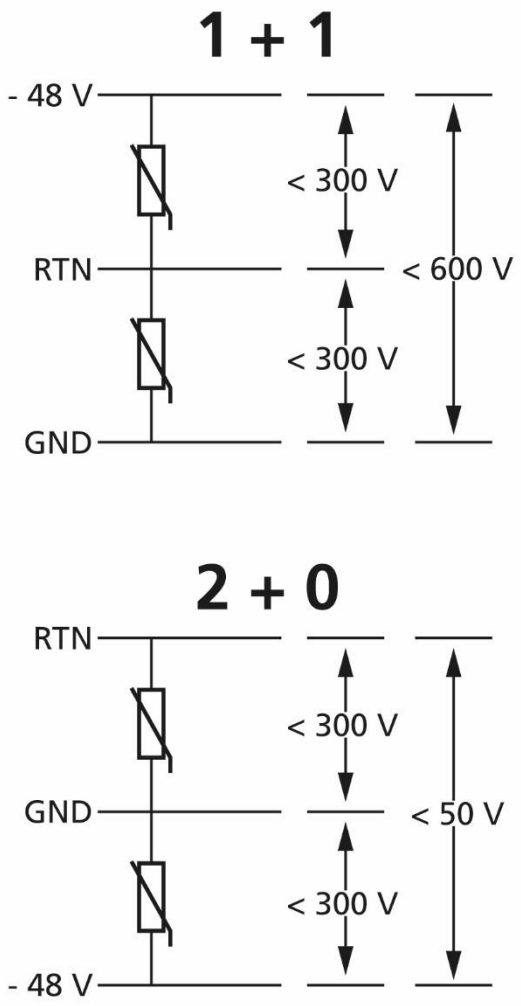




Using a 2+0 (-48 V to RTN plus -48 V to GND) configuration at the RRH is equivalent to protecting TIP to GND and RING to GND on a local loop. The surge is longitudinal (common mode) with very little metallic (differential mode) component.

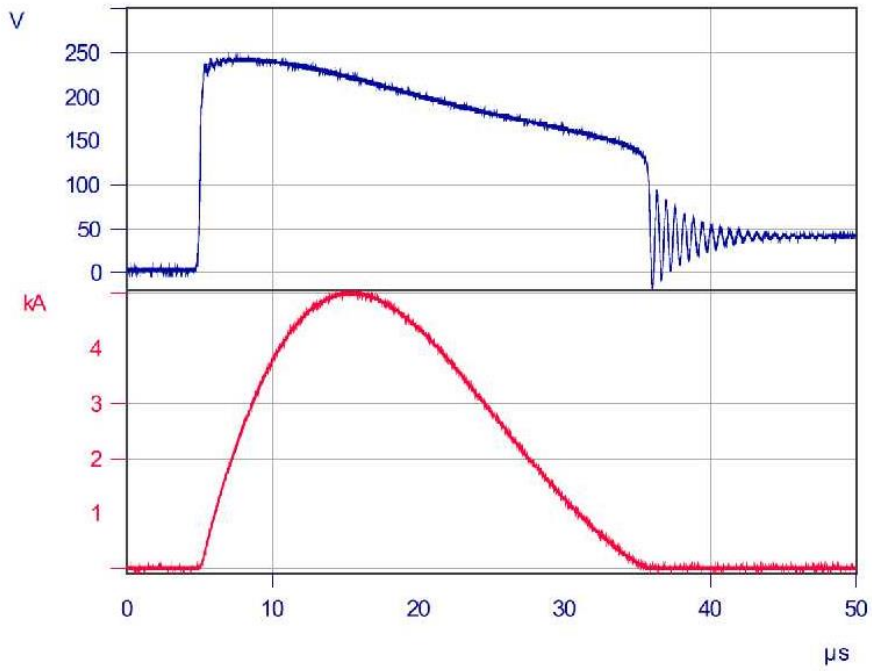
Result is reduced -48 V to RTN (aka metallic or differential) let through voltage



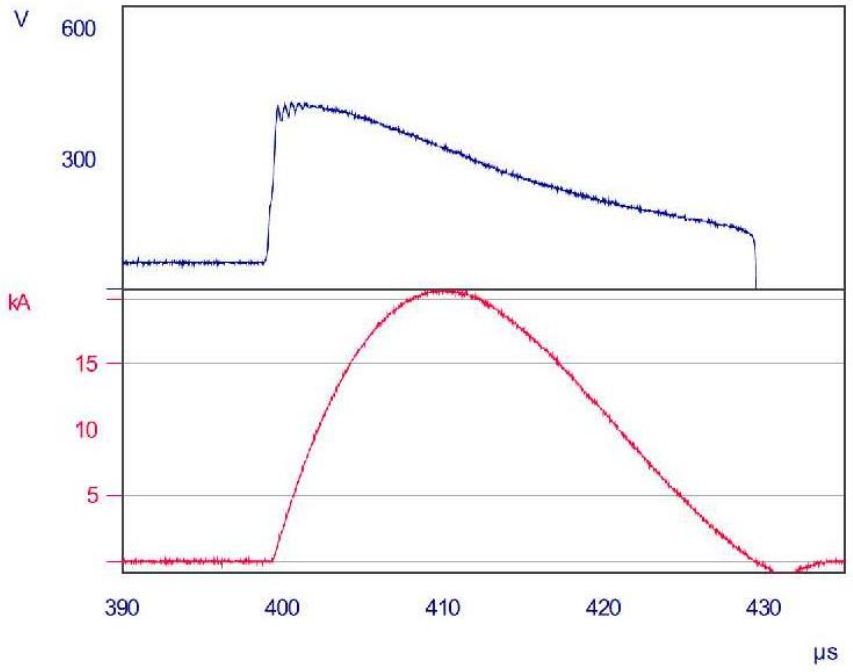


DEHNguard 75 MOV Based RRH Protector

250 V Let Through Voltage @ 5 kA 8/20 µs



400 V Let Through Voltage @ 20 kA 8/20 µs

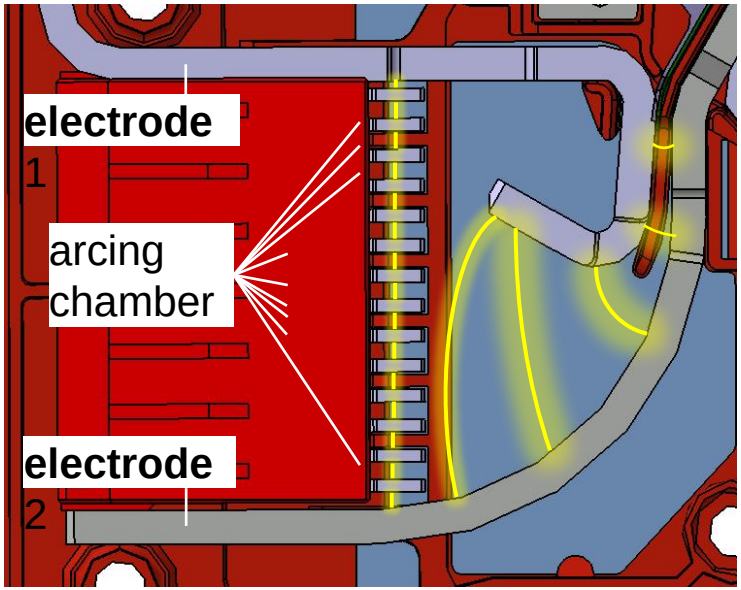


Coordination of External SPD with SPDs Embedded in the Equipment

Type 1 arresters – different spark gaps – Spark gap with arcing chamber

Features

- Medium lightning impulse currents
- Space-saving (only 1 module per pole)
- Application-optimised for electrical installations with reduced technical requirements
- Non-exhausting
- Extremely low voltage protection level
- Capable of protecting terminal equipment



for a.c. applications

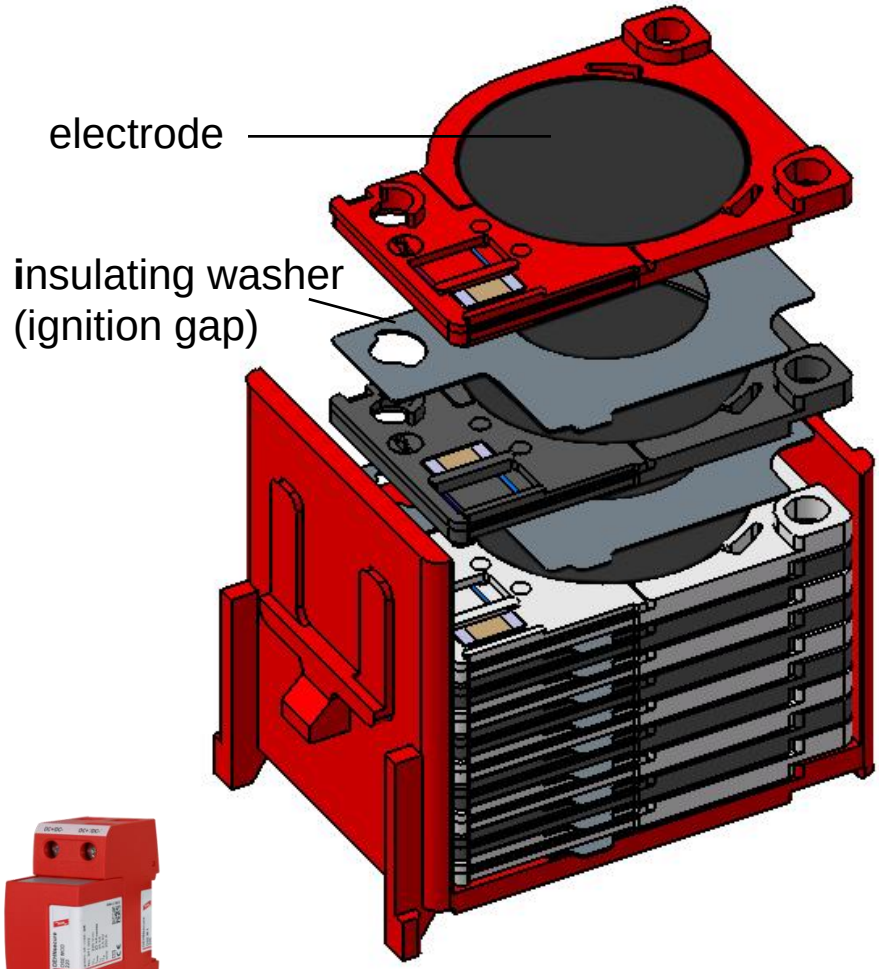
DEHNshield®

The arc is stretched due to the geometry of the electrodes, divided into small partial arcs in the arcing chambers and thus extinguished.

