

Alternative Fluids

Ester insulation for transformers, bushings, coils
and instrument transformers





Alternative fluids on the rise

Alternative fluids are an effective lever to increase sustainability and safety of transmission and distribution products. Natural and synthetic ester insulation is now not only available for transformers, but also for bushings, coils and instrument transformers.

Safety, reliability and a low environmental impact are crucial for energy equipment, especially in large cities or industrial applications. Occupied premises must be safe from the risk of fire or explosion of the installed electrical assets, supply disruption must be avoided by ensuring high network reliability, and environmental considerations are a high priority.

Siemens Energy was one of the first manufacturers to build transformers filled with ester instead of mineral oil. Having started with distribution transformers, small power transformer units were also insulated using ester soon after. The ratings grew bigger, and, in addition to synthetic ester, research and development of natural ester-filled transformers also started.

Today, Siemens Energy and its affiliated companies Trench and HSP are the partners of choice for customers worldwide when it comes to substituting mineral oil. Maybe your transformer, bushing, coil or instrument transformer will be our next project?

Reasons for alternative fluids

When Siemens Energy started using alternative fluids as transformer insulation, customers were usually forced to substitute mineral oil due to external circumstances like

environmental protection, nearby lakes or drinking water reservoirs. Fire safety measures were also sometimes a reason to look for alternatives.

Today the capabilities of esters are almost unlimited, as are the reasons why equipment operators decide to choose these fluids. They are used in almost any application and any location. Their benefits are just as numerous.

As the ageing performance of esters exceeds those of mineral oil, transformers, bushings, coils and instrument transformers filled with ester can be operated at higher temperatures than conventionally filled units. This is also proposed by IEC 60076-14 which includes over temperatures and hotspot temperatures for winding designs using thermally upgraded paper.

Energy equipment operators have been relying on the expertise of Siemens Energy and Trench for decades when it comes to their assets. If you want to lever the advantages of alternatively insulated units as well, you are welcome to make use of our know-how and consultancy services.



Technical benefits of ester insulation

Ester insulation offers considerable benefits to grid operators. They are not only readily biodegradable but have additional advantages due to their specific technical characteristics.

We differentiate between three types of alternative fluids:

- Silicone oil (fully synthetic)
- Synthetic ester (derived from chemicals)
- Natural ester (derived from plant seed oils)

What they all have in common is that they extend product lifetime – if the equipment is designed and manufactured at the highest possible quality level. The degree of polymerization decreases more slowly with alternative fluids than with mineral oil. All the fluids mentioned above have a high capability to remove water from the cellulose insulation of the active part, while their dielectric strength is unaffected by water. Their chemical characteristics also allow for higher temperature limits, which is a benefit when operating any kind of transformer.

Advantages of ester insulation:

- Increase sustainability
 - Readily biodegradable
- Greater fire safety
 - Higher flash and fire point
 - K class rating (IEC 61100 / 61039)
 - Lower gas conversion factor
 - Tank rupture prevention
- Lifetime extension
 - Slower decrease in the degree of polymerization
 - High capability to remove water from cellulose
 - Dielectric strength unaffected by water
 - Higher temperature limits
- Cost savings
 - Lower annual insurance premiums

Technical characteristics of insulation liquids

Type	Characteristics	Disadvantages	Advantages
Mineral oil	Made from non-renewable resources	• Limited biodegradability • Low fire point	
Silicon oil	Fully synthetic	• High viscosity at high temperatures • Poor lubrication properties • Limited biodegradability	• High flash point • Self-extinguishing • High thermal stability
Synthetic ester	Derived from chemicals		• Higher oxidation stability than natural ester • Strongly hygroscopic • Better cold temperature performance than natural ester • Readily biodegradable
Natural ester	Made from plant seed oils (e.g. soya, canola, sunflower)		• Less paper ageing than mineral oil • Higher flash and fire points than synthetic ester • Best renewability for processing • Readily biodegradable

Ester in all product classes

Today Siemens Energy provides ester-insulated transformers for distribution and transmission applications. Its subsidiary Trench offers bushings, coils and instrument transformers filled with ester oil.

The Siemens Energy transformer portfolio filled with synthetic and natural ester oils

Our extensive and in-depth research in our own labs allows us to fill transformers for all kinds of applications and even HVDC transformers with ester instead of mineral oil. As one of the innovation leaders in the transformer industry, we strive to be the first to provide our customers with innovative solutions in terms of ester usage, and we are keen to work with you to meet your challenges in this regard.



The Trench portfolio filled with synthetic and natural ester oils

A growing number of Trench products is already available with natural and synthetic ester insulation. These products are the perfect solution for addressing the increasing demand for sustainable equipment as well enhanced safety requirements.

