Paris Session 2022

Pretact EcoSafeT Concept

SC A2 – PS2 – Q2.1

What possibilities are there for development of new transformer design concepts? In particular, what prospects are there for development of new insulation liquids with improved properties compared with existing liquids? Also, what prospects are there for development of new dry-type transformer technologies? Finally, what possibilities are there for substitution of sulphur hexafluoride by alternative gases?

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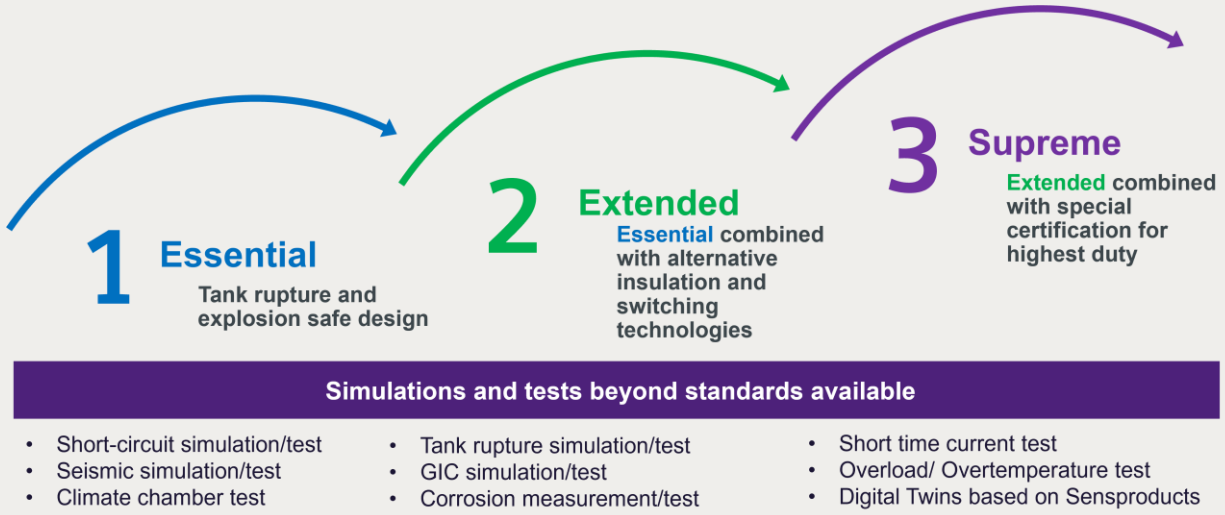
SIEMENS ENERGY

Development of new transformer design concepts

- Focus on an explosion- and fire safe substation. Developing new standards in environment, health and safety to achieve a reliable fire safe solution for the entire substation and all its products.



Conceptional approach to

- significantly enhanced safety
- improved grid availability and performance
- drive to decarbonization (by avoiding e.g. the use of mineral oil or SF_6) and avoidance of potential environmental contamination

Development of new transformer design concepts

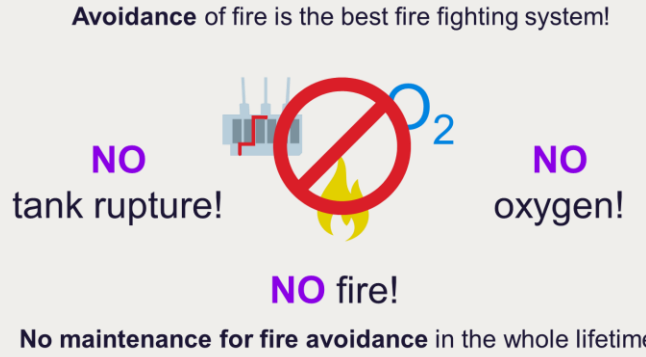
- **Essential – a rupture and explosion safe tank design**

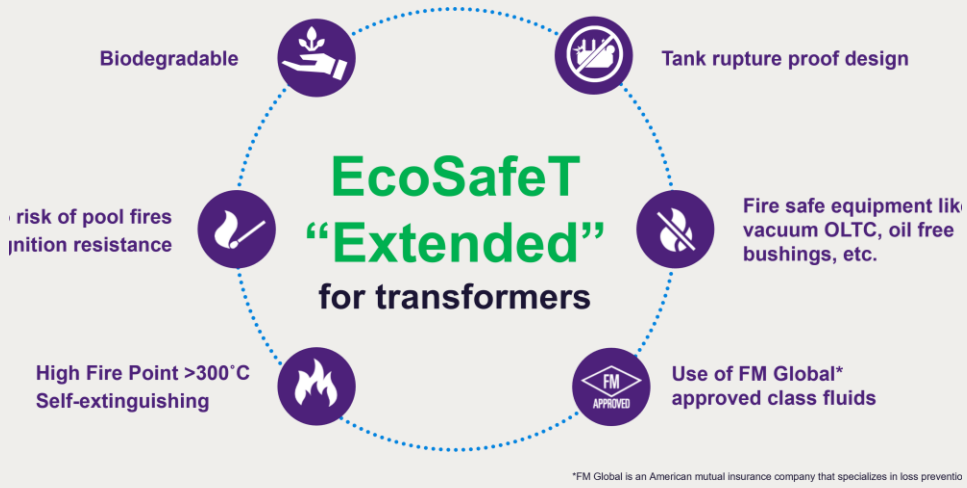
  This level ensures, that nobody will be injured by a rupture or explosion and there will be no release of mineral oil or SF_6 for the defined worst-case scenarios. This safety level ensures that neither the surrounding nor any other equipment will be affected by a worst-case malfunction.