Type 1 arresters – different spark gaps – Spark gap with graphite stacks

Features

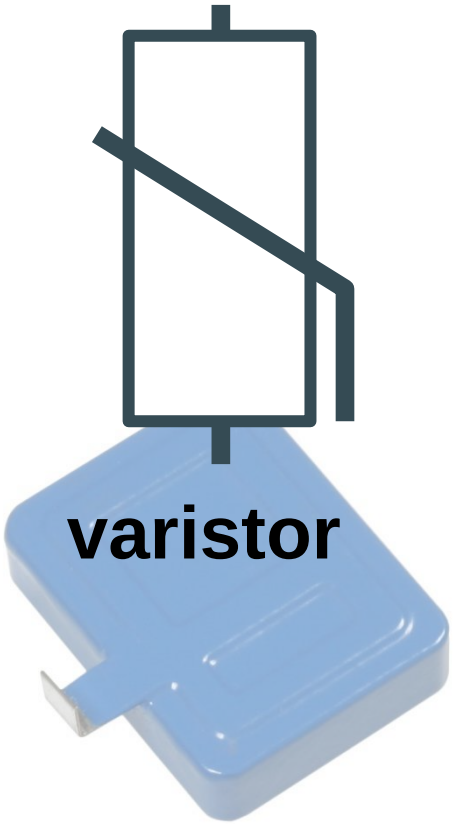
- Extremely high lightning impulse currents
- Division into partial arcs generates resulting arc voltage ≥ system voltage → no leakage currents
- Directly coordinated with DEHNguard® surge protective devices without additional cable lengths
- Low voltage protection level

