

Study Committee A3

Transmission and Distribution Equipment

Paper 10848_2022

Switchgear scalability demonstration using environment friendly C4-FN / O₂ / CO₂ gas mixture in 420kV GIS substations

Cyril GREGOIRE, Quentin ROGNARD, Thomas BERTELOOT, Diana LEQUIZAMON, Joël OZIL, Samuel SOUCHAL, Félix BERNARD, Yannick KIEFFEL

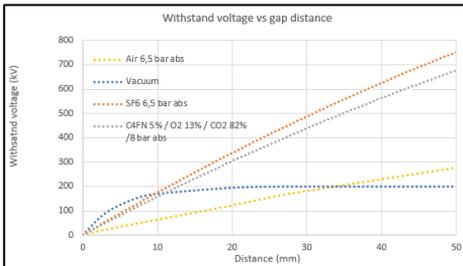
GE Grid Solutions – France

Motivation

- In recent years, extensive work has been done on C4-FN solutions to enlarge equipment portfolio, now covering HV range from 145kV GIS to 420kV GIL with 25 utilities
- To go a step further on replacement of SF₆, work is currently done to achieve the development of a full 420kV 63kA GIS, including the Circuit-Breaker, using C4-FN gas mixture

Technology scalability

- As for SF₆, C4-FN-based gas mixture do not show any scalability limit, in opposite to vacuum
- 420kV single break using C4-FN / O₂ / CO₂ gas mixture already achieved several breaking performances, proving the scalability towards high voltage ranges



Circuit-breaker

lifeGRID
Cleaner energy. Safer future

- The European Commission is co-funding the development of the C4-FN-based 420kV 63kA GIS Circuit-breaker under its LIFE Climate action program called lifeGRID (LIFE18 CCM/FR/001096)



Fast Earthing Switch

- SF₆ design slightly modified to increase and optimize gas flow
- Full interruption achieved in less than 20ms !



Disconnecter

- Experiments were carried to demonstrate bus transfer switching performance of the disconnecter at 3000A.
- Pre arcing and arcing times are stable during the 100 CO, this is the same known behavior as in SF₆



Conclusion

- Breaking and switching capabilities of Circuit-breaking, Fast Earthing Switch and Disconnecter with C4-FN gas mixture have been achieved covering 420kV 63kA GIS application using C4-FN gas mixture
- Equipment keep the same footprint as SF₆ designs.



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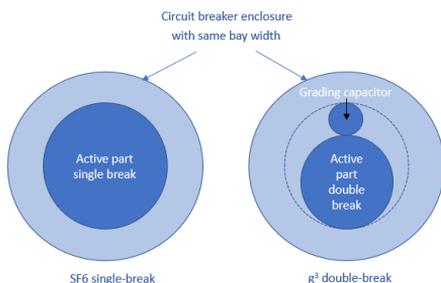
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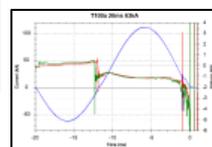
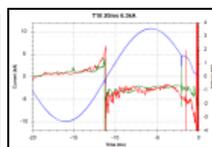
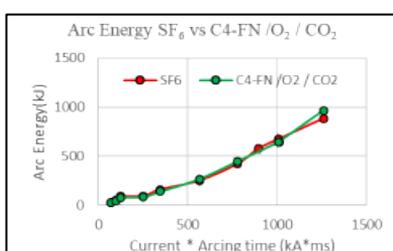
Strategy for the development of a GIS 420kV CB based on C4-FN gas mixture

- Rising need for GIS SF₆-free solutions pushed towards developing one breaking chamber to be used as single break at 245kV and double break for 420kV
- 245kV interrupting unit is more compact, allowing to keep the same bay width as SF₆ single break



Arc interruption behaviour comparison with SF₆

- Arc energy between the SF₆ and the C4-FN (5%) / O₂ (13%) / CO₂ (82%) mixture is very similar: slightly higher (+10%) for SF₆ for the lower current amplitude, slightly lower for the higher currents amplitude.

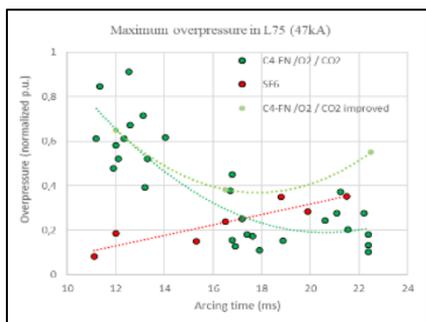


Design adaptation to retrieve similar breaking performance than SF₆

- Higher overpressures arc generally required with C4-FN / O₂ / CO₂ compared to SF₆
- Additional design feature was implemented to maintain higher overpressure on long arcing times

Tests results on GIS CB 420kV 63kV k_{pp} = 1.3/1.5 - C4-FN/ O₂ / CO₂ double-chamber circuit-breaker

- Full dielectric (50Hz / BIL / SIL / BIAS / Vcc)
- T10 / T30 / T60 / T100s / T100a
- L75 / L90
- Out of phase OP2



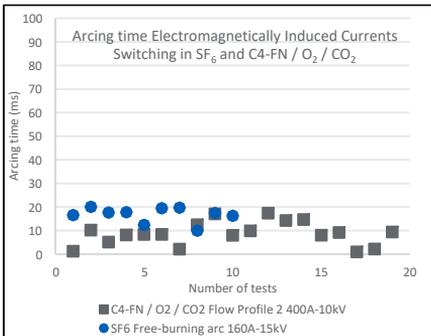
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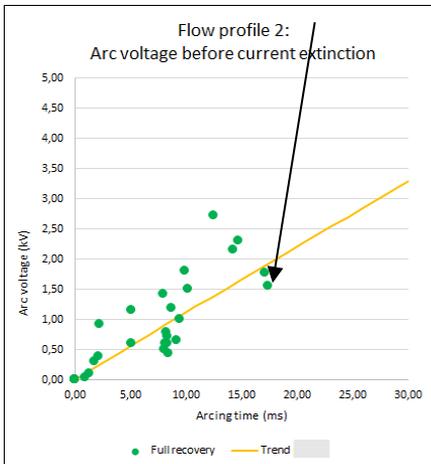
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Fast Earthing Switch

- Experiments were carried at 400A -10kV for Electromagnetic Current Switching of Fast Earthing Switches with C4-FN gas mixture (7 bar rel – gas composition: C4-FN (5%) / O₂ (13%) / CO₂ (82%))
- SF₆ design slightly modified to increase and optimize gas flow.
- Arcing times with C4-FN mixture modified design are lower than SF₆ standard design for harder conditions.



- Full interruption achieved in less than 20ms!



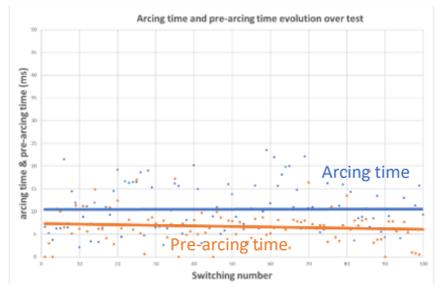
- The modified design does not impact the footprint of the apparatus

Disconnecter

- Experiments were carried to demonstrate bus transfer switching performance of the disconnecter at 3000A.
- 100 Close/Open operations + Voltage Check Condition as per IEC 62271-102 standard.



- Pre arcing and arcing times are stable during the 100 CO, this is the same known behavior as in SF₆



Conclusion

- Switching capabilities of Fast Earthing Switch and Disconnecter with C4-FN gas mixture have been achieved. Both switches kept the same footprint as SF₆ design.