

Study Committee A3

Transmission and Distribution Equipment

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SF₆-alternative 145 kV live-tank circuit breaker

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Summary and motivation

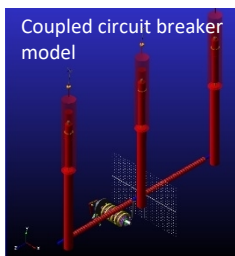
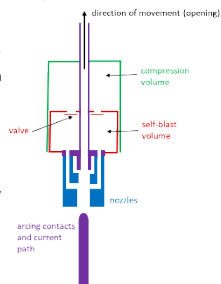
- 145 kV / 40 kA / 3150 A / 50 Hz live-tank circuit breaker using a mixture of CO₂ and O₂ has been developed
- Circuit breaker passed all type tests required by IEC 62271-100 standard
- Changes to arc zone made to address different thermodynamic and transport properties of CO₂ compared to SF₆ (e.g., speed of sound and adiabatic coefficient)
- Gas analysis and toxicity assessment after exposure to high arc energy input demonstrate that resulting gas mixture is not classified as toxic according to Globally Harmonized System of Classification and Labeling of Chemicals

Arc zone modifications to improve CO₂ / O₂ performance

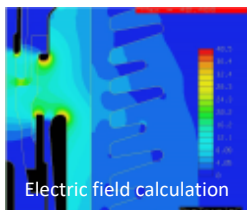
- Increase in gas pressure and increase in contact gap to improve dielectric performance
- Increase in size of compression volume to ensure sufficient cooling gas outflow even at higher speeds of sound
- Double move design implemented to minimize any increase in drive energy

Simulations and FEM analysis

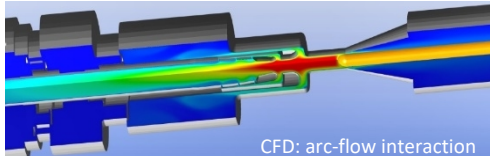
- FEM calculations to determine electric field distribution to optimize contact gap and design of contacts and shields → design with similar margins as SF₆ circuit breaker
- Computational fluid dynamics (CFD) simulations of arc zone coupled to mechanical simulation of circuit breaker → circuit breaker with size and footprint identical to SF₆ circuit breaker



Coupled circuit breaker model



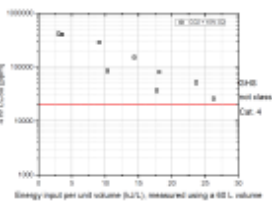
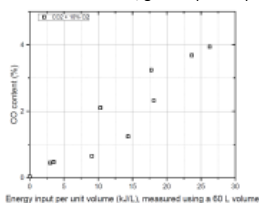
Electric field calculation



CFD: arc-flow interaction

Re-combination of the arcing medium

- As in case of SF₆, almost all CO₂ and O₂ molecules that decompose in the arc recombine once the gas cools
- O₂ ensures CO and solid carbon formation is minimized
- Decomposition products form in low concentrations
- Short-circuit interruptions performed on a model circuit breaker; gas samples acquired and analyzed (FTIR + GC-MS)



Conclusion

- 145 kV live-tank circuit breaker passed all type tests required by IEC 62271-100, launched as product, and installed at sites in several countries
- Gas mixture was analyzed after exposure to high arc energy input and found to be not classified as toxic according to GHS