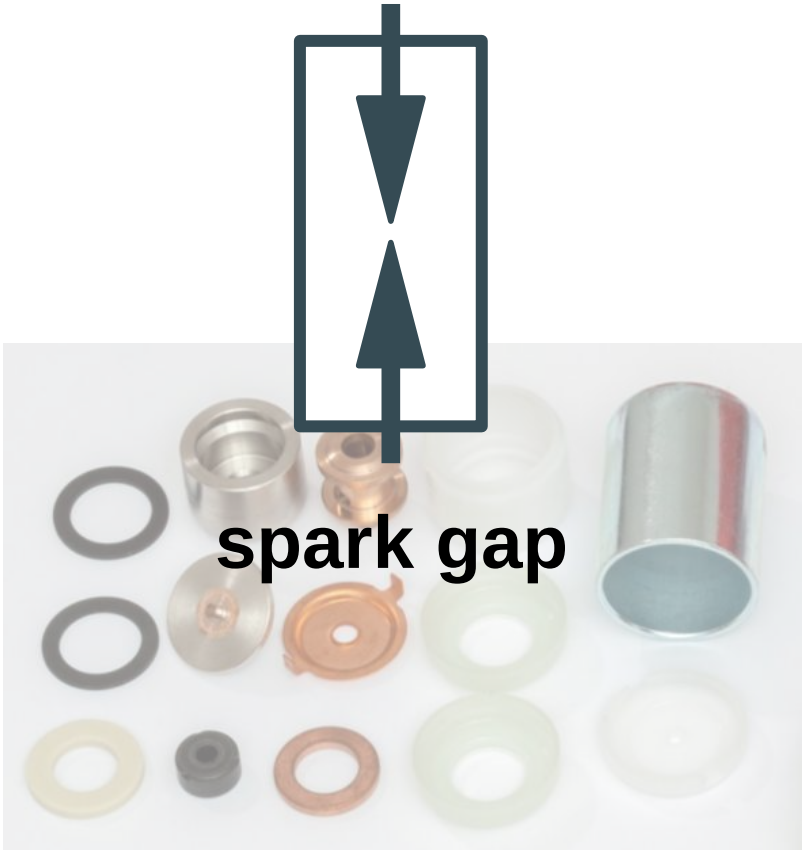


Ideally suited for d.c. applications

DEHNsolid, DEHNsecure

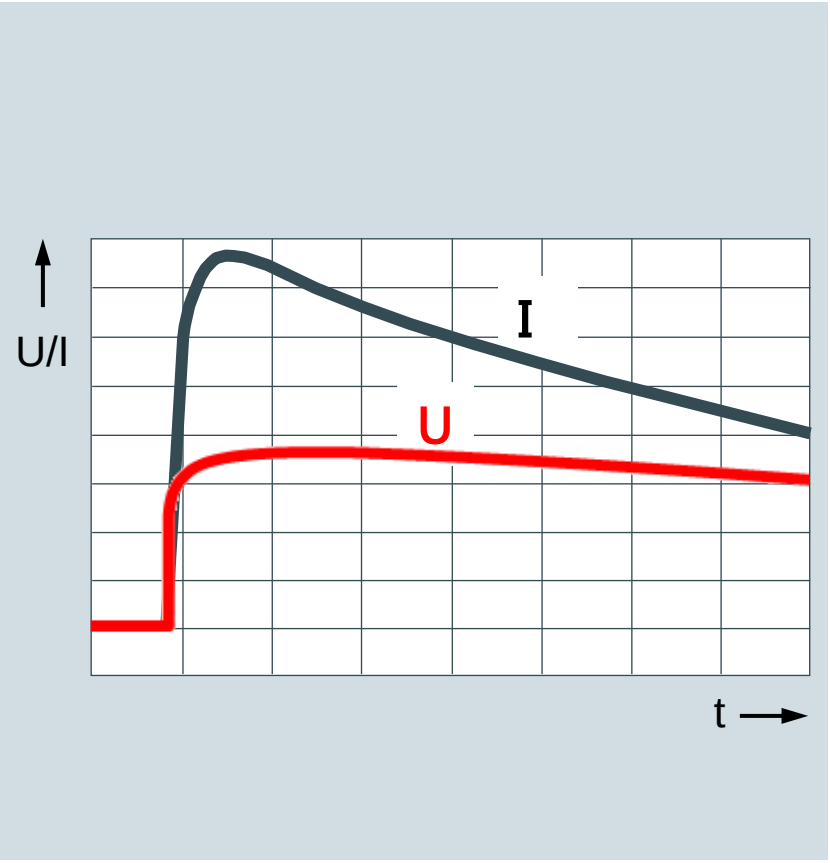
COMPARISON



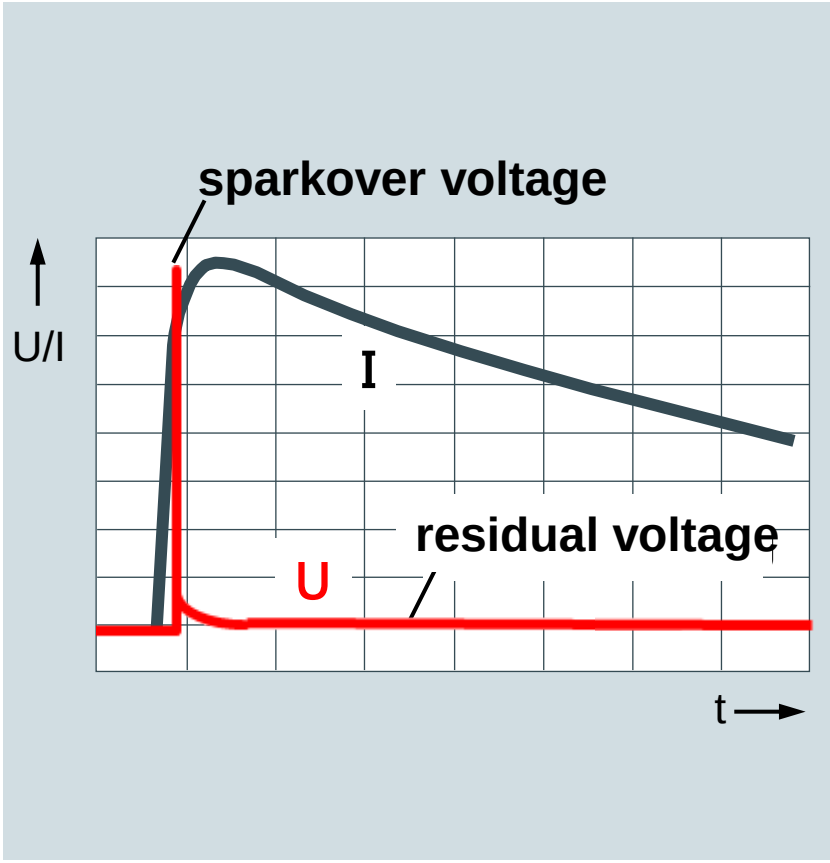


Technologies for surge protective devices used in power supply systems

Varistor



Spark gap



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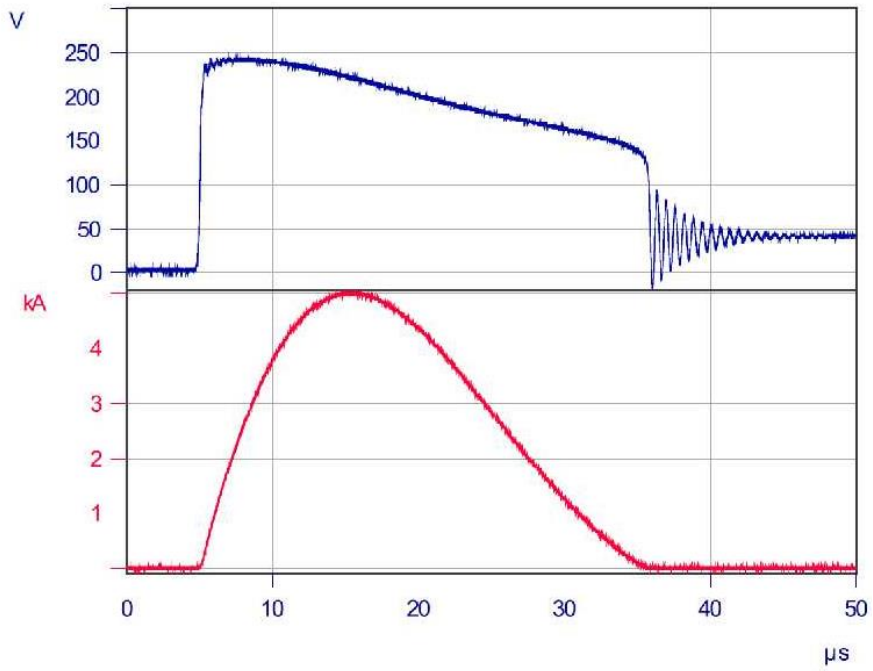
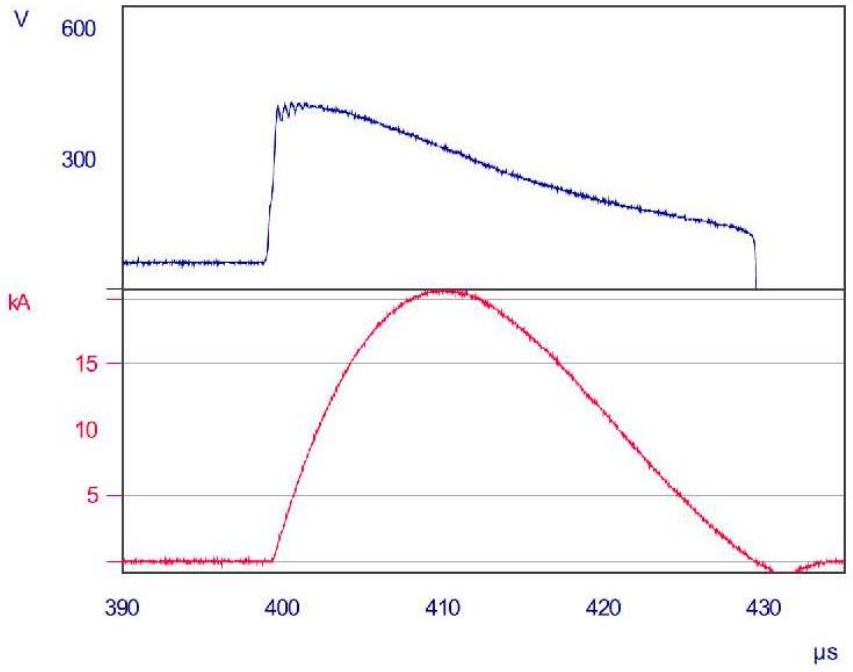
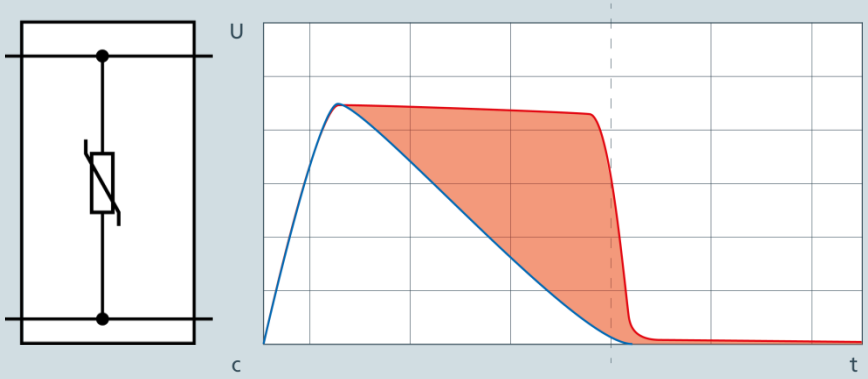


400 V Let Through Voltage @ 20 kA 8/20 µs



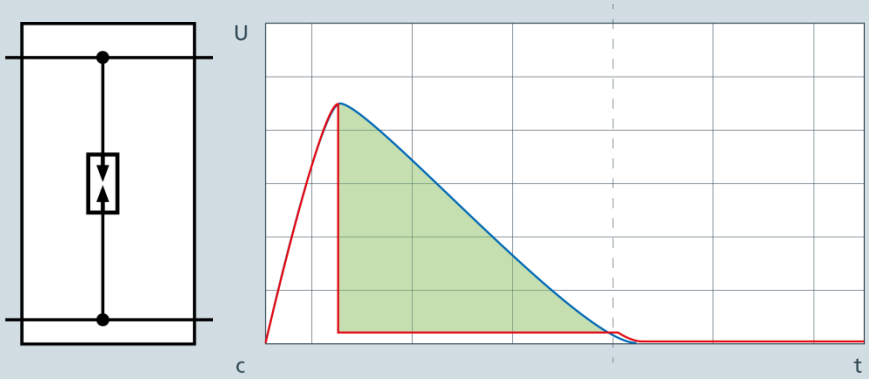
Comparision of the protection principles Varistor - Spark gap

Varistor (voltage-limiting)



Terminal equipment is overloaded

Spark gap (voltage-switching)



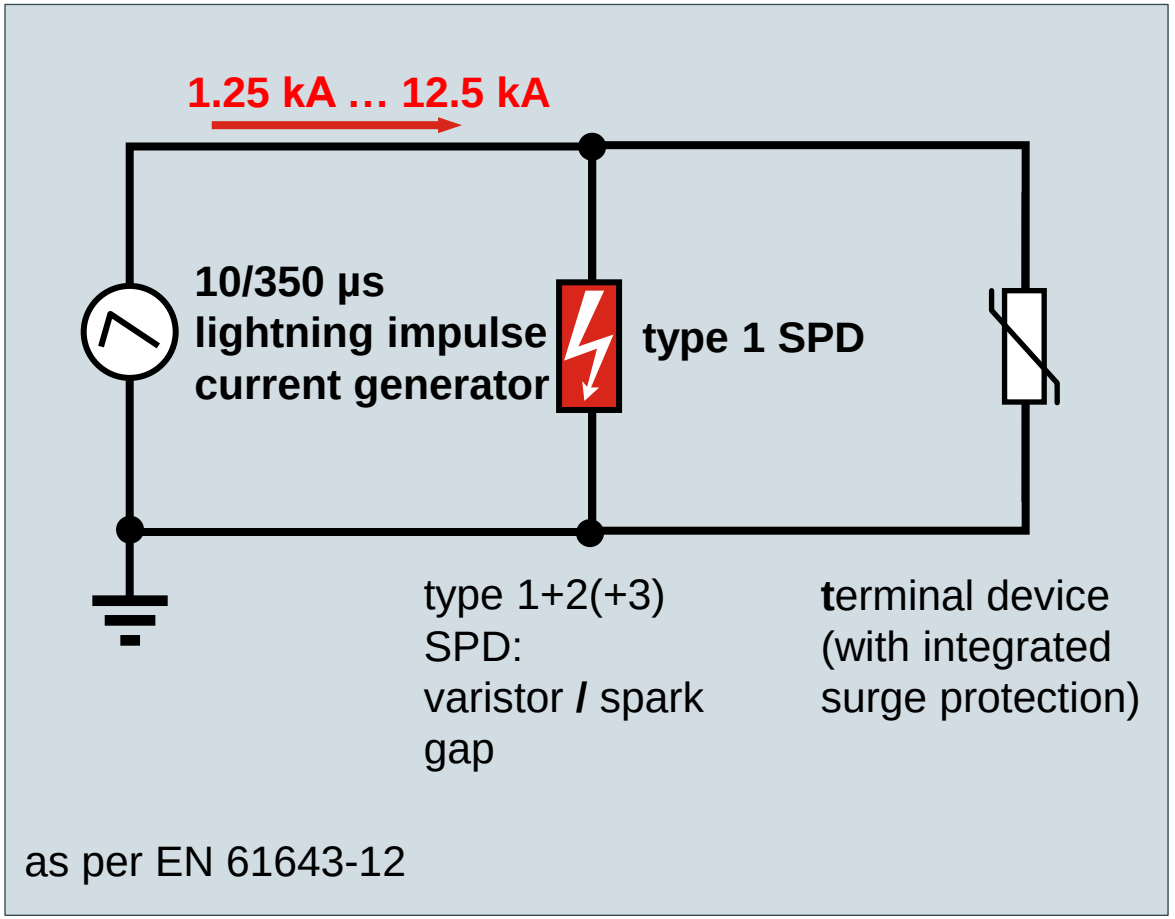
Terminal equipment is not overloaded

red = response behaviour
blue = 1.2/50 test pulse for terminal equipment as per IEC 61000-4-5

