

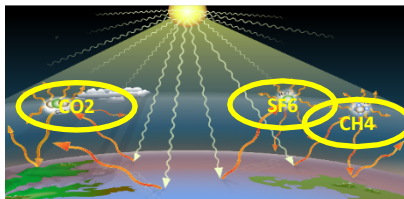
Instrument Transformers and Bushings using alternative and eco-friendly High Voltage insulation systems

Lorenzo GIOVANELLI¹, Udo PRUCKER², Eseddik FERDJALLAH KHERKHACHI³

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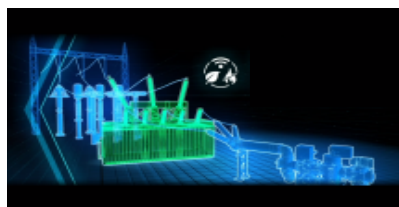
Growing energy markets and increasing decarbonization demands

- Acc to IEA Global energy demand were set to increase by > 4,6% in 2021, Electricity demand is heading for its fastest growth than last 10 years.
- Energy related CO2 emissions were projected to grow by 4,8% in 2021 representing 1500 Mt CO2 eq.
- GHG gazes : CO2, CH4, SF6 are participating to global warming by absorbs and emits radiant energy within the thermal infrared range



Greenhouse gazes (GHG) participating to global warming

- Under the UNFCCC Paris Agreement it was agreed to limit anthropogenic global warming to well under 2° centigrade.
- The goal for Trench Group is to be climate neutral in own operation by 2030.



Digitalization and decarbonization are a must in nowadays power equipment

Innovative solutions for challenging topics

- Beside the increasing demand of electricity, the market requires low impact environmental solutions and equipment.
- Reduced environment impact needs to be considered during the complete value chain : design, manufacturing, service and end of life.
- The ecofriendly solutions must keep high level of performances ,reliability and risk mitigation particularly in applications such as transportation, near population, renewable energies, etc.
- Eco-friendly instrument transformers (ITs) and bushings (BUs) are developed to fulfill all above requirement and ensure network best performances.

Customer's benefits

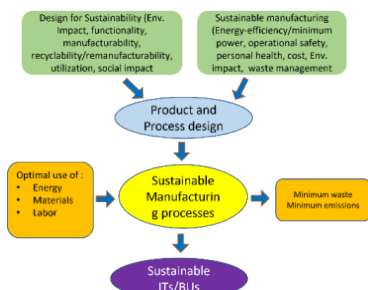
- Fulfill governmental regulations regarding CO2 footprint
- High targeting of CO2 reduction goals is possible
- Better recycling capability at end of life
- Equivalent or better service performances compared to existing insulation systems (i.e. bushings' overload capability)
- Same or even better reliability of existing insulation systems (higher aging resistance)
- Better product environmental footprint of existing insulation systems
- Interchangeability with existing installed fleet guarantee
- No SF6 gas nor mineral oil used as High Voltage Insulation System

Design for sustainability

- The sustainability challenge is considered in all development stages of the ITs and BUs.



Sustainable BUs and ITs direct benefits



Portfolio Available

- Ester insulated bushings up to 245 kV (higher voltages on development) (page 02)
- Ester Insulated instrument transformers up to 550kV (page 02)
- Synthetic Air (Clean Air) instrument transformers and bushings up to 420kV (page 03)

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Ester insulated bushings (CET) key features

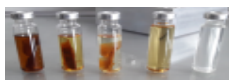
- Increased fire safety thanks to ester higher fire point
- Improved aging resistance due to better moisture resistance
- Readily biodegradable (up to 89% within one month in laboratory conditions)
- No fire risk and no hazardous pollution
- Higher overload capability due to better thermal class **E** of complex ester/paper

CET 72.5	CET 100	CET 123	CET 145	CET 170	CET 245
1.27	1.49	1.27	1.41	1.30	1.30

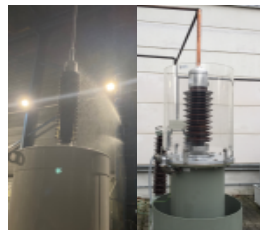
Overload capability of CET bushings based on portfolio temperature rise test (current design 800A)

