



Vacuum Interrupter

Basic switching technology

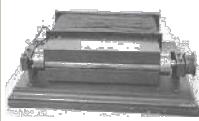
Andreas Stelzer, Head Sales Medium Voltage Components
VAR Partner Day 2022 | September 12 -14 | Zagreb, Croatia

Table of contents

Agenda

• Energy Innovation & Global share of switching mediums	3
• Basic environment for current interruption	5
• Vacuum Interrupter – Overview basic functions	6
• Function 1 – Normal & Peak current	7
• Function 2 – Current interruption & physics & geometry	8
• Function 3 – High voltage withstand	14
• Core advantages & competencies	15
• Portfolio overview	19
• Typical applications	20

Energy innovations for more than 155 years



1866
Dynamo



1930
Expansion switch



1977
First Vacuum
Interrupter



2008
World's first
800 kV HVDC
power line



2014
Molded case
circuit breakers
3VA



2014
Energy IP® –
platform for Smart
Grid applications

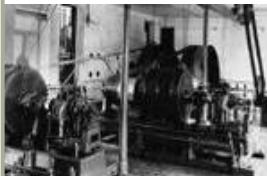


2015
Full bridge technology
for converter stations

1866

TODAY

1892
First public
alternating current
power plant



1964
First SF6
circuit
breaker



1989
Infinitely variable
three-phase
compensator



2012
Arc-Fault Detection
Units



2015
DC Grid Access with
Diode Rectifier Units



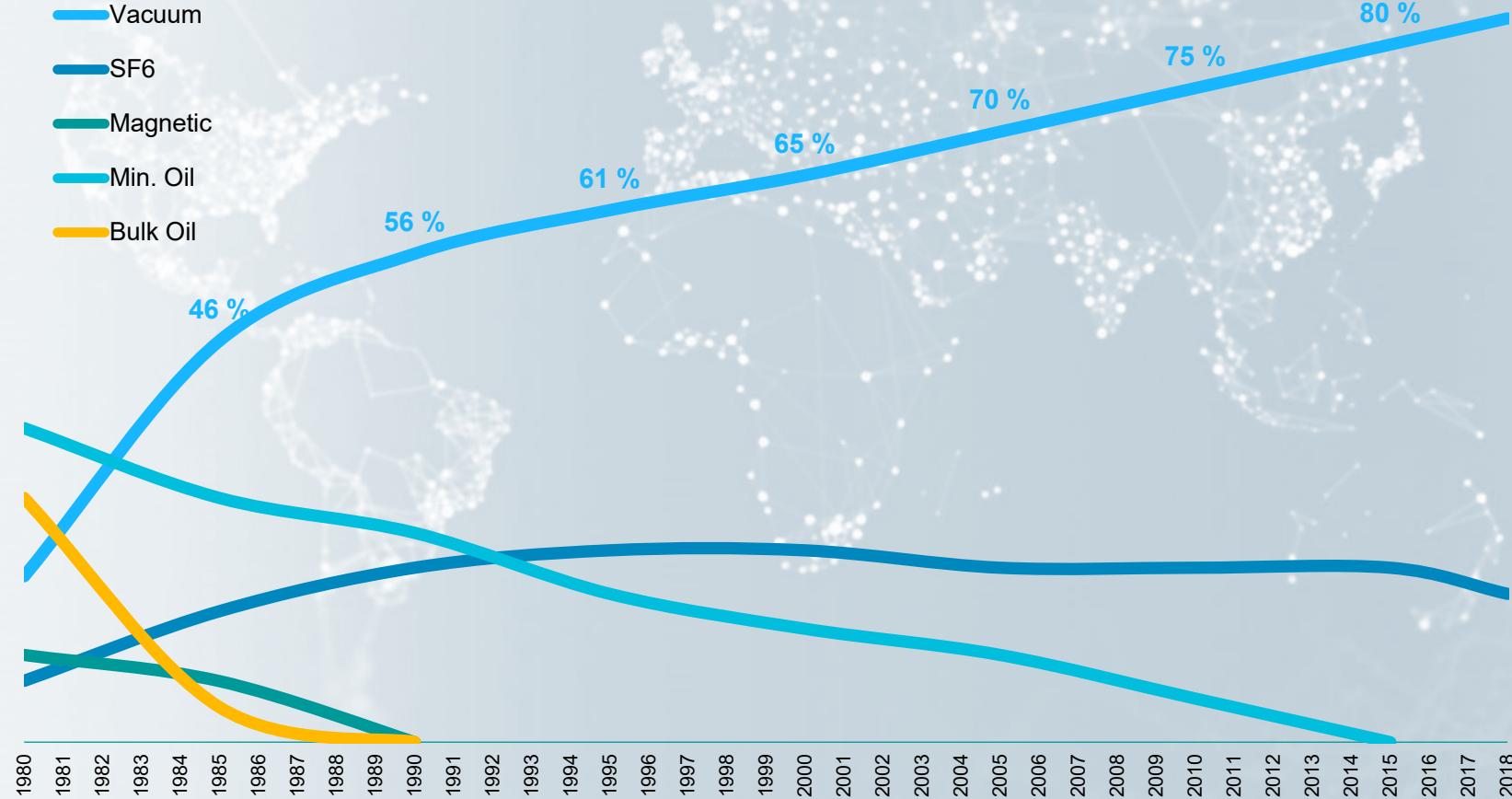
2015
SIHARBOR - Shore
connection system
for cruise ships