Comparison of type 1+2(+3) arresters: Varistor versus spark gap

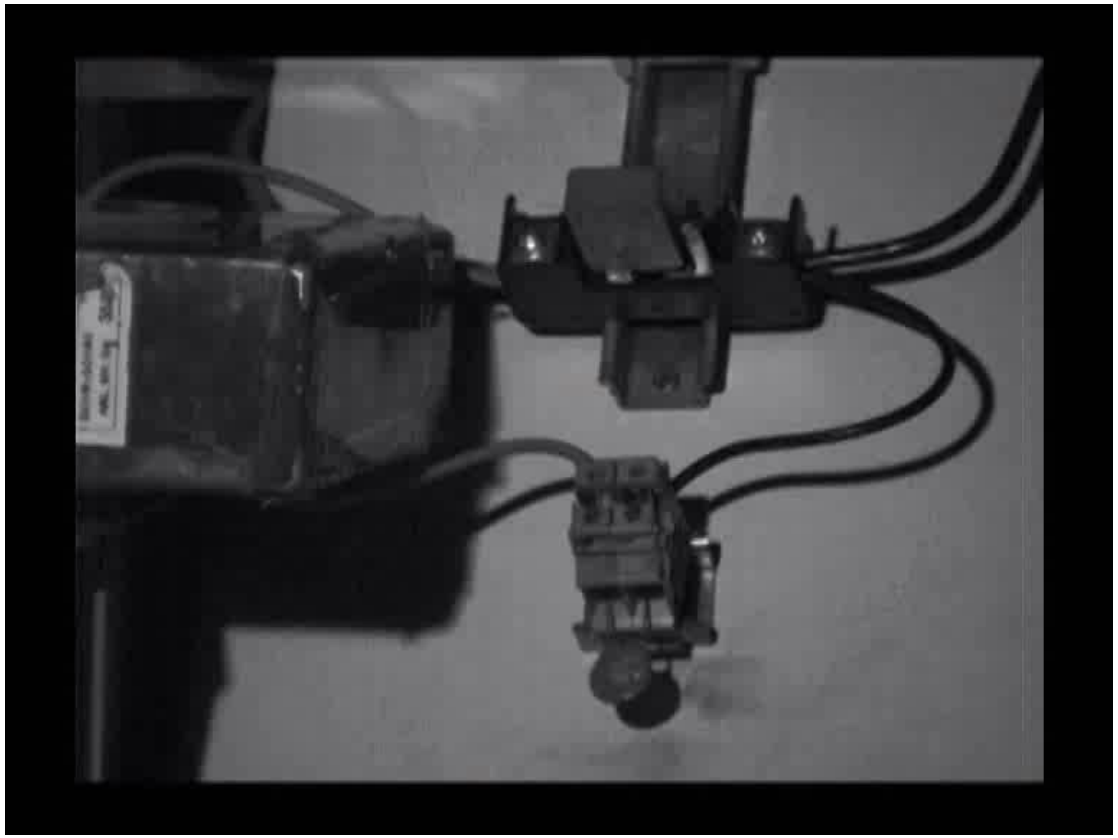
- Varistor / spark gap (DEHNventil®)
- Variation: lightning currents from 1.25 kA to 12.5 kA (lightning currents of different intensities)
- Interaction of type 1 SPD with downstream terminal device

Test set-up:



Application conflict spark gap – varistor
Coordination with the varistor of a terminal device

Coordination of a type 1 varistor with the varistor of a terminal device



High-speed video

Load:

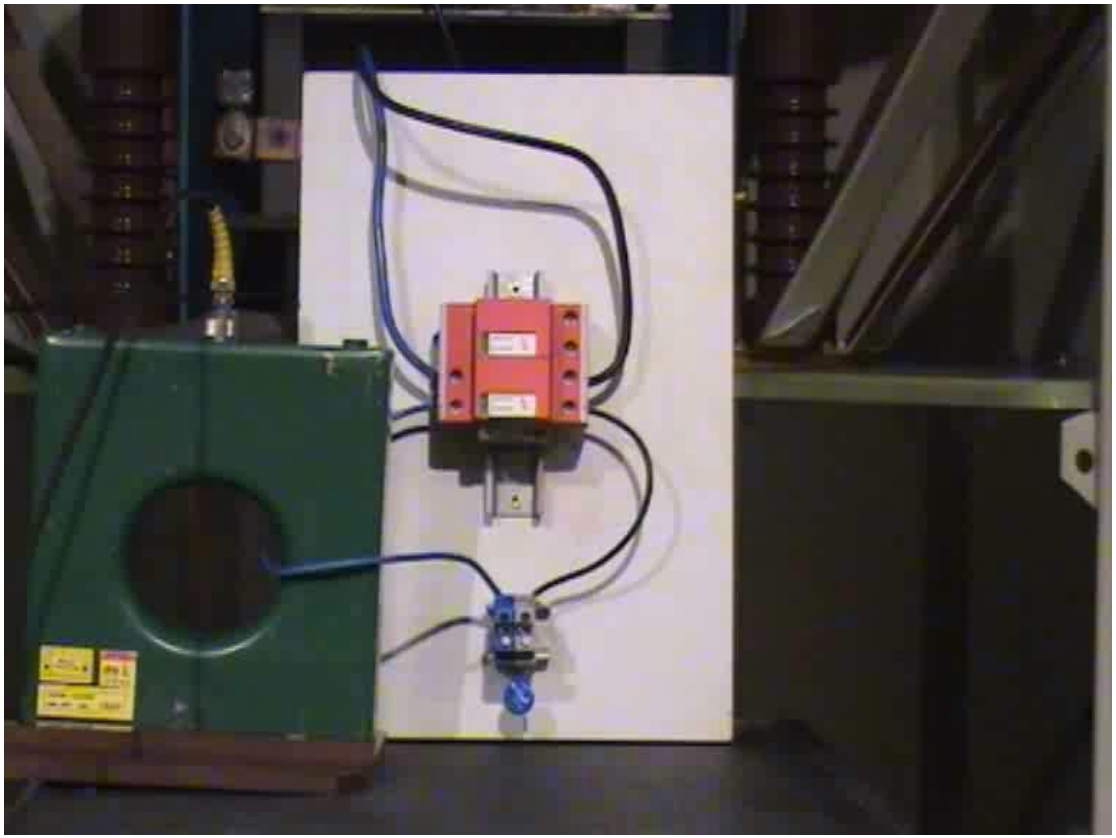
12.5kA (10/350µs)

Result:

Overload / destruction of the terminal device

Application conflict spark gap – varistor
Coordination with the varistor of a terminal device

Coordination of a type 1 spark gap with the varistor of a terminal device



High-speed video

Load:

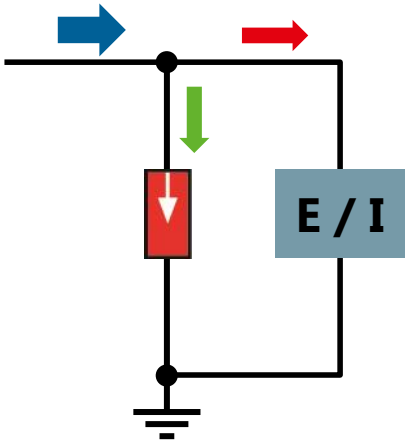
12.5kA (10/350µs)

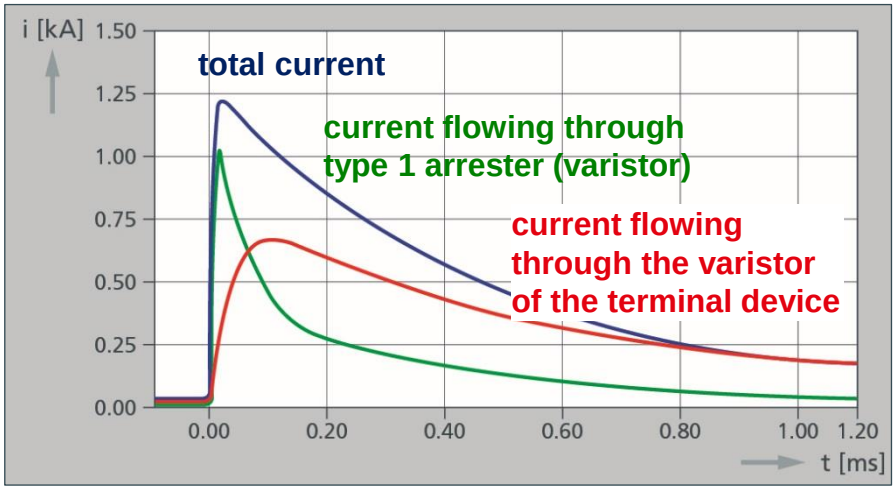
Result:

No overload

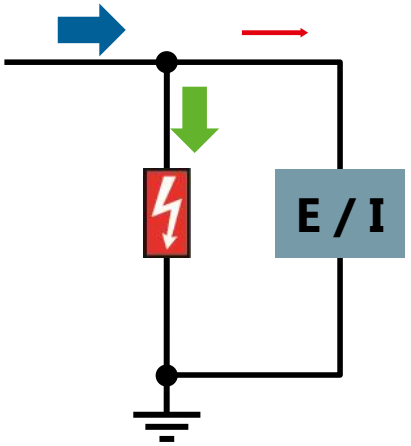
Application conflict spark gap – varistor
Comparison of the coordination behaviour

