

Behavior of Vacuum Interrupter during Switching Operations with a High RRRV

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Behavior of vacuum interrupters during switching operations with a high rate of rise of recovery voltage (RRRV)

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ABB

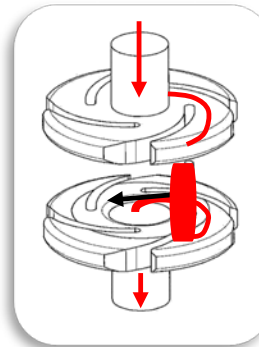
- Introduction
- Experimental results
- Analysis
- Conclusions

Introduction

Vacuum Interrupters - Principle of vacuum switching



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- **Metal vapor**
- **No gas molecule**
- **Very fast de-ionization (recovery strength)**
- **Minimal loss of contact material**
- **Minimal mechanical energy**



Three phase vacuum circuit breaker with embedded vacuum interrupter pole parts

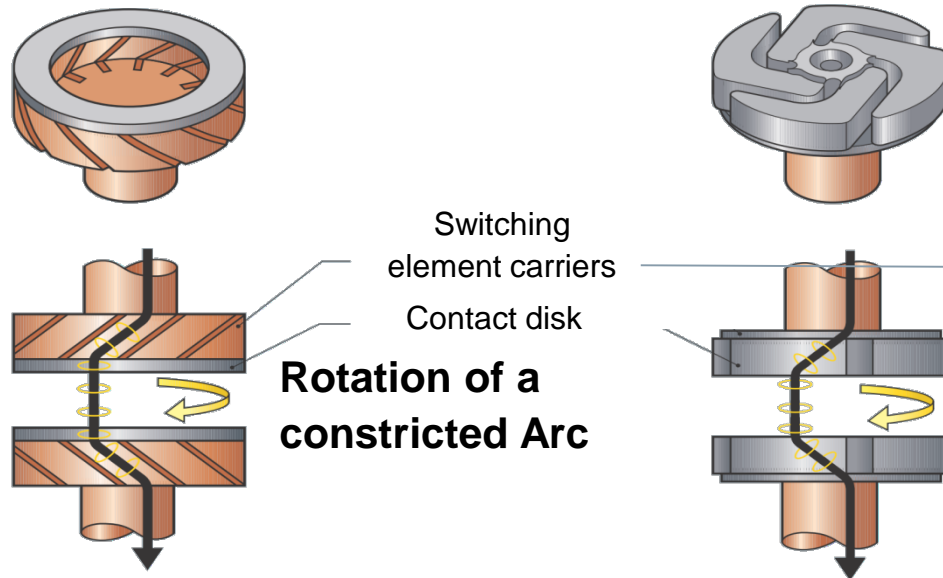
Introduction

Vacuum Interrupters - Contact geometries for $> 10 \text{ kA } I_{sc}$

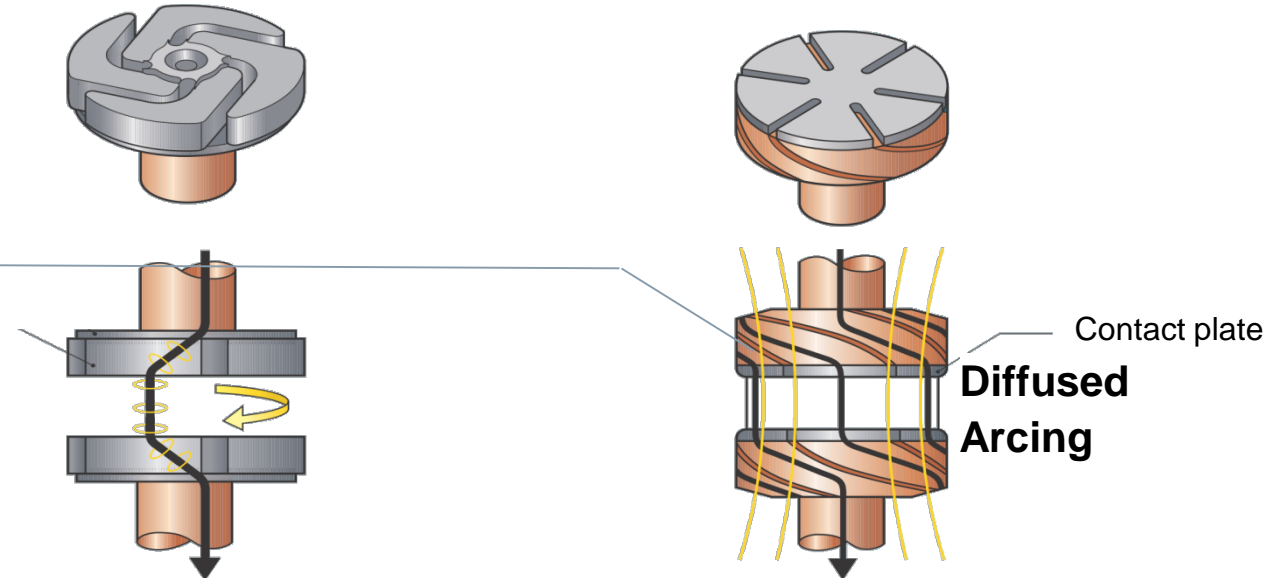


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Radial magnetic field contact (TMF)



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 & voltage ratings.

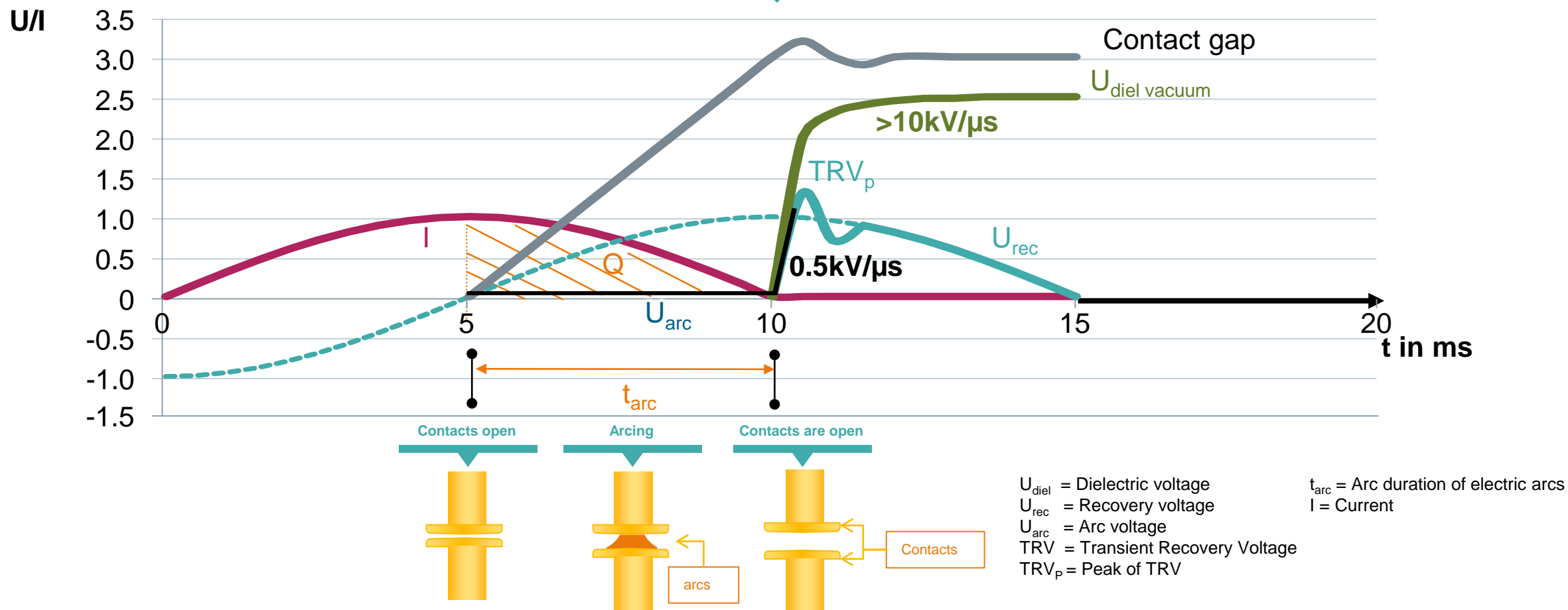
Introduction

Vacuum Interrupters - Principle of vacuum switching



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Extinguishing the arc in the zero point passing



