

Take Aways T&D Equipment

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cigre

For power system expertise

Content

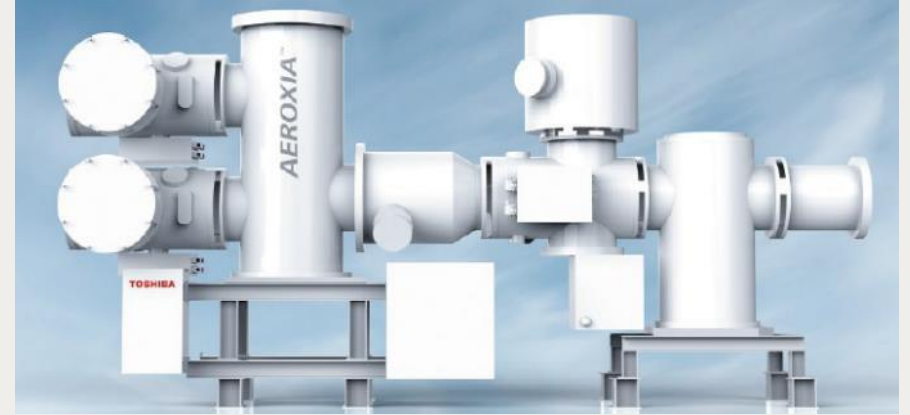
52 reports, 51 prepared contributions

- SF₆ alternatives (35%)
- Instrument transformers
- Controlled switching
- Aerial surveillance of stations
- AM: Monitoring data management, health index
- Digitalization: AI, IoT, digital twin
- Fault current limitation
- HVDC switchgear
- Miscellaneous