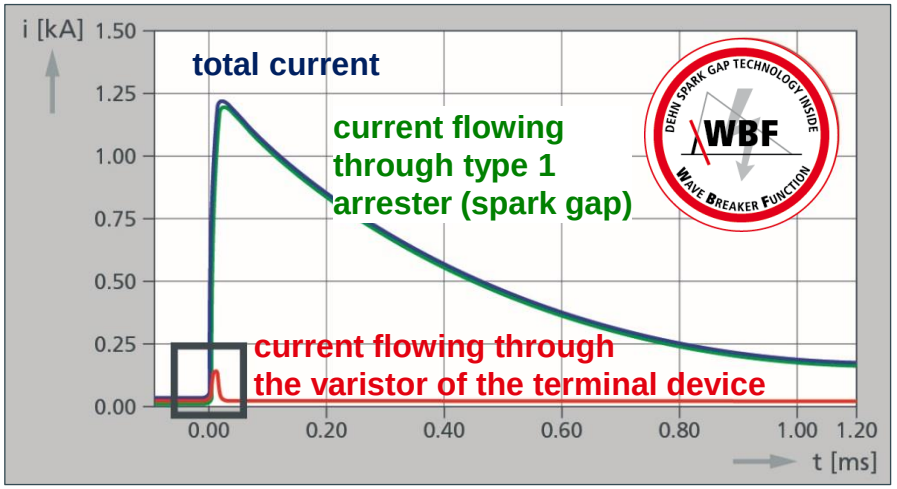
Varistor-based type 1 SPD



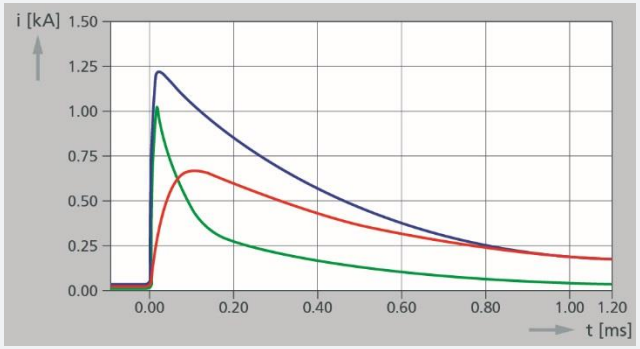
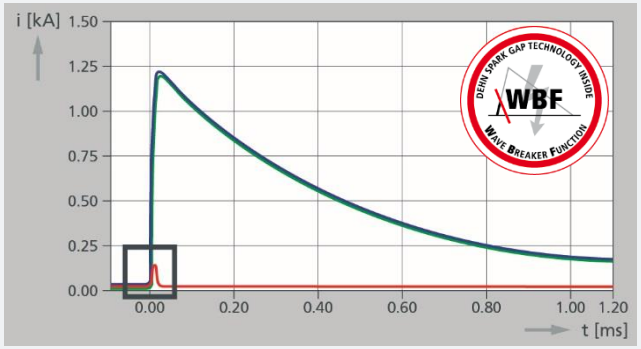


Spark-gap-based type 1 SPD





Application conflict spark gap – varistor
Comparison of the coordination behaviour

	Varistor-based type 1 arrester	Spark-gap-based type 1 arrester
		
Impulse current characteristic	Current is flowing into the varistor of the terminal device almost over the entire impulse current duration	After the spark gap is activated, no more current flows into the varistor of the terminal device ➔ "Reduction of the pulse time" / "wave breaker function"
Energy load in the varistor of the terminal device	Energy overload or destruction even in case of small impulse current amplitudes	Almost no energy load even in case of the maximum impulse current

RRH Protection Considerations - Agenda

- Modes, Surges, Let Through Voltage, Coordination Issues, and Use of Modern Sparkgaps for Coordination
- **Installation Locations and Isolated Down Conductors**

HVI®Conductor

Technology
Fields of application

HVI®Lightning Protection for cell sites

no metal parts may be located in the sealing end range!