World share – Switching technologies

Medium voltage applications

Market Share evolution of MV Circuit Breakers quenching method



From 20% in 1980
to more than

80%

of market share,
Due to **proven track**
records & successful
Implementation & MTTF

Vacuum Interrupters

Basic environment for current interruption

1000 mbar

800 mbar

3×10^{-4} mbar

1×10^{-7} mbar

1×10^{-11} mbar

1×10^{-15} mbar

1×10^{-16} mbar



Atmosphere

“Vacuum” Cleaner



Approx edge of the space

Vacuum Interrupter



Surface of the moon



Interplanetary space



Interstellar space

Vacuum Interrupters

Core element of all AC current cases – Basic functions

1

Normal & peak current flow

- Uninterrupted flow of nominal current
- Longterm low resistance - μOhm



2

Current switching and interruption

- Highest normal current levels
- All kinds of Short circuit currents
- Major safety function



3

Withstand against inner and outer voltages

- Power frequency withstand voltage
- Lightning impulse voltage



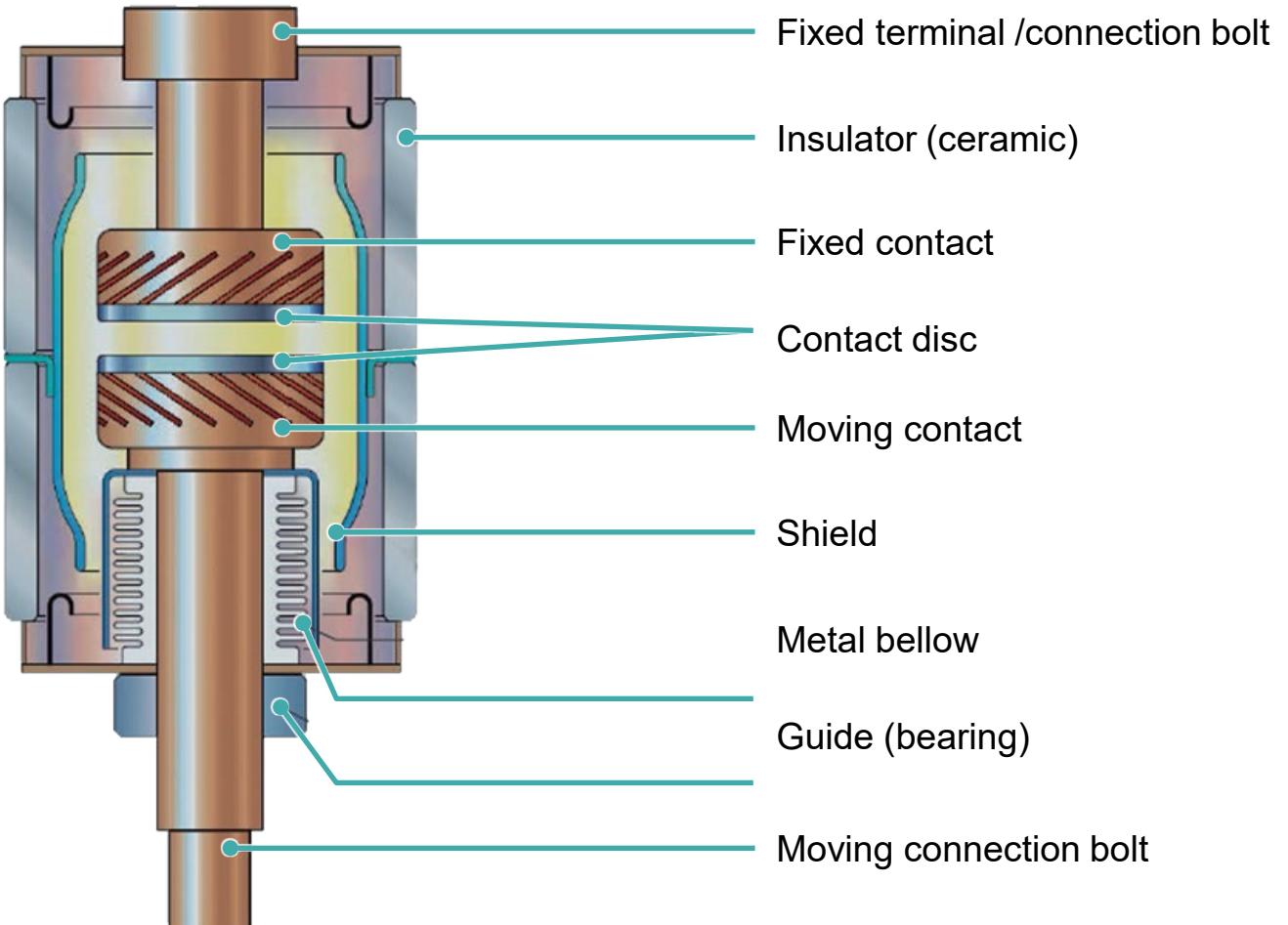
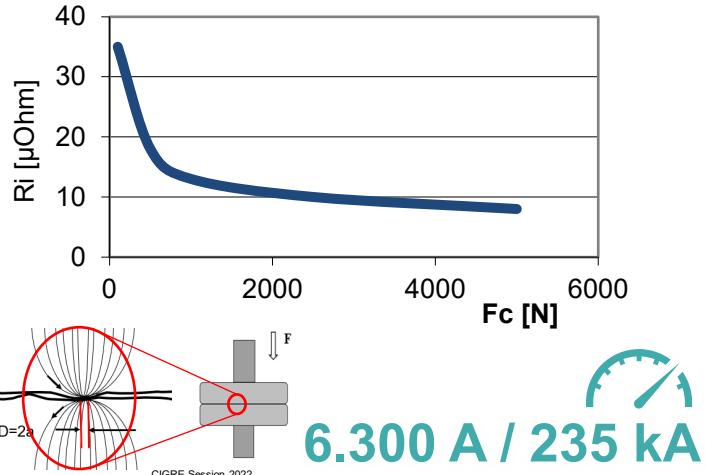
Vacuum Switching Technology