Ester-impregnated paper transformer bushings

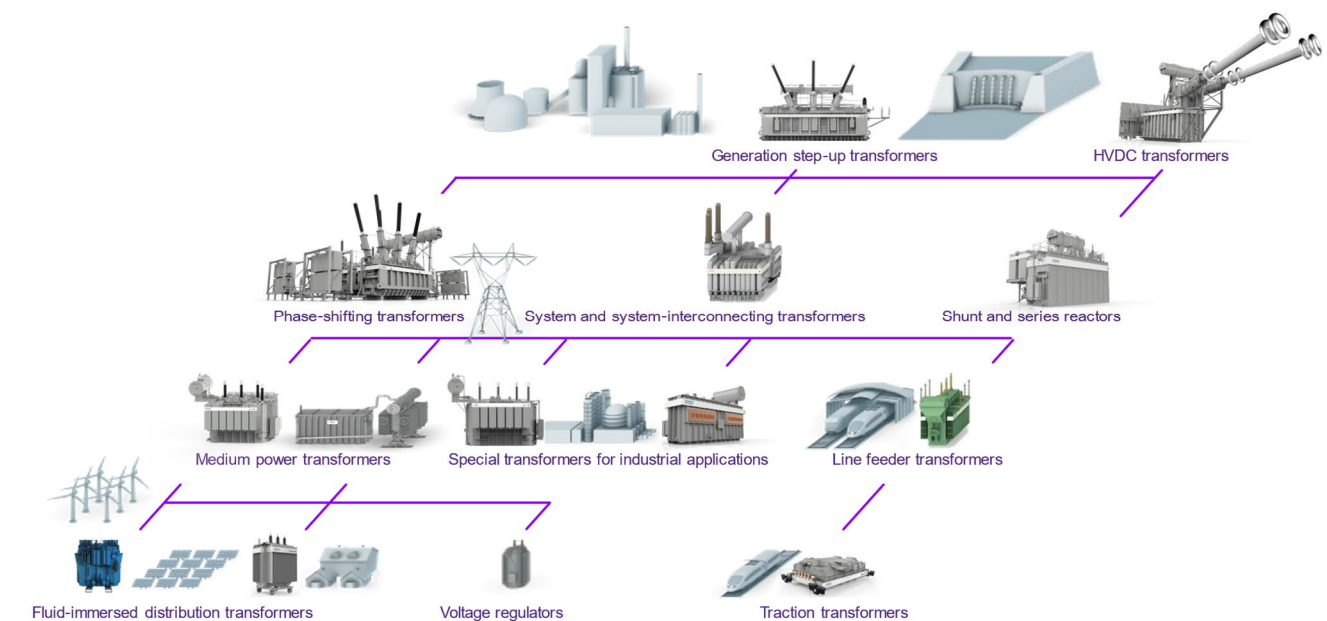
The introduction of ester fluid as an insulating medium in 2020 was the next development step based on the well established technology of oil-impregnated paper. The ester-impregnated transformer bushings are the perfect solution for ester-filled power transformers, providing a unique solution for a full ester application. They can also be installed on conventional mineral oil-insulated power transformers.

Ester-insulated instrument transformers

The new Trench ester-insulated instrument transformers were introduced in 2020, and are based on Trench's long-standing conventional and proven insulation know-how. The use of these instrument transformers reduces the risk of environmental damage in the event of insulating liquid leakages.

Ester-filled arc suppression coils

Variable arc suppression coils provide ideal compensation for earth-fault currents, the most common type of failure in an electrical power distribution network. Trench now also provides these complex products with ester insulation.



Siemens Energy's transformer portfolio with alternative insulation

Selection of references



World's first 420 kV power transformer with natural ester insulation

In 2013 the first 420 kV / 300 MVA transformer with natural ester insulation was supplied to TransnetBW. The use of the transformer in the substation in Bruchsal, Germany, is an essential part of the environmental strategy of the German transmission system operator.

Ratio	405 +/- 11% / 115 / 22 kV
Insulation liquid:	Natural ester
Design insulation level:	
AC induced	630 kV
Lightning impulse	1425 kV
Switching impulse	1050 kV
OLTC:	MR VRC
Total weight:	400 tons
Cooling type:	KDAF/KNAN

World's first phase-shifting transformer with ester insulation

In 2017 this phase-shifting transformer was ordered by a local U.S. utility to control the power flow and rapidly adjust to changes in the power demand in a metropolitan area. The transformer is extremely quiet and meets the particularly high requirements in terms of reliability and eco-friendliness to protect the environment in the unlikely event of a failure.

Ratio	300 MVA 138 ±25°// 138 kV
Insulation liquid:	Synthetic ester
Design insulation level:	
AC induced	145 kV
Lightning impulse	650 kV
Switching impulse	540 kV
OLTC:	MR VRC
Total / fluid weight:	≈ 311 tons / ≈ 86 ton
Cooling type:	KNAN/KDAN



World's first ester-insulated power transformer bushing

In 2020 Trench France launched the first ester-impregnated paper transformer bushing portfolio (from 72,5kV to 245kV). It belongs to the new ester oil bushings product family, has undergone extensive testing and complies with the IEC standard. The product offers customers a biodegradable solution supporting the decarbonization of the high voltage industry.

Um	245 kV
Insulation liquid:	Synthetic ester
Design insulation levels:	
AC (50 Hz, dry)	505 kV
BIL (1.2/50 µs)	1050 kV
SIL (250/2500 µs)	850 kV
Maximum rated current with removable conductor	1250 A
Specific creepage distance (Um)	31 kV/mm



Um = Rated highest voltage for equipment
AC = Power frequency withstand voltage
BIL = Rated lightning impulse withstand voltage
SIL = Rated switching impulse withstand voltage

Published by

Siemens Energy Global GmbH & Co. KG
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For the U.S. published by

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