EB element installed inside the supporting tube

air-termination tip

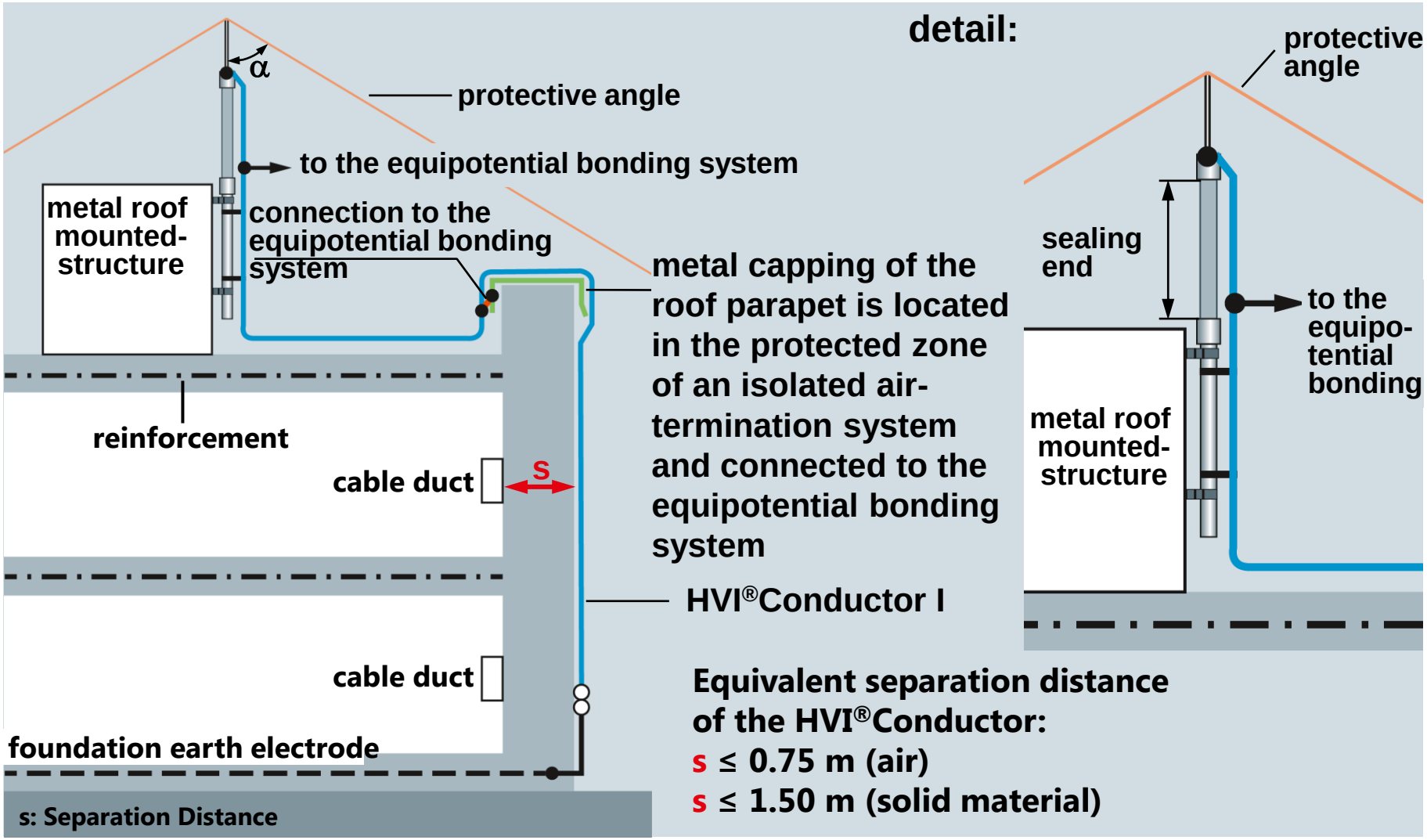
GRP supporting tube

aluminium supporting tube

HVI®Conductor

source: Bischof-Blitzschutz, Weyhe

HVI®Conductor
Sufficient separation distance

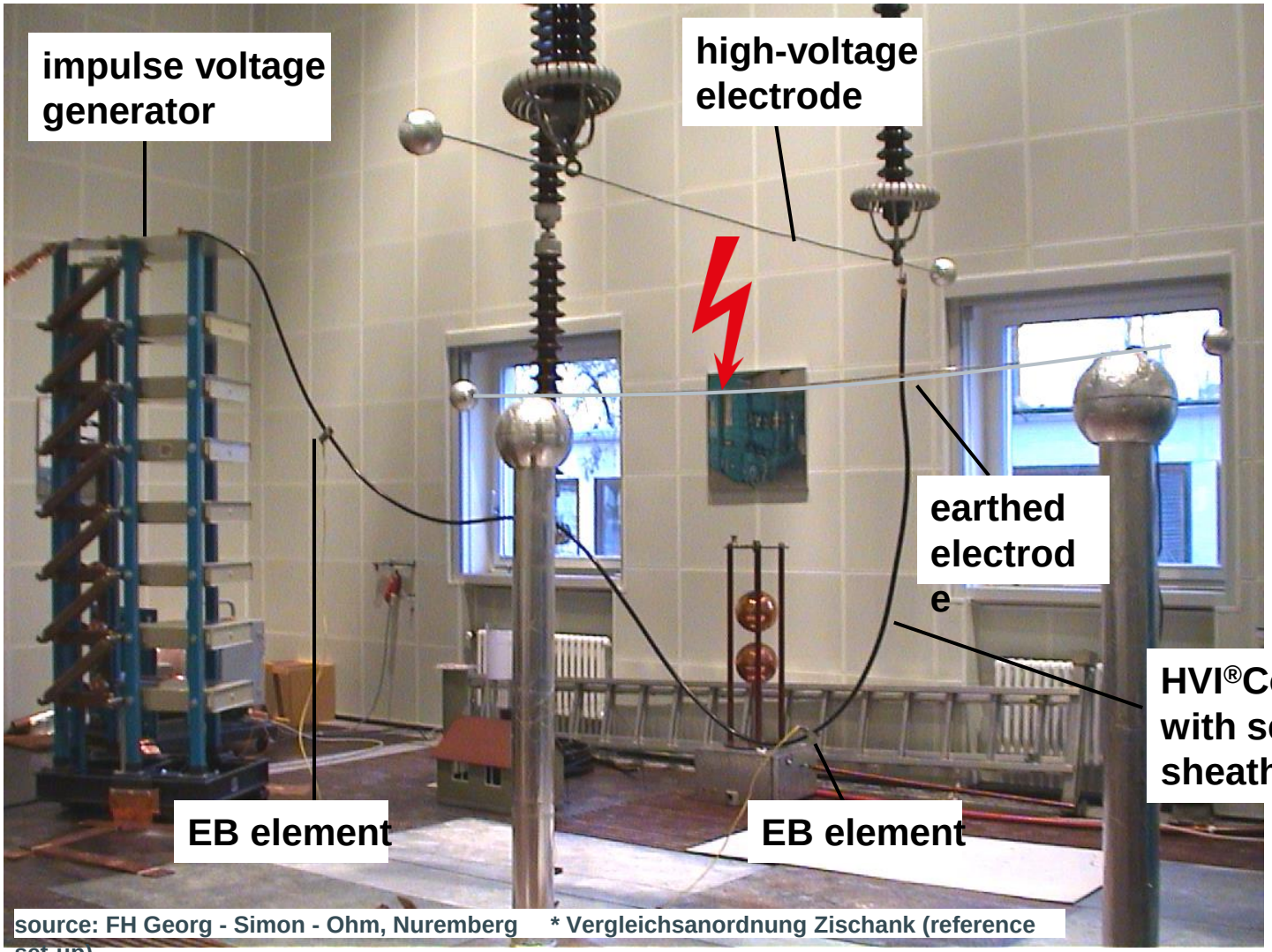


Equivalent separation distance of the HVI®Conductor:

s ≤ 0.75 m (air)

s ≤ 1.50 m (solid material)

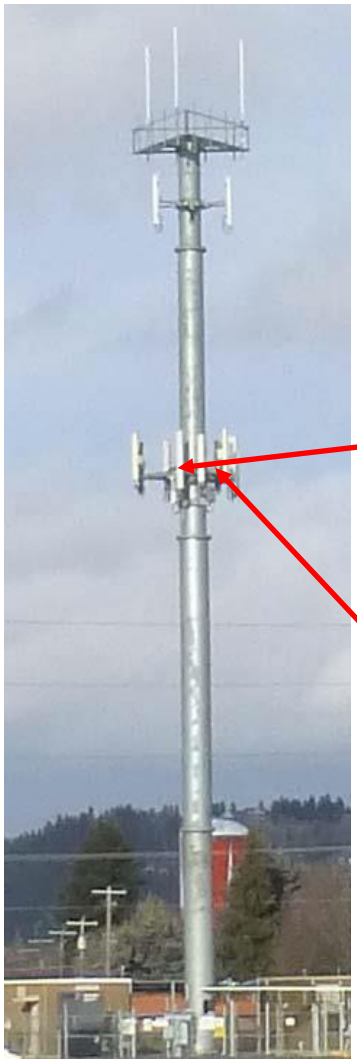
HVI®Conductor - Testing the dielectric strength in the reference set-up*



source: FH Georg - Simon - Ohm, Nuremberg * Vergleichsanordnung Zischank (reference set-up)

RRH Physical Installation Examples - The Good, The Bad, and the Ugly

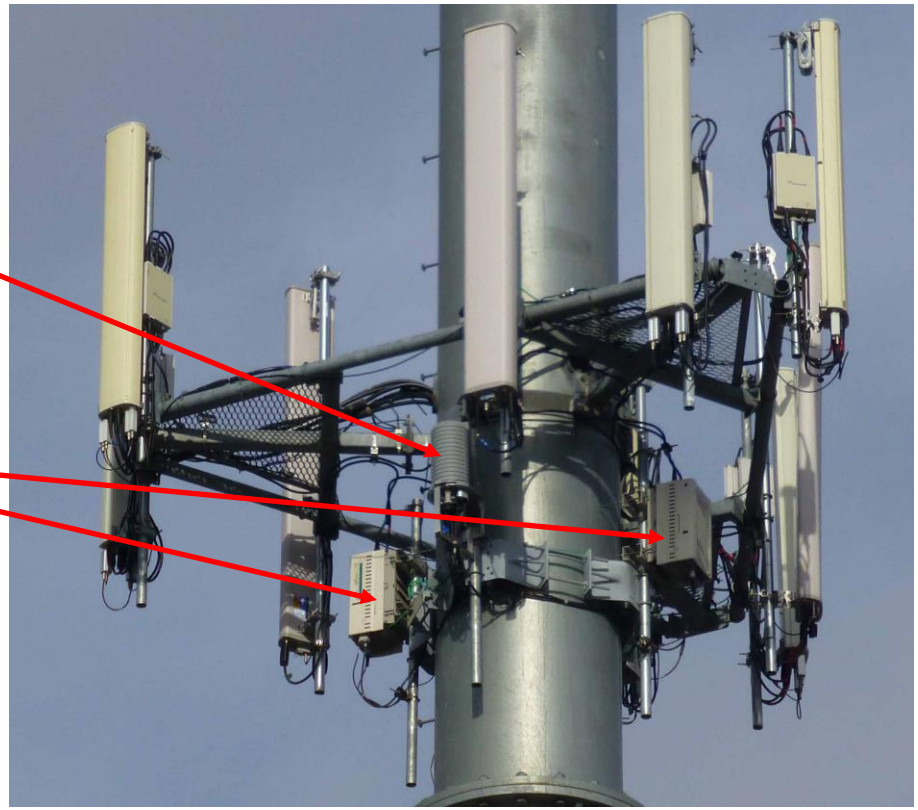
AT&T RRH Site
Spokane Valley, WA



Radios and Centralized OVP reference same position on monopole
Lightning attachment will be well above this position.
THIS IS AS GOOD AS IT GETS!

OVP: Fiber/Copper Cross Connect with DC Protectors

Remote Radio Heads (RRH)



T-Mobile RRH site
Liberty Lake, WA

Radios and Centralized OVP reference same position on monopole
Lightning attachment will be well above this position.
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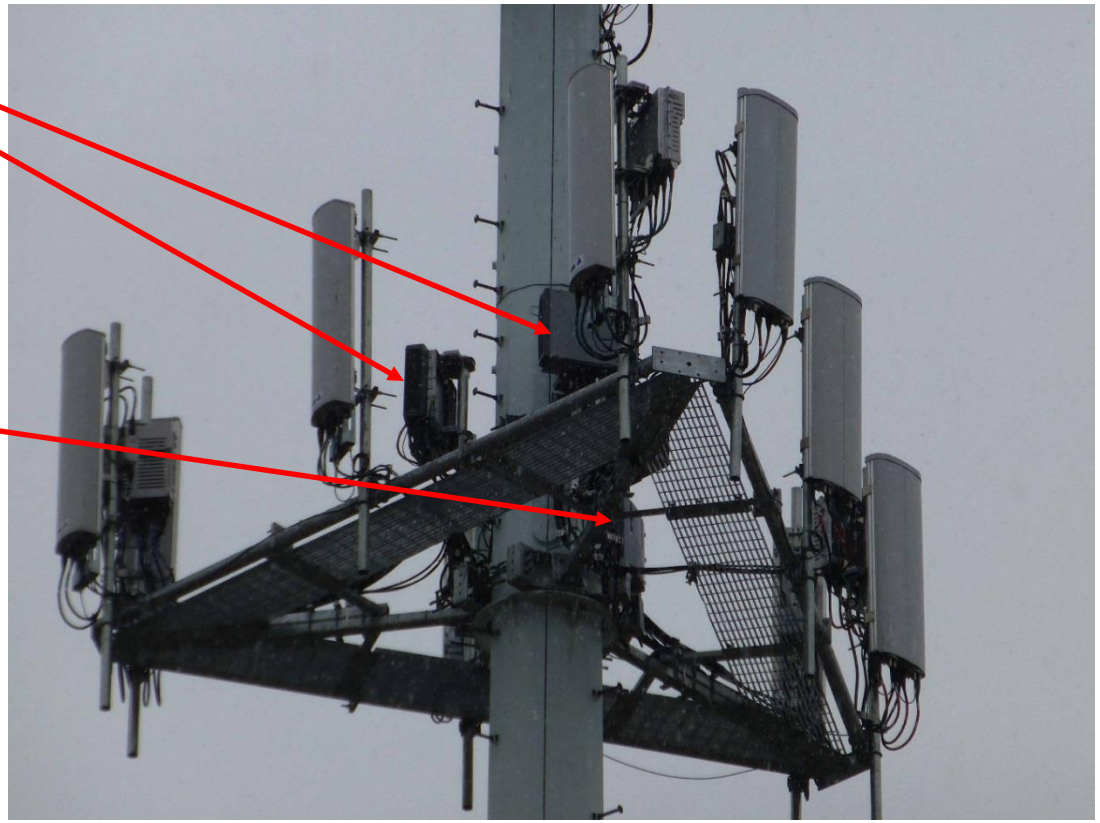
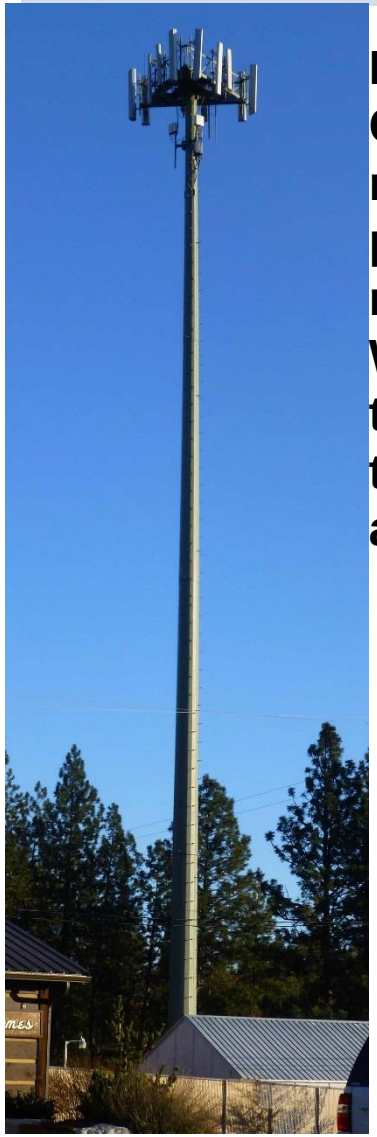
Remote Radio Heads (RRH)