- **Extended – Essential combined with alternative insulation and switching technologies**

  By applying the measures of the "Essential" level, the safety is extended with alternative insulation and switching technologies.

  In addition, the safety aspect is further enhanced by e.g. plug-in bushings in RIP or RIS technology. Therefore, this extended level provides a safe and sustainable solution for the energy supply of the future. Resin-impregnated paper or resin-impregnated synthetic

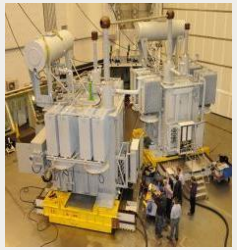


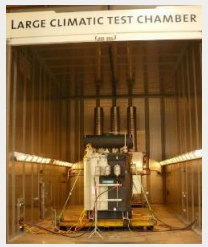


Development of new transformer design concepts

Supreme safety features beyond standards

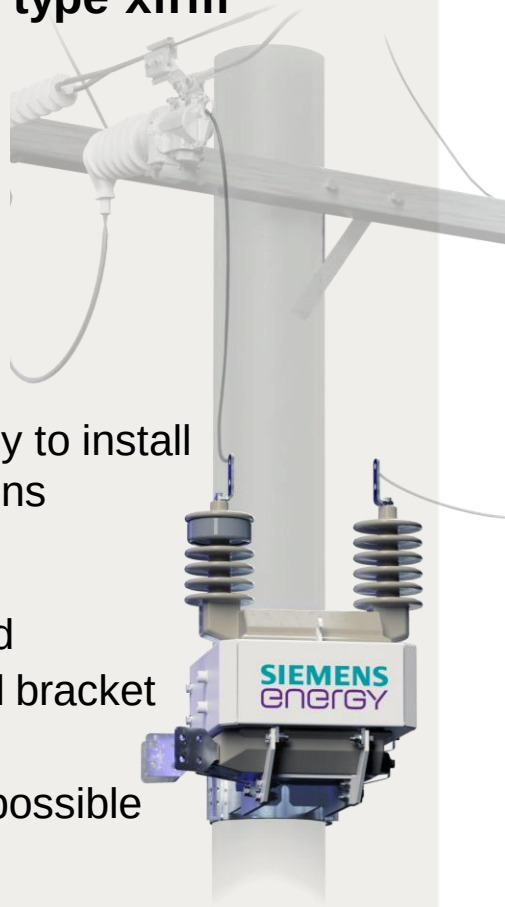
- Short-circuit simulation/test
- Seismic simulation/test
- Climate chamber test
- Tank rupture simulation/test
- GIC simulation/test
- Corrosion measurement/test
- Short time current test
- Overload/ Overtemperature test
- Digital Twins





Group Discussion Meeting

- New application für **pole mounted dry type xfrm**
  - Vacuum casted resin coils
  - Fire resistant
  - Self-extinguishing
  - No oil leaks or spills
  - Recyclable
  - No risk of toxic gas from in case of fire
- Easy to handle – maintenance-free and easy to install
  - Limited to check the vegetation conditions
- Easy installation and grid connection
  - **Direct replacing** of liquid-filled overhead distribution transformers due to identical bracket
  - **Mounting at any angle**
  - **Immediate energizing** after installation possible



A2 – Q2.1: What possibilities are there for substitution of sulphur hexafluoride by alternative gases

Applicable for gas insulated products (except transformers):

- **Intensive research on more than 200 gases was done to substitute SF_6**
  The two most promising options are:
  A) **Natural gases**, like compressed air; switching in vacuum
  B) **Other F-gas-mixes** like Flournitrile

- The number of **SF_6 free installations** worldwide is **growing rapidly.**

- **A full SF_6–free and F-gas-free portfolio based on natural gases** up to 145 kV and Instrument Transformers up to 420 kV is **available and in operation**

For transformers:

- **Ester** solutions are state of the art for the whole product range**.**

	SF_6	Clean Air	F-Gas-mix based on Fluoronitrile
Chemical formular	SF_6	$N_2 + O_2$ (79,5%/20,5%)	C4F7N
CO_2-equivalent / GWP_{100} (100 years horizon)	22.800 (IPCC AR4) 23.500 (IPCC AR5) 25.200 (IPCC AR6 2022)	0	2.100 (Manufacturer data) 2.750 (New in IPCC AR6 2022)
Boiling point (°Celsius)	-64°	< -183°	-4,7°
Life time (years)	3.200	-	30
Carrier gas	Pur or mixed with N_2, CF_4	-	CO2 + C4F7N and in some cases + O2
CO_2-equivalent / GWP_{100}	25.200	0	> 500 based on applications
Boiling point (°Celsius)	<- 64° (variable)	< -183°	-30°...-25°C dependant on C4F7N amount
Dielectric strength	1 (normalized)	~ 0,4	~ 0,7
Arcing impact			
Dissociation/decomposition	~ 2000 K (reversib.)	~ 7000 K (N2 reversib.)	> 920 K (irreversib.)
Decomposition products	HF, SO_2, sulphur compounds	None under normal operating conditions (VIU) If failure: Ozone, NOx	F-Nitrile [4]: HF, CO, COF_2, CF_3CN, C_2F_5CN, C_2F_6 C5-K. [6]: HF, CF_4, C_2F_6, $C_5F_{10}O$, C_3F_8, C_4F_{10},C_3HF_7 C_4F_8, C_4F_6, C_3F_6, C_2F_3N, C_2N_2 in MV GIS with air

Preferred property Compromised property