SF₆ alternatives workshop

Vacuum circuit breaker tutorial

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72.5 KV F-gas free GIS



18 reports on SF₆-free substation equipment

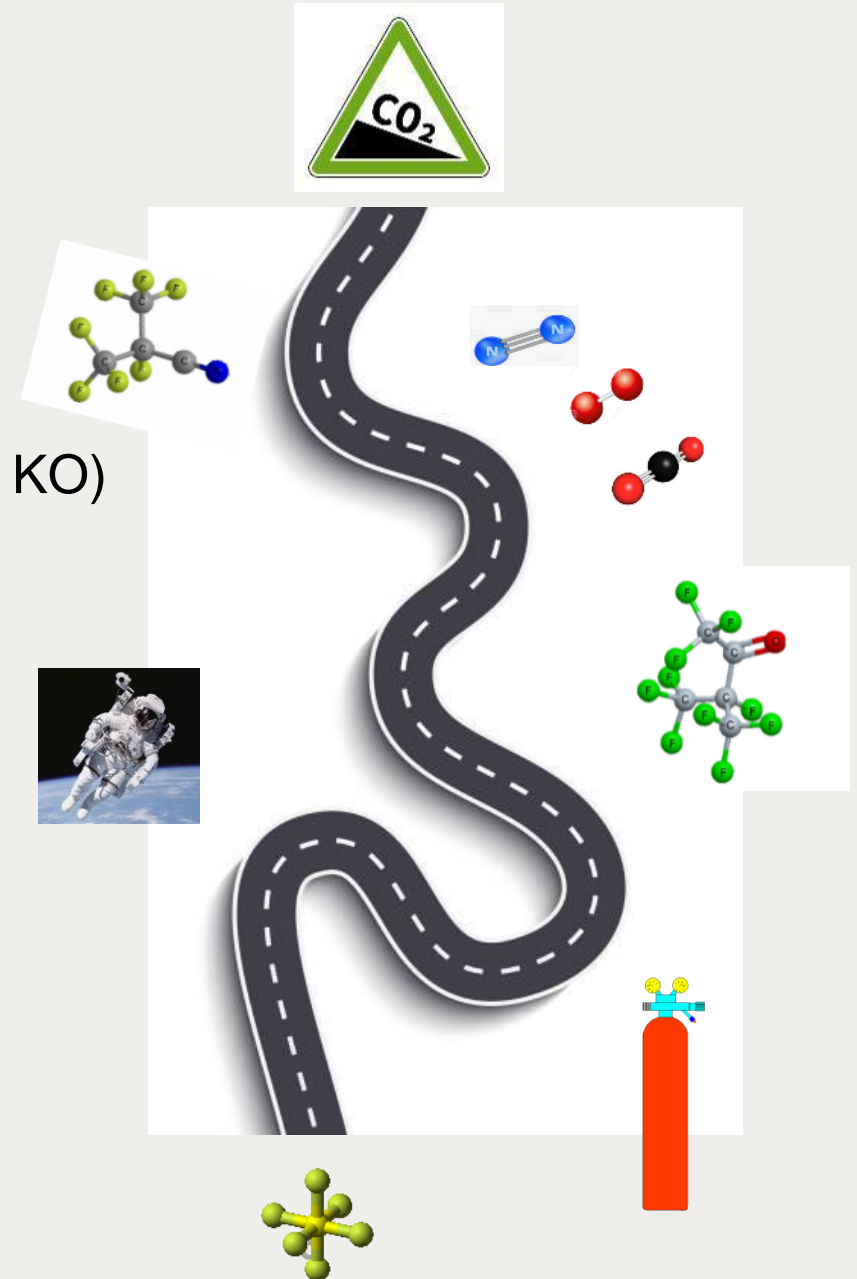
Natural-origin gases GWP < 1

- For insulation of:
 - Transmission assets: GIL @ 420 kV (DE)
 - Instrument transformers: 420 kV (DE)
 - High-voltage vacuum circuit breakers: GIS @ 170 kV (DE, KO)
- For insulation and current interruption: 145 kV CO₂/O₂ (SE)

Fluoronitrile (C4-FN) mixtures GWP 300 - 750

- For insulation of:
 - Transmission assets: GIL @ 1000 kV (FR, UK, CN)
 - Instrument transformers: 420 kV (FR)
- For insulation and current interruption
 - (GIS) HV circuit breakers 245 kV -> 420 kV (FR, KO)
 - MV load break switch (US)

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Natural-origin gases

10657: Pressurized Air Cable (CH)

- Hybrid between GIL and cable, pressurized (≤ 1.1 MPa) air insulation
- AC, BIL and temperature rise testing reported on a 145 kV section
- Novel design of machined flanges eliminates welding and bolting
- 12 - 145 kV products available, scalability is up to 420 kV



245 kV 4000 A

11069: F-gas free equipment experience (DE, DK, UK)

- Reports projects with switchgear (145 kV) and VT (420 kV)
- Extensive comparison between switching/insulation media and regulations
- Has a focus towards application in wind turbines
- Maximum single break vacuum breaker is expected to be 245 kV

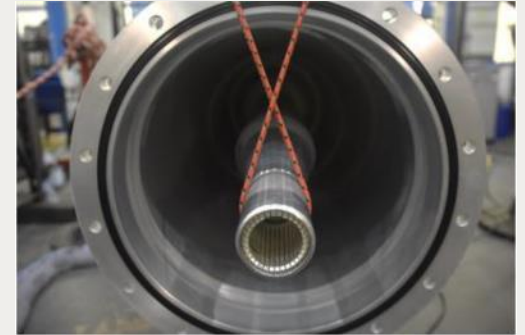


72.5 kV synthetic air insulated
compact wind turbine GIS

C4-FN mixtures

10103: Retro-fill of SF₆ GIB with C4-FN mixture (UK, US)

- Replace 420 kV SF₆ GIS section by C4-FN/CO₂ (20/80%) at 0.45 MPa
- Dielectric tests show comparable withstand as SF₆ filling
- Application limit is -10° C, sufficient for 40% of UK's SF₆ inventory



Straight conductor section of GIB demonstrator setup

10848: Scalability of 245 kV unit for a 420 kV 63 kA breaker (FR)

- 420 kV breaker needs two cascaded 245 kV units with grading caps
- Same footprint as a single-break SF₆ 420 kV breaker
- FES fulfils induced current requirements
- DS confirmed to transfer 3000 A (60% of rated)



245 kV C4-FN breaker

C4-FN mixtures

10658: 145 kV GIS (CH, DE)

- Design modifications needed because of higher sonic velocity of CO₂
- 0.88 MPa_{abs} is needed vs 0.68 MPa_{abs} in SF₆
- Increased contact opening speed needs modified drive systems
- 12% higher temperature rise, but still within the 2017 62271-1 standard