OVP: Fiber/Copper Cross Connect with DC Protectors



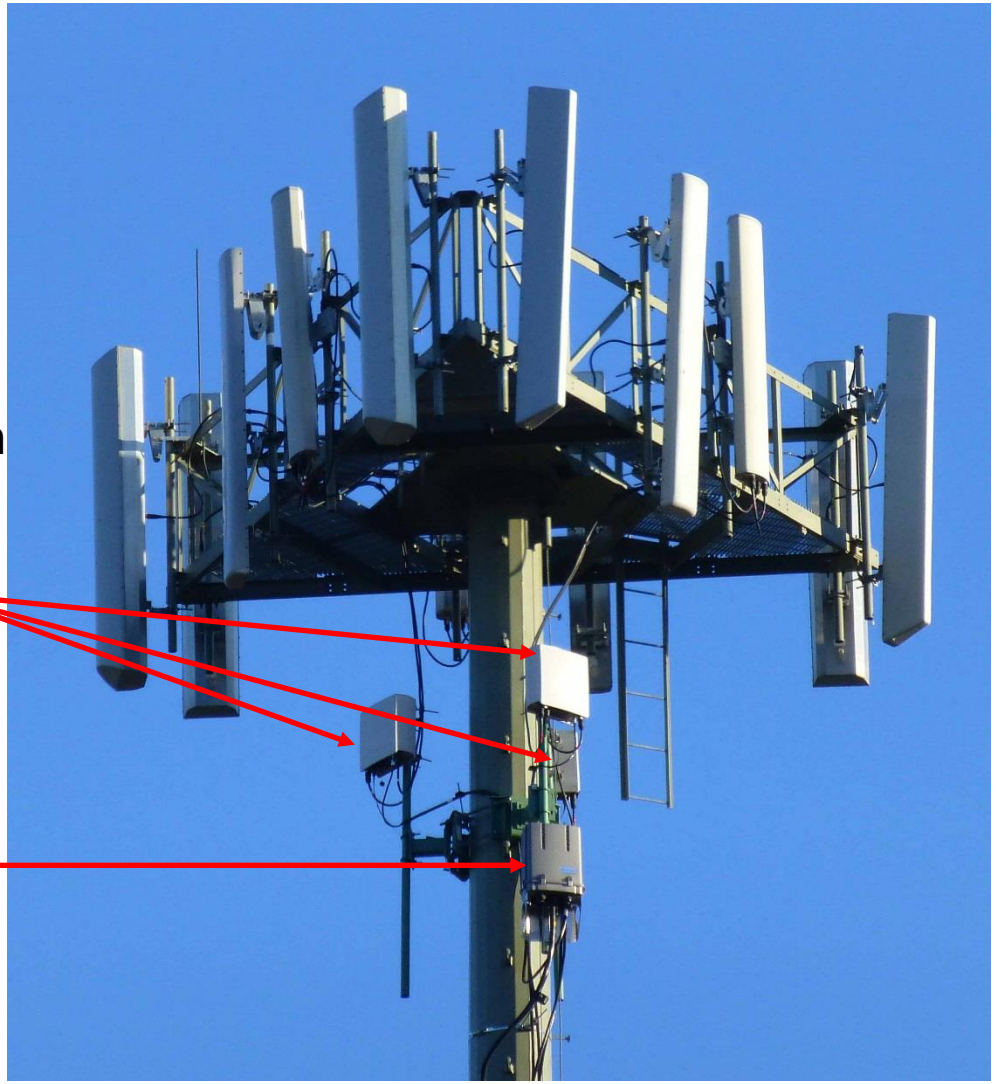
Verizon Wireless RRH site
Post Falls, ID, USA



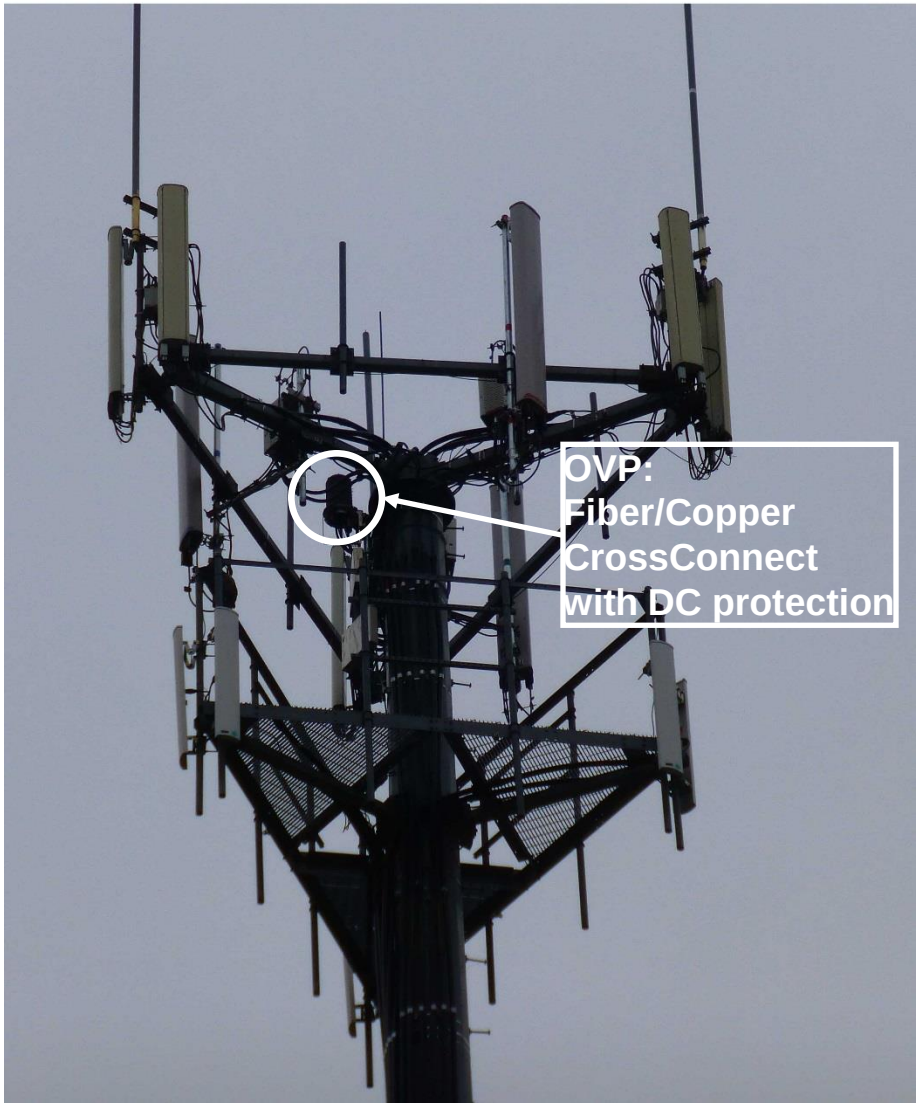
Radios and Centralized OVP reference same position on monopole
Would prefer to see taller lightning rods to achieve protection angle

Remote Radio Heads (RRH)

OVP: Fiber/Copper Cross Connect with DC Protectors



AT&T RRH site
Liberty Lake, WA, USA



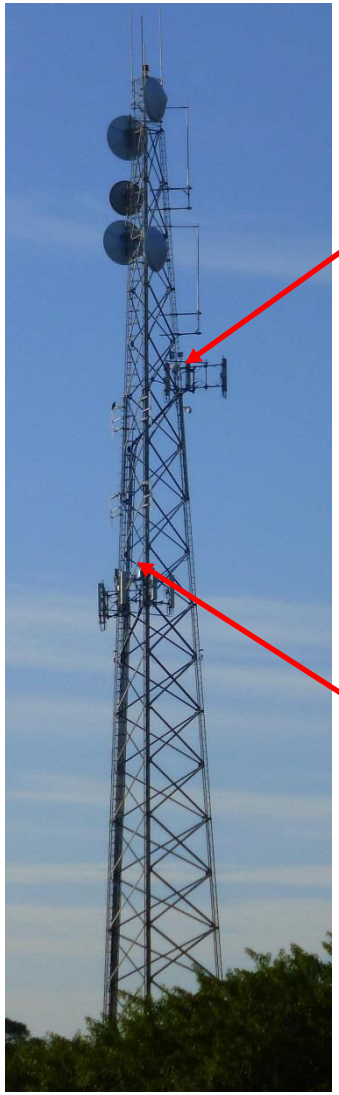
OVP is in middle on monopole
Radios are on arms partway between lightning rods and OVP.
Voltage drop across arm between RRH and OVP will be felt at RRH