Details of a vacuum interrupter

1

Normal & Peak current flow

- Low resistance by oxygen free copper
- Optimized contact design
- Adequate contact force



Siemens vacuum interrupters

Advantages of vacuum switching

2

Current switching & interruption

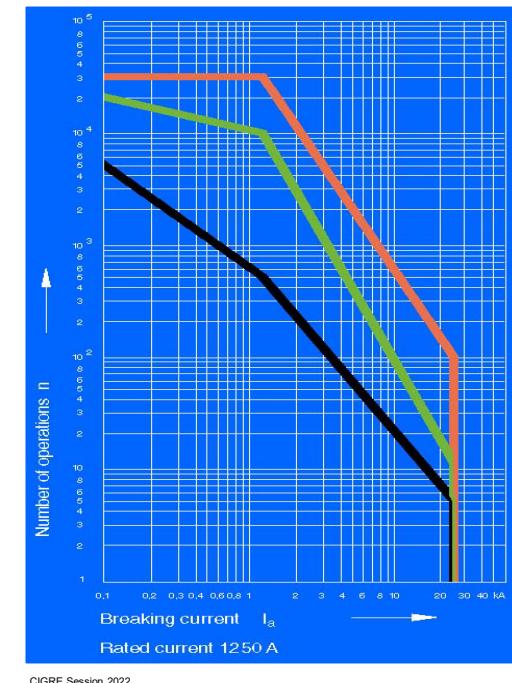
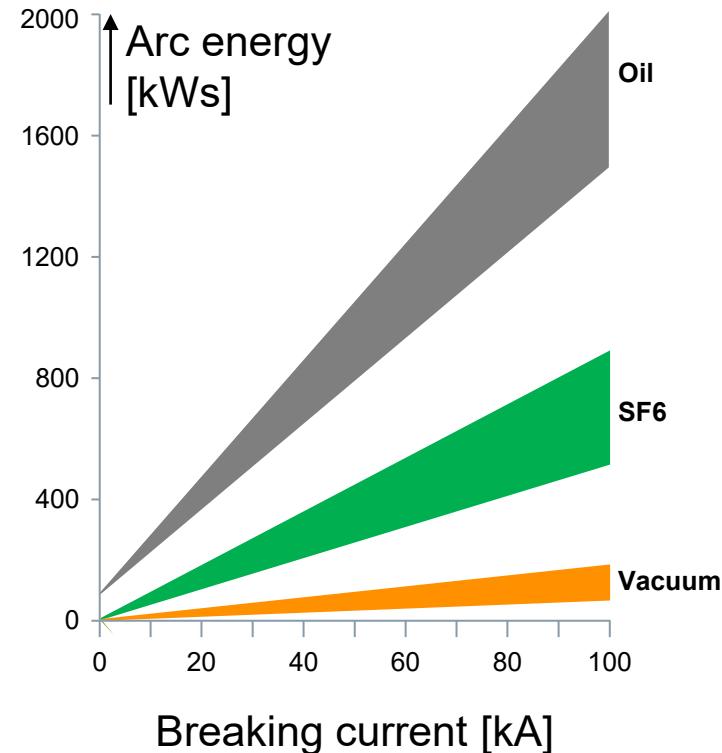
$$W = \int_0^T u_{arc} * i * dt$$