Test ratings and parameters

Current interruption – TRV and RRRV



IEC 62271-100

U_r kV (r.m.s)	Breaker class	K_{pp}	Test duty	TRV _{peak} kV	RRRV kV/μs
12	S1	1,5	T10	2,1 x U_r	1,92
			T30	2,0 x U_r	1,81
			T60	1,8 x U_r	0,81
			T100	1,7 x U_r	0,34
36	S1	1,5	T10	2,1 x U_r	3,13
			T30	2,0 x U_r	2,94
			T60	1,8 x U_r	1,38
			T100	1,7 x U_r	0,57
36	S2	1,5	T10	2,2 x U_r	3,45
			T30	2,1 x U_r	3,33
			T60	2,0 x U_r	1,91
			T100	1,9 x U_r	1,19
145	--	1,5	T10	1,9 x U_r	7
			T30	1,9 x U_r	5
			T60	1,8 x U_r	3
			T100	1,7 x U_r	2



IEEE

IEC/IEEE 62271-37-013

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TRV parameters for system-source faults @ T100

Transformer rating	Prospective TRV		
	Time t_3	TRV peak value u_c	RRRV
MVA	μs	kV	kV/μs
10 – 50	0,58 U_r	1,84 U_r	3,2
51 – 100	0,53 U_r	1,84 U_r	3,5
101 – 200	0,48 U_r	1,84 U_r	4,0
201 – 400	0,41 U_r	1,84 U_r	4,5
401 – 600	0,37 U_r	1,84 U_r	5,0

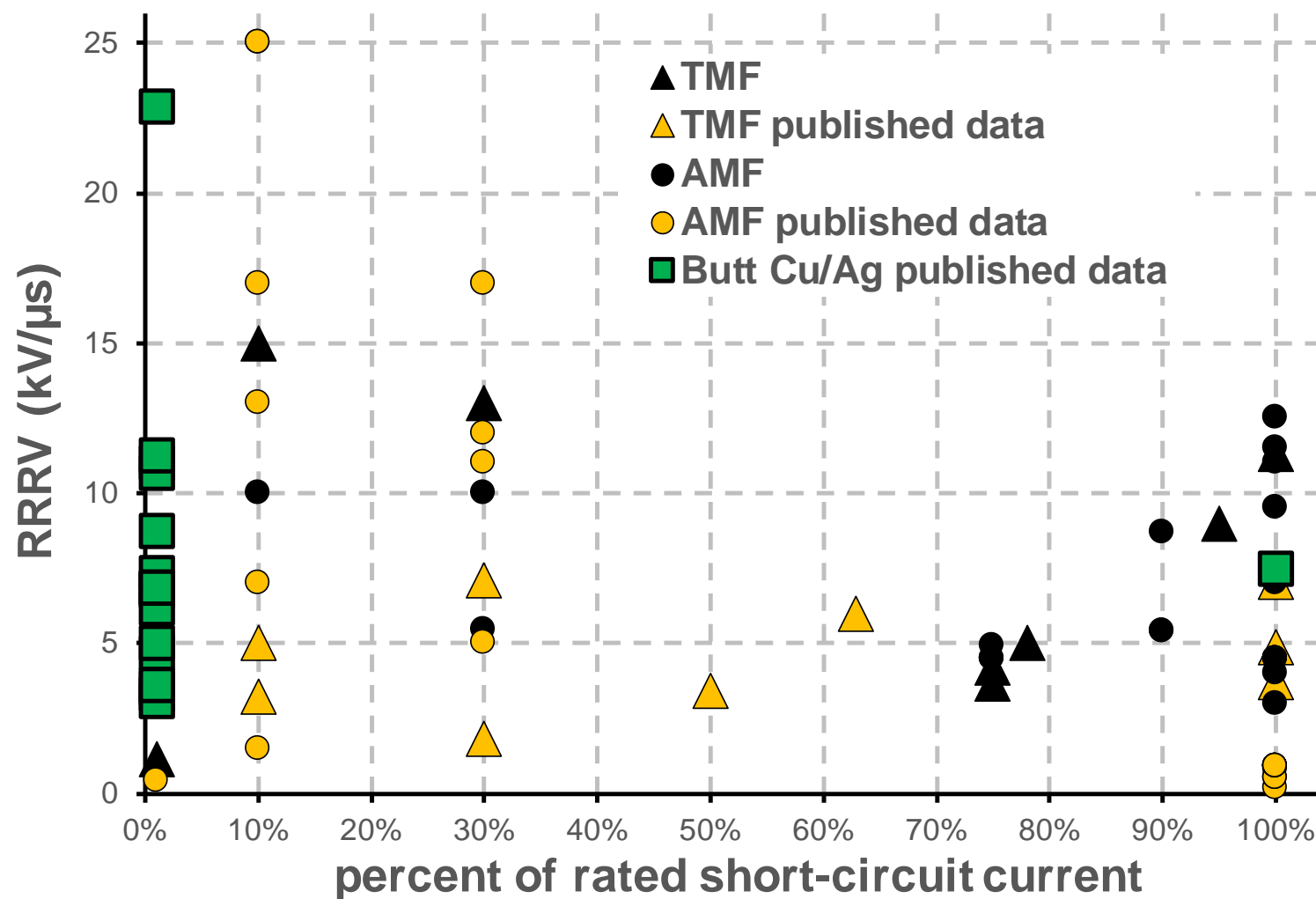
TRV parameters for out-of-phase current switching @ T100

