

Study Committee C1

Power System Development and Economics

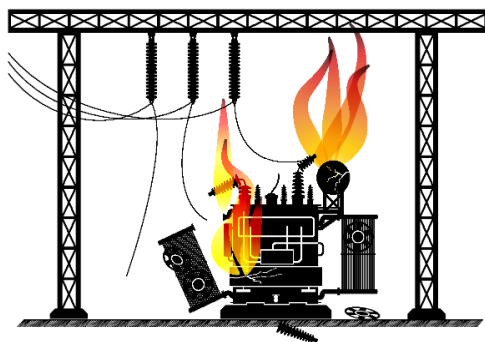
Paper C1 10821_2022

CONCEPTS FOR CONSIDERING ENVIRONMENTAL NEEDS AND PERSONAL SAFETY FOR SUBSTATION DESIGN AND INCREASE THE RESILIENCE OF THE GRID

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Siemens Energy

Motivation



Method / Approach

- Significantly enhanced personal safety,
- Drive to decarbonization (by avoiding e.g., the use of mineral oil and SF₆),
- Avoidance of potential environmental contamination,
- Improved grid availability and performance by sustainable, safe products and components.

New performance levels for transformers, AIS / GIS and components



Simulations and tests beyond standards

- Short-circuit simulation/test
- Seismic simulation/test
- Climate chamber test
- Tank rupture simulation/test
- GIC simulation/test
- Corrosion measurement/test
- Short time current test
- Overload/ Overtemperature test
- Digital Twins

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Technologies for Essential Resilience

- State of the art design tools,
- Static and dynamic simulations which are verified with tests and based on sound material data,
- Composite insulators and reliable components,
- Qualified and approved sub-suppliers.

Avoidance of fire is the best fire fighting system!



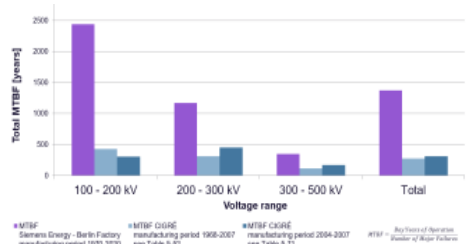
No maintenance for fire avoidance in the whole lifetime!

Switchgear with Essential Resilience

2,700,000 tons of CO₂ equivalent (based on average 12 months full of operation information available in industrial plant)

- 12.5 kV Blue Circuit Breakers, LT (in operation in USA, UK, USA, AUS since 2019)
- 72.5 kV Blue 600 MVA (in operation)
- 140 kV Blue 600 MVA (in operation)
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Switchgear with Essential Resilience



MTBF of an essential resilience GIS in comparison to an average GIS according CIGRE's 3rd Survey WG A3.06 (TB 513)

Technologies for Extended Resilience

Essential combined with alternative insulation and switching technologies. To use no mineral oil, SF₆, F-gas or any other greenhouse gas at all. As an alternative, apply biodegradable ester fluids or insulation which is SF₆-free and has zero-global warming potential.



Technologies for Supreme Resilience

- Validated simulations and the verification by tests, even beyond available standards are the base for special certification,
- This guarantees the highest availability and overall optimized total cost of ownership.



Transformer designed to withstand an internal pressure of more than eight bars and an energy level of more than 45 Megajoules (MJ) - that equals the energy injection caused by approximately 23 dynamite sticks exploding in the transformers tank – without rupture of the tank



Clean Air Vacuum GIS 145 kV / 40 kA / 3150 A / -50°C / 1g

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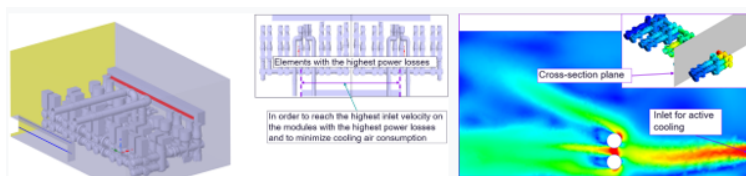
✓ Type tests according IEC / IEEE passed

Voltage: U_1, U_2, U_3	145 kV / 275 kV / 650 kV
Current I_1, I_2	up to 3150 A / 40 kA (3s)
Rated frequency f_1	50 / 60 Hz
Temperature range	-50 °C...+40 °C w/o liquefaction & rating reduction
Class classification	C2, E2, M2
Capacitive performance	LC/CC/BC
Min. nom. current switching operations I_r	10.000 versus SF ₆ -CB typically 6.000
Min. short-circuit current operations I_{sc}	30 versus SF ₆ -CB typically 6
Interrupter- / insulation Technology	Vacuum / Clean Air (synthetic air with 80 % N ₂ + 20 % O ₂) w/o any other chemical substances
First major inspection / Expected lifetime	> 25 years / > 50 years
Standards	IEC / IEEE

☐ Main technical benefits in comparison to SF₆ GIS beside GWP = 0



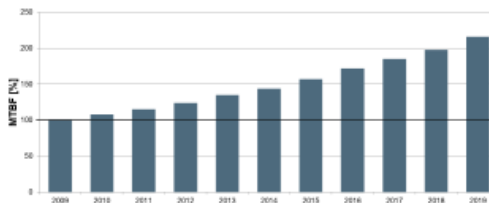
Clean Air Vacuum GIS with supreme resilience: GHG-free; -50°C operating temperature, 10.000 min. nom. current switching operations, 30 min. short-circuit current operations



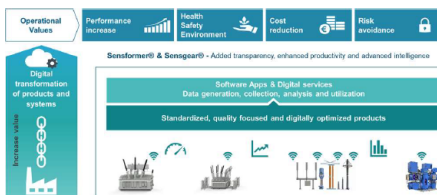
CFD-Simulation set-up and results for Gas-Insulated Switchgear

Conclusion

- Selection of materials and suppliers,
- Digitalization / digital twins,
- Solution for future challenges e.g. climate change, flexibility,
- Low maintenance technologies,
- Reliability / MTBF,
- Enhanced use of simulation methods.



Example of continuously improved MTBF for HV-Switchgear (Mean Time between Failure)



Operational values by connecting reliable equipment with new digital functionalities