Vacuum Interrupters

- Low arc voltage
- Low arc length
- Low arc energy

110 kA

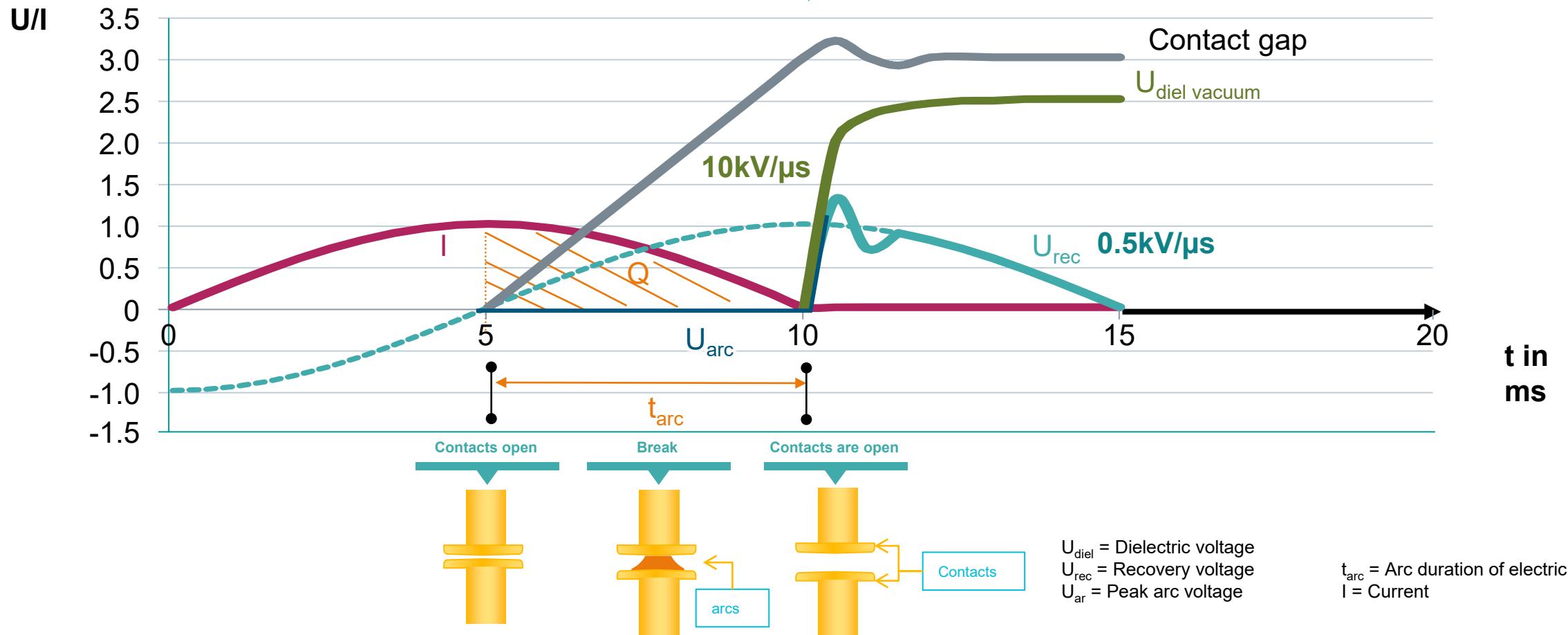
Arc energy for different environment



Siemens vacuum interrupters

Principle of vacuum switching

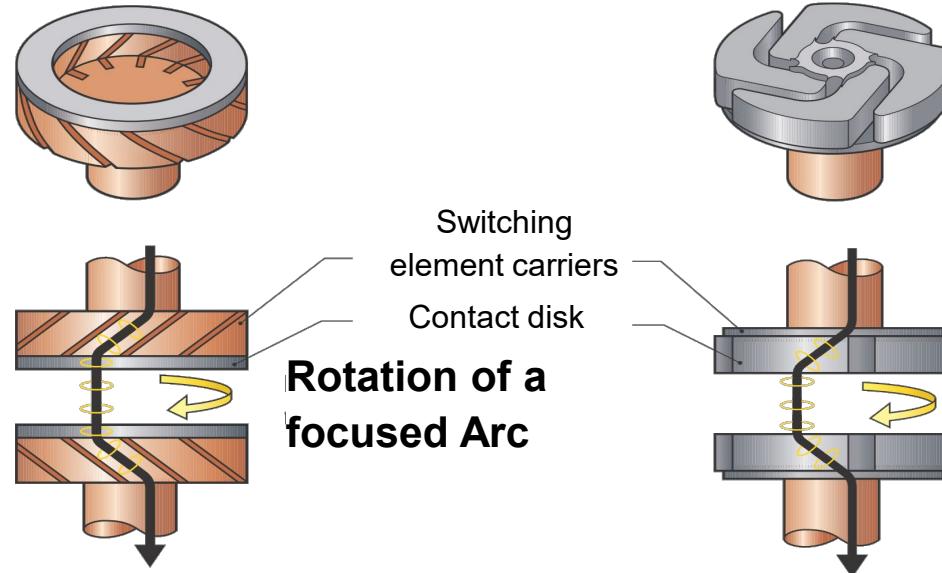
Extinguishing the arc in the zero point passing