Generator rating	Prospective TRV		
	Time t_3	TRV peak value u_c	RRRV
MVA	μs	kV	kV/μs
10 – 50	0,87 U_r	2,6 U_r	3,0
51 – 100	0,79 U_r	2,6 U_r	3,3
101 – 400	0,64 U_r	2,6 U_r	4,1
401 – 800	0,56 U_r	2,6 U_r	4,7

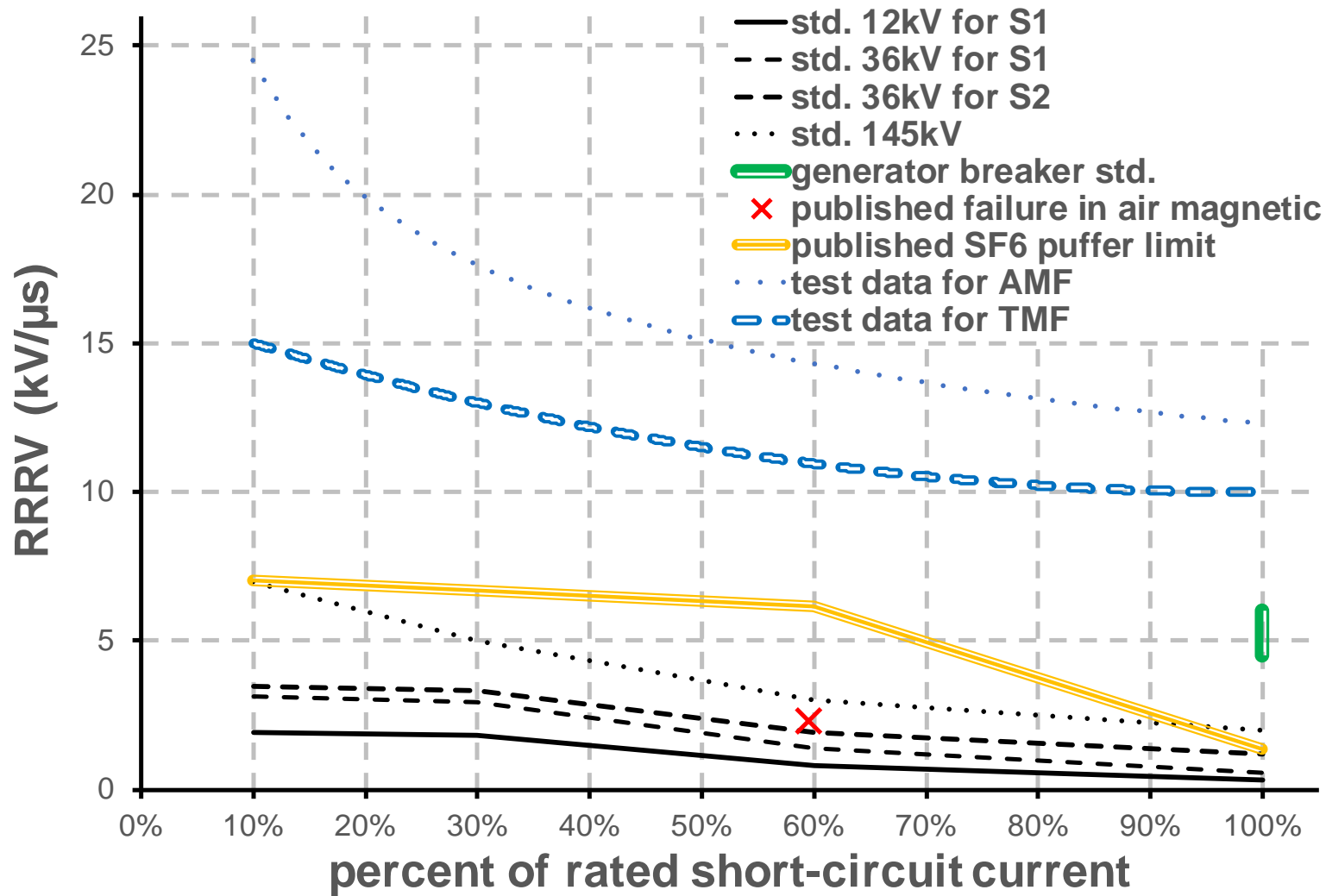
Successful current interruptions of different contact systems