420 kV GIS model circuit breaker

Novel equipment

Superconducting fault current limitation

- 10226: 23 kV / 2000 A, 7 x 3 x 3.3 m, field tested (KO)
- 10357: 220 kV / 4500 A, in grid (RU)



220 kV FCL in Moscow grid

HVDC equipment

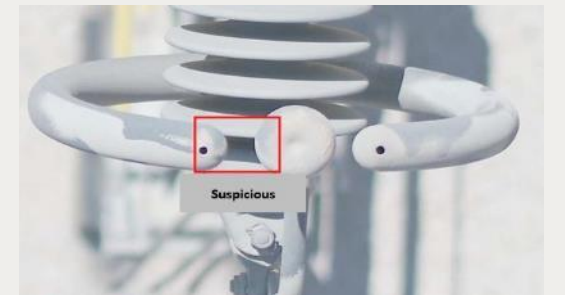
- 10773: Sizing of disconnectors 250 - 1000 kV, input to new standard (FR)
- 10545: HVDC circuit breaker high-power testing 80 – 320 kV (NL)
- 10133: On-line defect id of HVDC wall bushings with machine learning (BR)



800 kV DC disconnector

Aerial surveillance of stations

- 10105: PD sensing through RF by UAV above 400 kV station (UK)
- 11133: Visual inspection deformation > 1 mm of insulators strings (IL)



Insulator observation

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Novel equipment

Instrument transformers

- 10844: Risk-based IT replacement policy needs database (FR)
- 10209: Dry-type 600 kV CT; internal arc after 1 yr compared to oil-filled (CA)
- 10347: LPIT for 145 kV 3-ph GIS based on Rogowski-coil and cap VD (KO)
- 10659: LPIT for 145 kV GIS C4-FN mix SF₆-free (FR)
- 11060: Conventional SF₆-free (technical air) up to 420 kV, 12.5 bar (IT)
- 10950: Transmitted overvoltages in AIS, status and input to standard (CR)
- 10876: LPIT dedicated to controlled switching: high sampling rate (FR)

Controlled switching

- 10660: Implementation of controllers, sensors, EM drives in IEC 61850 (CH)
- 10655: Dynamic dielectric strength of 145, 245 kV at various pressures (CH)
- 10566: For 500 kV shunt reactor in 600 MW PV plant (VT)

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600 kV CT, dry, oil-filled
after IA



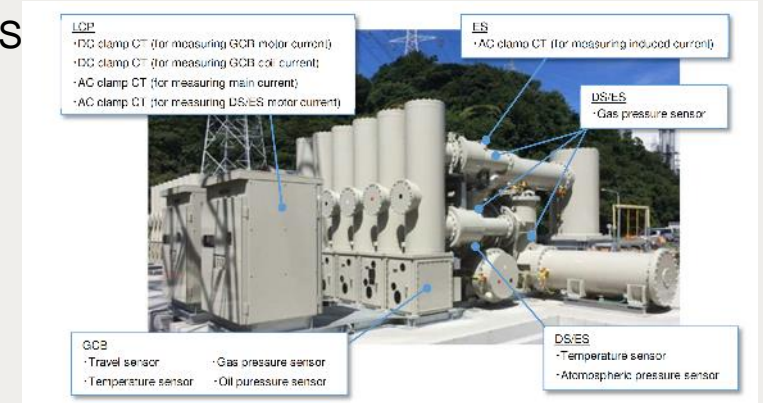
Electronic IT and process bus
in 'digital' station

Asset management

Digital 300 kV GIS

Digitalization

- 10286: Digital twin technology for switchgear O&M (CN)
- 10645: Switchgear CBM by IoT: control current and acoustic (JP)
- 10644: GIS digitization TBM -> CBM; data management; AI based diagnostics (JP)
- 10866: Disconnecter monitoring by wireless temperature, position sensors (SP)
- 10877: Remote commissioning of equipment, M/A/VR, for SAT/FAT (FR)



Temperature sensor in DS blade

Miscellaneous

- 10843: Large study on pollution performance, long-term test suggestions (FR)
- 10132: Station overstress management. Summary of CIGRE TB 816, 2020
- 10134: Real time leakage current measurement of glass insulators @ 230 kV (BR)