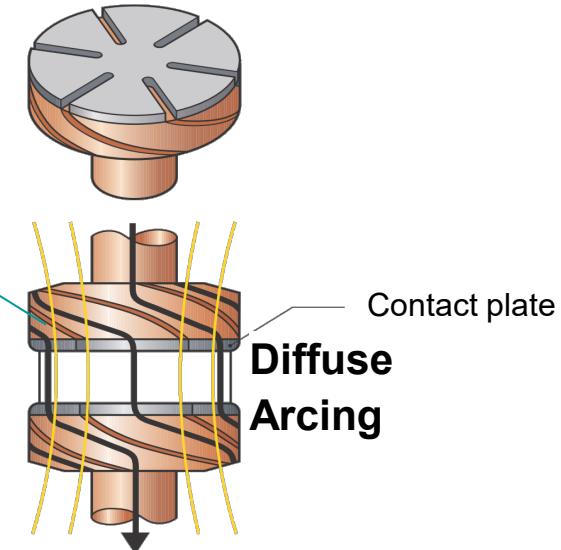
Siemens vacuum interrupters

Contact geometries for > 10 kA I_{sc}

Radial magnetic field contact (RMF)



Axial magnetic field contact (AMF)

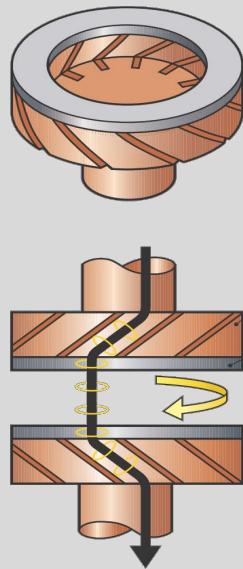


The contact geometry & magnetic field creation have a decisive influence on the switching capacity of a vacuum interrupter. Various contact geometries are used depending on the current intensity.

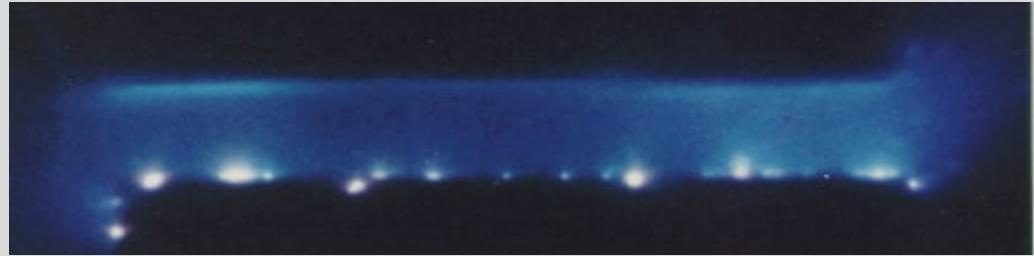
Vacuum interrupter contact geometries

Radial magnetic field contact (RMF)

Contact system



High-speed images with exposure time of 13 µs, cathode at the bottom



Diffuse arc before current zero ($i = 2 \text{ kA}$)



Constricted arc ($i = 40 \text{ kA}$)

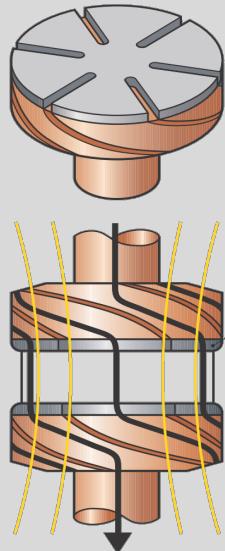
Vacuum interrupter



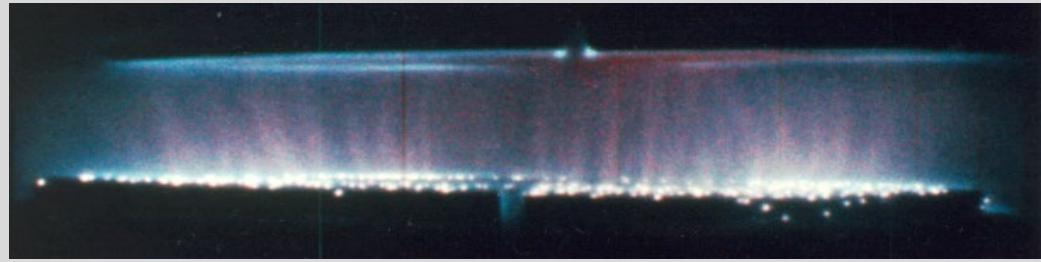
Vacuum interrupter contact geometries

Axial magnetic field contact (AMF)