Better to strip radios to monopole

Boom Arm Site with Ericsson RRHs
4 RRH per sector (12 total)

Boom Arm Site with Alcatel-Lucent RRHs
1 RRH per sector (3 total)

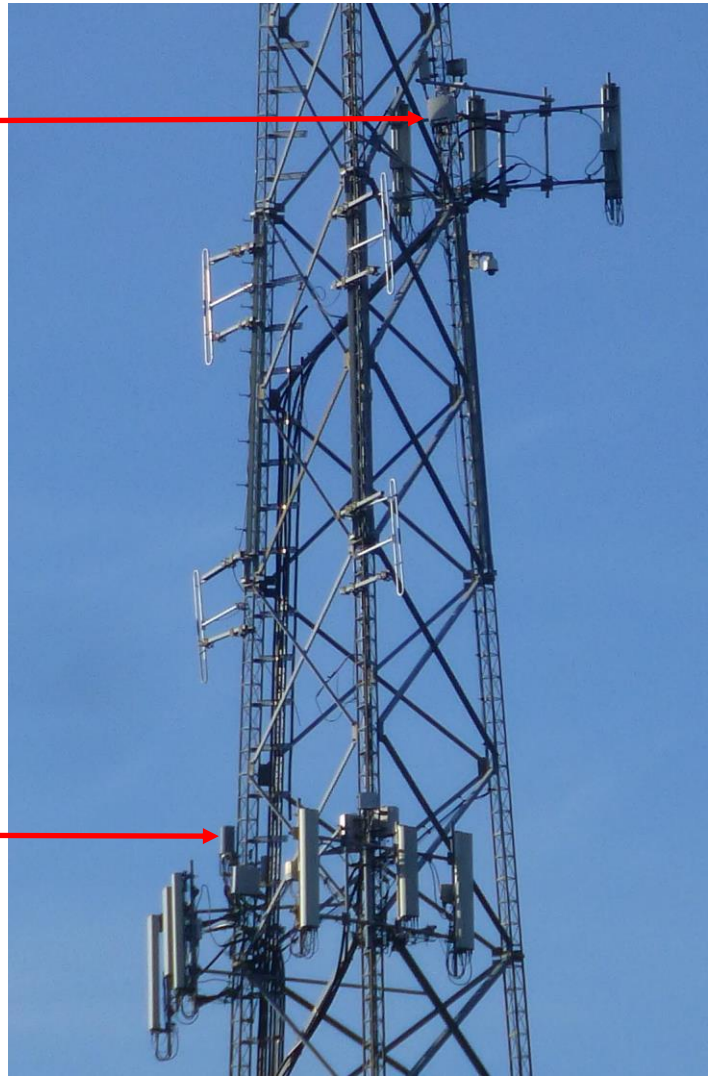
AT&T RRH Site in Ft Pierce, FL
Upper Sector RRH ~ 30 vertical ft. from OVP



RRH

Third sector RRH is approx. 30 vertical feet from centralized OVP
THIS IS AS BAD AS IT GETS!

OVP



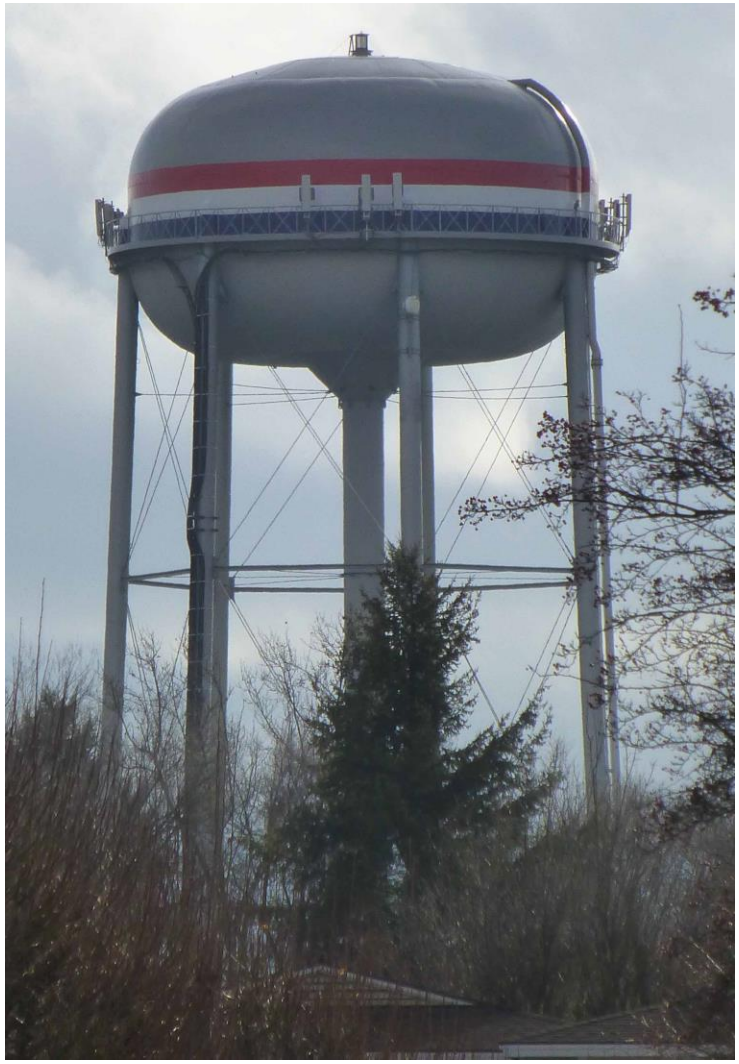
RRH site on High Voltage Tower

Water Tower with Pad Mount BTS

OVP: fiber/copper cross connect box with DC protectors

Water tower
No separate OVP in visible sector

Water Tower RRH site
Spokane Valley, WA

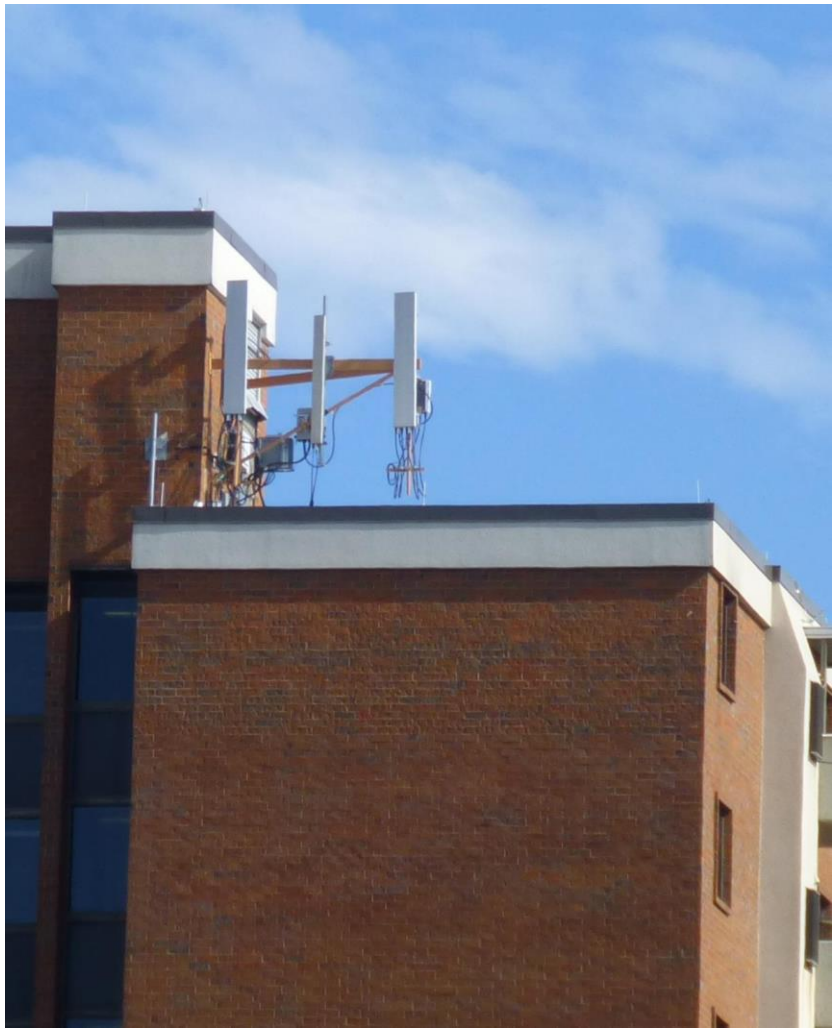


Concrete Water Tank
In Parallel with DC conductors ???

AT&T RoofTop RRH site
Atlanta, GA, USA

Rooftop Sites use SEPARATE DC protection / fiber cross-connect boxes at each sector.

Note 2x4 mounting of antennas



Summary

- Ensure that the RTN to GND SPD protecting the RRH is monitored for failure to prevent ground currents from flowing into the buried ground rings.
- We can lower -48 V to RTN let through voltage at the RRH with a 2+0 (-48 V to GND, RTN-GND) protection scheme as the surge appears longitudinally on the power pair.
- For RRHs with internal MOVs, using spark gaps in the OVP can eliminate coordination problems.
- The OVP needs to be a the same potential as the RRH during the lightning strike. High Voltage Isolated down conductors may help in some situations.
- There is no such thing as a standard tower.