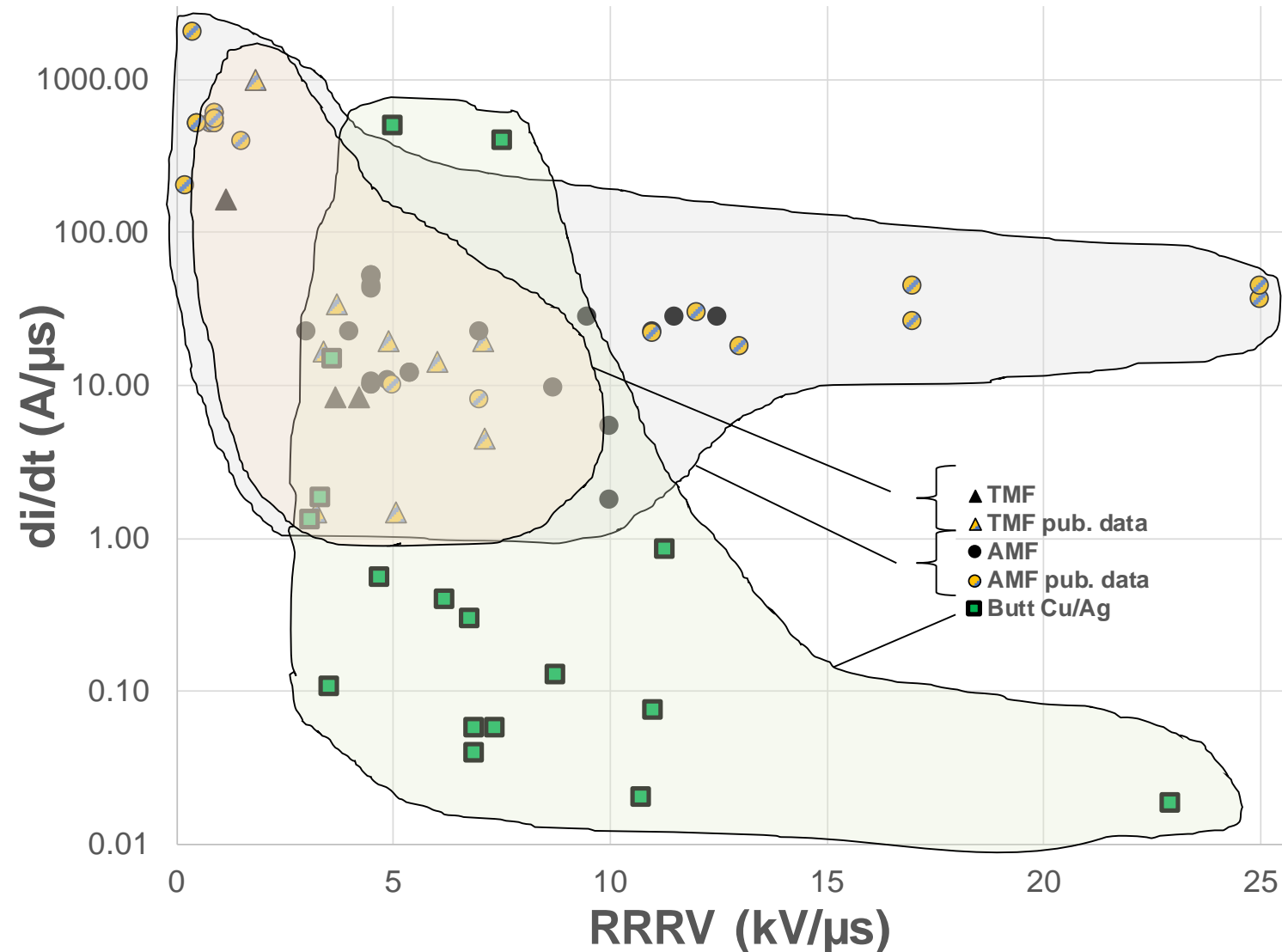
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Known performance compared to the requirement of the standards