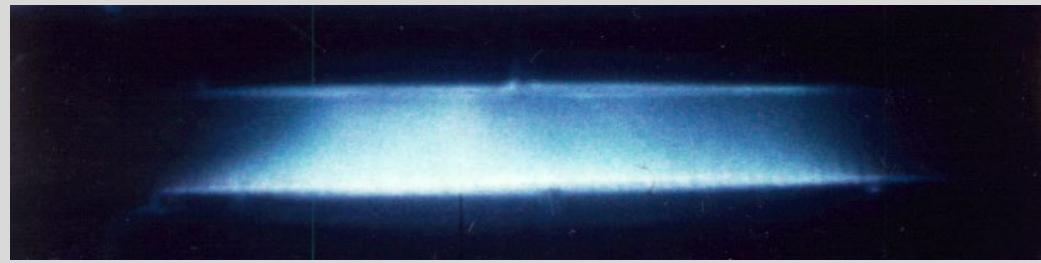
Contact system



High-speed images with exposure time of 13 µs, cathode at the bottom



Diffuse arc before current zero ($i = 10 \text{ kA}$)



Diffuse high-current discharge $i = 60 \text{ kA}$)

Vacuum interrupter



Vacuum Switching Principles

Contact material - the key for our success

CuCr

Inhouse production assures

- Constant Quality – precise Powder mixture
- High purity – Vacuum recast metallurgy
- Fine grained rapid solidified structure

- Small contact erosion
- Highest switching capability
- High dielectric strength
- Excellent electrical conductivity
- Low tendency to contact „welding“
- Small chopping current



