

Alternative Fluids

Ester insulation for 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.

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 are the partners of choice for customers worldwide when it comes to substituting mineral oil. Maybe your 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 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 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

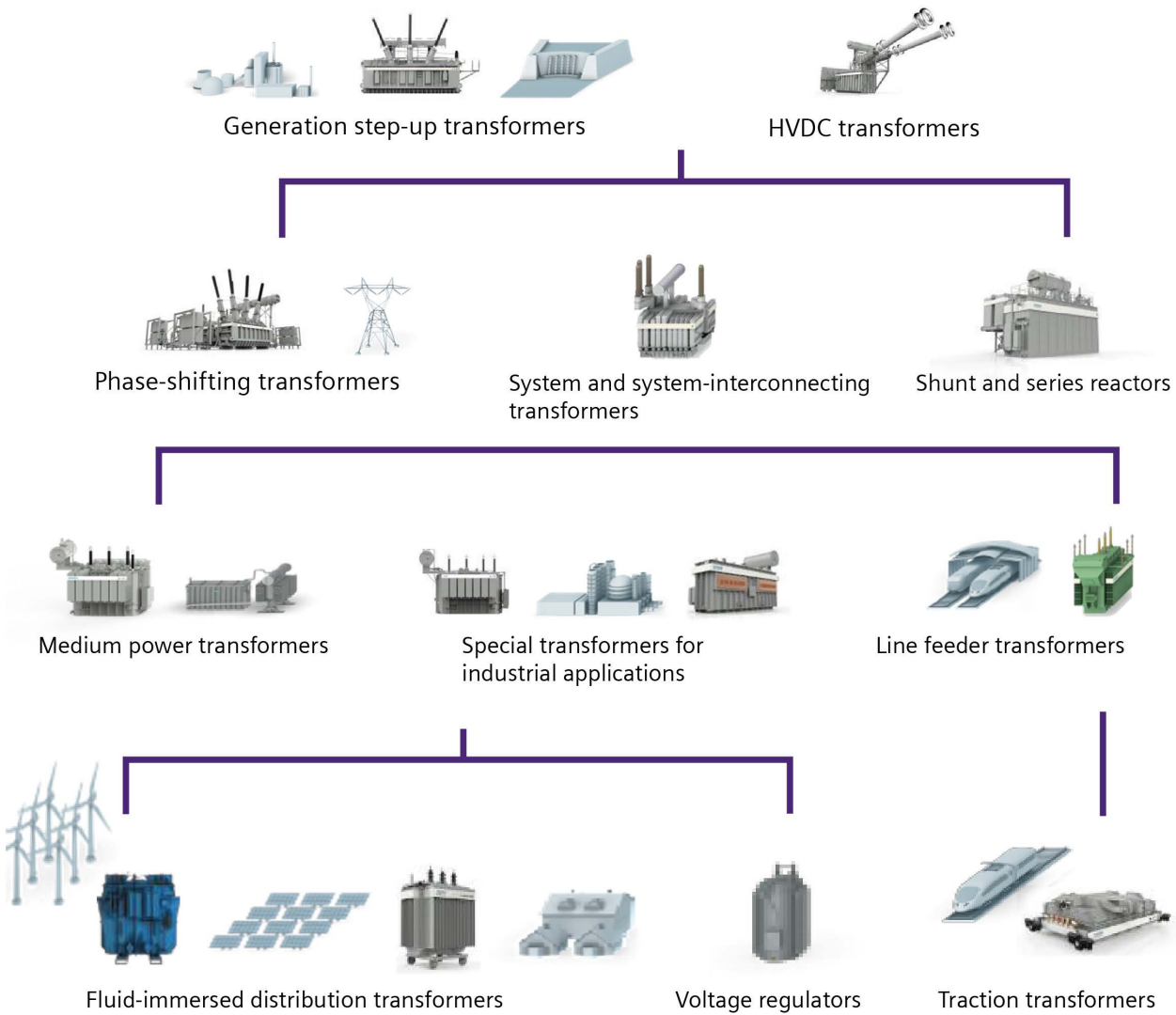
Type	Characteristics	Disadvantages	Advantages
Mineral oil	Made from non-renewable resources	<ul style="list-style-type: none"> • Limited biodegradability • Low fire point 	
Biodegradable mineral oil	Made from renewable or non-renewable resources	<ul style="list-style-type: none"> • Low fire point 	<ul style="list-style-type: none"> • Readily biodegradable
Silicon oil	Fully synthetic	<ul style="list-style-type: none"> • High viscosity at high temperatures • Poor lubrication properties • Limited biodegradability 	<ul style="list-style-type: none"> • High flash point • Self-extinguishing • High thermal stability
Synthetic ester	Derived from chemicals		<ul style="list-style-type: none"> • Higher oxidation stability than natural ester • Higher hygroscopic properties • Better cold temperature performance than natural ester • Readily biodegradable
Natural ester	Made from plant seed oils (e.g. soya, canola, sunflower)		<ul style="list-style-type: none"> • Less paper ageing than mineral oil • Higher flash and fire points than synthetic ester • Readily biodegradable

Ester in all product classes

Today Siemens Energy provides ester-insulated transformers for distribution and transmission applications.

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. 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.



Siemens Energy's transformer portfolio with alternative insulation

Selection of references



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 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

Published by

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

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Raleigh, NC 27616
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