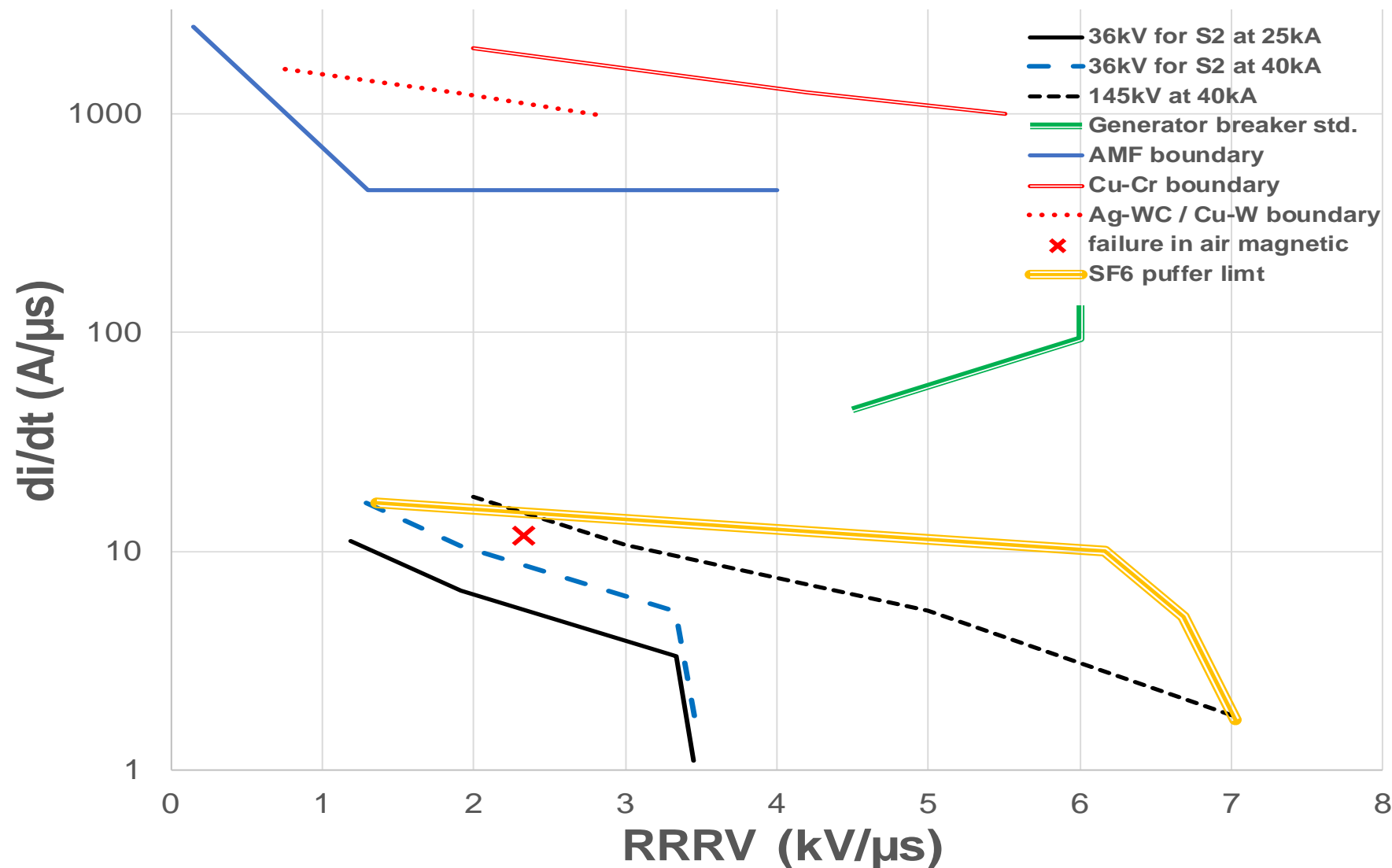
di/dt and RRRV of successful current interruptions



Specific Ratings and performance limits



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Conclusions



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- Concerning the RRRV a performance limit of vacuum interrupters has not been reached yet.
- There is a limit for high di/dt for vacuum interrupters which is of no concern for electrical power applications.
- Only when interrupting DC currents with a counter current it is recommended to stay lower than $450 \text{ A}/\mu\text{s}$ for di/dt .
- Other interrupting media such as SF_6 can require an additional capacitor to reduce the RRRV since their performance is more limited.

Thank you very much for your attention!



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