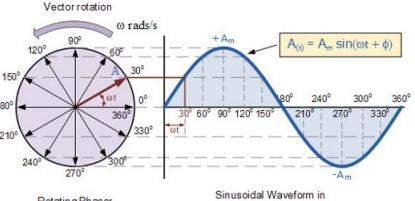
High Voltage

Definition & Behavior

3

Withstand against inner & outer voltages

- Power frequency withstand voltage - 50/ 60 Hz

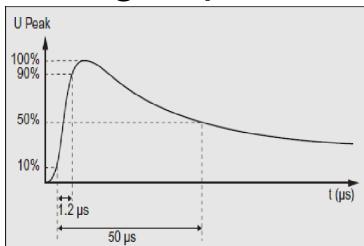


95 kV

Source: George Brown College, CA

Ur : 3,6 kV – 7,2 kV – 12 kV – 17,5 kV – 24 kV – 36 kV – 40,5 kV – 52 kV

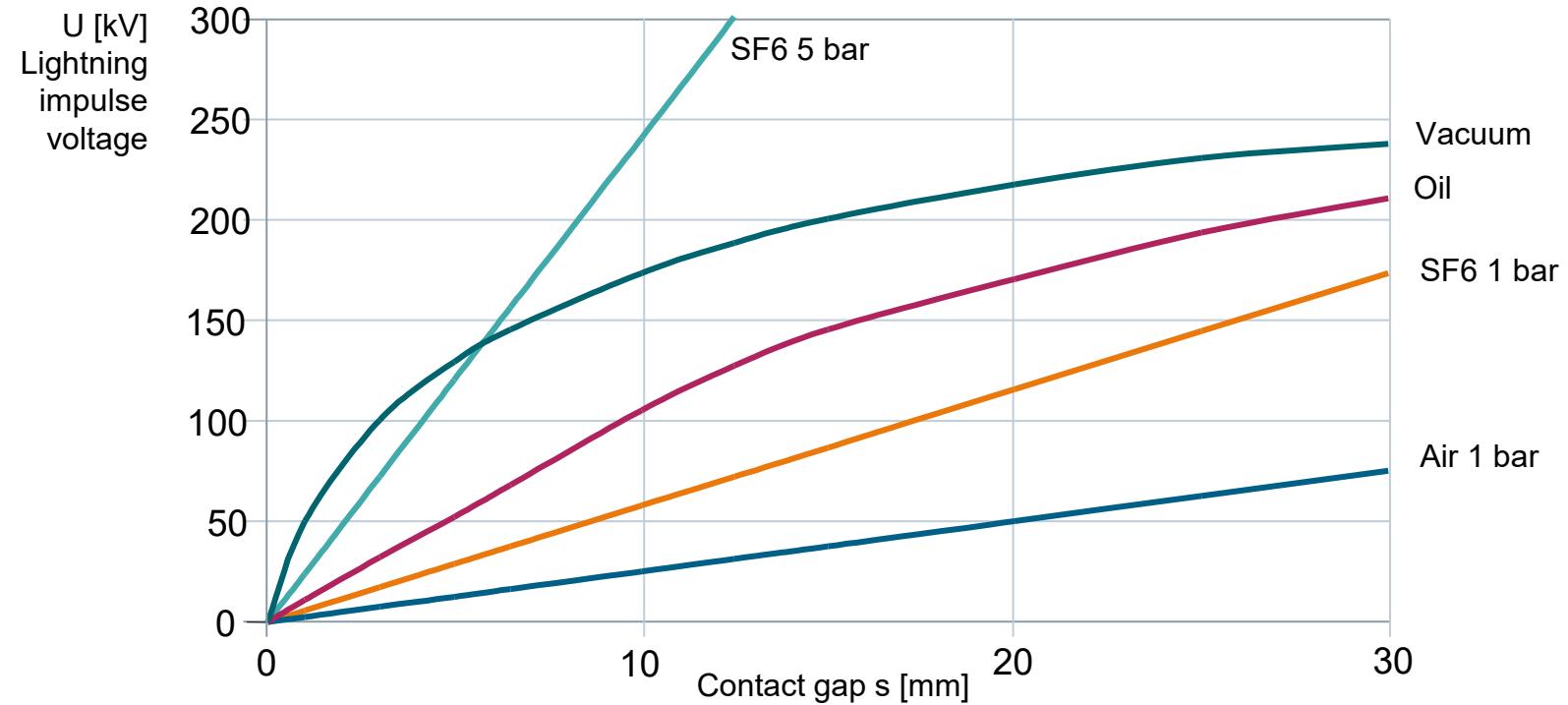
- Lightning impulse voltage



250 kV

Source: Research Gate

Breakdown voltage as a function of the contact stroke



Dielectric strength in vacuum is ensured over the entire service life

Vacuum Switching Technology

Core advantages over the whole live time

Constant vacuum pressure & dielectric

- Independent of environmental influences by hermetically sealed vacuum interrupters
- Switching operations in vacuum do not produce decomposition products
- Outside insulation in Air/ SF₆ / Solids/ Liquids

Constant contact resistance

- Contact surfaces remain pure metallic since oxidation does not occur in vacuum
- Contact resistance remains constant at lowest level throughout the entire lifetime

Applicable for all switching applications

- Low chopping currents
- No/ Low restrikes probability
- Switching of highest normal and short-circuit currents up to 110 kA



Vacuum Switching Technology

Core advantages over the whole live time

Economic benefit

- Vacuum interrupters are maintenance-free up to the type tested limits
- Modern vacuum circuit-breakers are maintenance-free up to 10,000 – 30.000 operations



High reliability

- Less moving parts in the arcing chamber
- MTTF of the vacuum interrupters: 84,000 years
- MTBF of the circuit-breakers (3AE series): 18,000 years

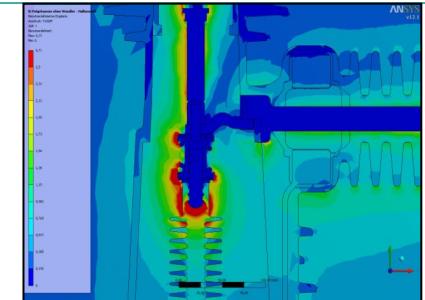


Siemens vacuum switching technology

Competencies

All research and development departments are in-house

- Basic research lab at Corporate Technology Departments
- Development departments in Energy Management R&D



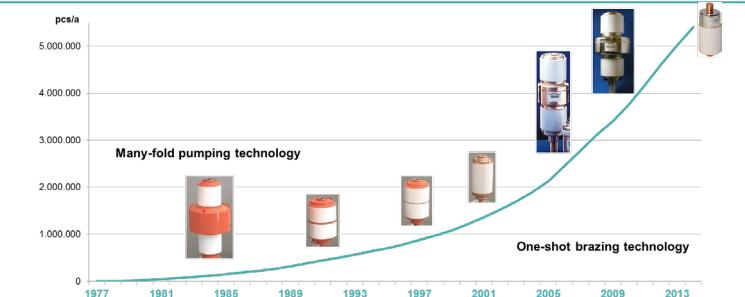
Quality management from raw materials to the final product

- Own manufacturing processes
- Proprietary technologies
- Seamless quality monitoring