CET bushing probation process

- Complete type tests acc. to IEC 60137
- Long duration electrical aging acc. to IEC 60505 to on CET 72.5 to draw the lifespan curves of CET bushings (ongoing)
- Dielectric destructive tests to estimate the electrical withstand margins
- Internal arc fault test to verify the self extinguish capacity of ester fluid



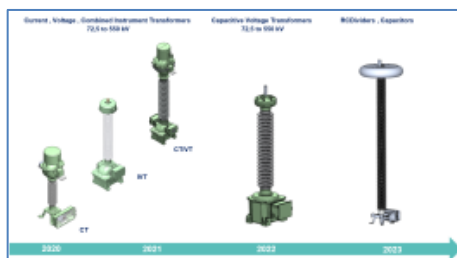
Chemical compatibility of all production materials is approved



Left : Wet dielectric withstand test
 Right: electrical accelerated aging test

Ester insulated instrument transformers key features

- Same electrical & mechanical performances as mineral oil insulated ones
- Same overall dimensions and weight as mineral oil insulated one allows quick and easy replacement of existing installed fleet
- HV Insulation using paper and "readily biodegradable" fluid
- No hazardous pollution risks in case of fluid leakages
- Fire safety thanks to high fire point and self extinguish behavior of ester fluid
- Suitable to be installed also at very low ambient temperature (up to -50°C)
- Type Tests performed according IEC 61869 Standards



Ester ITs development roadmap



Ester insulated Current and Voltage Transformers 170kV installed on Italian Windfarm plant



Ester IT equipped with remote monitoring system

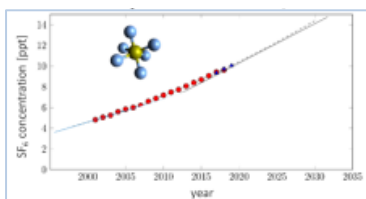
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Growing Market Demand for Decarbonization

- SF₆ is a strong green-house gas with a CO₂ equivalent of 23,500
- Global SF₆ concentration in the atmosphere continues to rise



Global SF₆ concentration in the atmosphere trend

Technical Data

All instrument transformers had been tested in compliance with IEC 61869 and third party witness by an independent test lab

	CTVT Comb1	CTVT Comb2	CTVT Comb3
AC [kV]	230	460	690
RII [kV]	350	1050	1425
CW [kV]	030	1200	1600
SH [kV]	-	-	1050
Ir [kA]	4000*	4000*	5000*
Ir [kA]	90	50*	80*

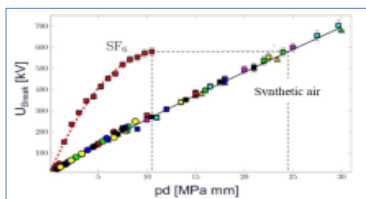
*Normal through HV terminals to core of VT
 AC: Rated power frequency withstand voltage (short IEL), Rated lightning impulse withstand voltage (peak)
 C/W: Clamped surge withstand voltage, SH: Rated to bushing to shielded voltage (peak)
 Ir: Rated to bushing to shielded voltage (peak)



Left and center : Electrical type testing of 420 kV combined and current transformer; Right : 245 kV current transformer during internal arc fault test

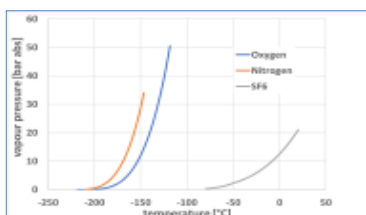
SF₆-free Instrument Transformers

- Same product performance and footprint as SF₆ ITs by increased gas pressure (13.5 bar vs. 5.5 bar abs.)



SF₆ and Synthetic air BIL breakdown voltage comparison

- Reinforced housing compliant with pressure vessel standards
- Explosion proof acc. IEC 61869 protection class II, protection stage 2
- Insulation by synthetic air 20% O₂ + 80% N₂
- Global Warming Potential GWP=0, Ozone Depletion potential ODP=0
- Wide service temperature range -60°C ... +55°C



Portfolio and Service Installations

The first Clean Air insulated IT pilot installation was put into service in June 2018. Meanwhile more than 400 units had been delivered.