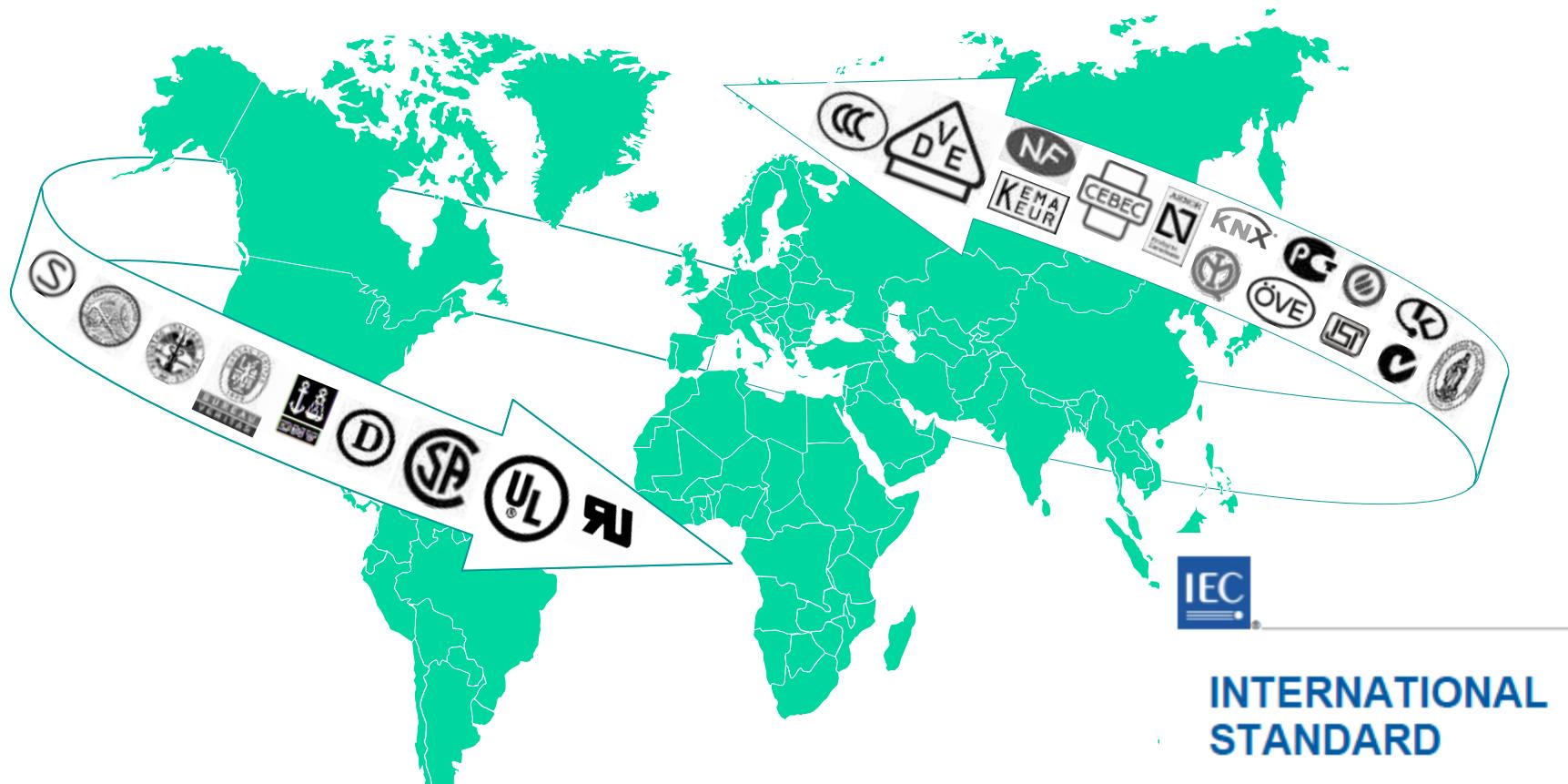


Strong & professional local support in each region

- Over 45 years' experience
- + 7,000,000 delivered vacuum interrupters
 - + 1,400,000 delivered vacuum switches



As international supplier we ensure the global availability of our products and systems



Standards for high availability and optimal personal protection

Siemens vacuum interrupters

Portfolio overview

	Contactors	Circuit breakers	Load-break switches	Reclosers
Rated voltage	1 - 24 kV	7.2 - 52 kV	7.2 - 15.5/ 27 kV	15.5 - 38 kV
Rated current	300 - 1400 A	Up to 6,300 A / 13.500 GVCB	800 A	800 A
Rated short circuit-breaking current	3 - 6 kA	Up to 110 kA	-	12.5 - 16 kA
Mechanical endurance	1 - 3 million C-O cycles	10,000 – 30,000 C-O cycles	10,000 – 30,000 C-O cycles	30,000 C-O cycles
External insulation media	Air	Air, SF6, Solid	Air, SF6, Solid	Solid

Typical Applications

Reliable and safe solutions for the vertical challenges



DSOs, municipalities



Renewables



Automotive



Chemicals



Data centers



Microgrids



TSOs



Metals



Oil and Gas



Large infrastructure



Rail



Construction,
real estate



Mining



Stadiums



Power generation

Disclaimer

© Siemens 2022

Subject to changes and errors. The information given in this document only contains general descriptions and/or performance features which may not always specifically reflect those described, or which may undergo modification in the course of further development of the products. The requested performance features are binding only when they are expressly agreed upon in the concluded contract.

All product designations may be trademarks or other rights of Siemens AG, its affiliated companies or other companies whose use by third parties for their own purposes could violate the rights of the respective owner.

| Contact

Published by Siemens AG

Andreas Stelzer

Head of Medium Voltage Primary Components Sales
Siemens AG / HQ / SI EA S CP PL PCS
Nonnendammallee 104
13629 Berlin
Germany

Mobile +49 (173) 7074487

E-mail andreas.stelzer@siemens.com

www.siemens.at/var