

Q&A

THE ROLE OF ESTER FLUIDS **IN FIRE SAFE, GREENER, BETTER PERFORMING POWER NETWORKS**

M&I Materials combines a long pedigree of established, proven products with a robust research and development ethos aimed at bringing new solutions to market.



Transformer Technology: First tell me about the company itself, its history and background.

Anthony Coker: To put it in context, MIDEL is one of a portfolio of brands owned by M&I Materials, an independent, privately owned British company whose roots can be traced back to 1901. M&I Materials exports to 60+ countries around the globe from our Manchester, UK base and we have an expanding network of international offices and production facilities across the Americas, Africa, Middle East, Europe and Asia Pacific.

Our combination of manufacturing, sales, marketing and technical expertise, combined with our global partnerships with leading universities and research facilities, enables us to help make tomorrow's innovations possible by commercializing materials for demanding applications. The company grew out of a division of GEC Alstom and was established in 1993 as a result of a management buy-out. M&I Materials combines a long pedigree of established, proven products with a robust research and development ethos aimed at bringing new solutions to market.

The company has been producing MIDEL ester transformer fluids since the 1970s, and now manufactures MIDEL in the USA and South Africa in addition to its UK operations. MIDEL is now seen as the world's leading brand of ester-based dielectric fluids and is chosen by utilities and transformer manufacturers worldwide because of its excellent track record and ability to effectively mitigate risk.

As it relates to ester fluids, tell me about MIDEL's initial roll-out as a replacement for PCBs in the 1970s, which were predominant in transformers at that time?

Mark Lashbrook: You're right, the drive to replace Polychlorinated Biphenyls (PCBs) in fire safe transformers was a key driver for the launch of MIDEL, which was patented and first deployed in the late 1970s, actually to refill a transformer in a British Steel facility. Plainly, the toxicity issues related to PCBs meant the industry was looking for a dielectric fluid that was safer to handle. MIDEL delivered that solution, in addition to the further benefits of fire safety, biodegradability and moisture tolerance.

AC: Just touching on that point, I see the market really starting to get the business case for ester transformer fluids. I think it's now accepted that in addition to the benefits Mark identified, MIDEL offers tangible advantages in terms of cost reductions, total cost of ownership and even Environmental, Social, and Corporate Governance (ESG) credentials.

What is the difference between Synthetic and Natural Esters? Is biodegradability the same for synthetic and natural ester fluids?

ML: To be clear, while mineral oil is a good dielectric liquid, it's neither a K class (high fire point) liquid nor is it readily biodegradable. Synthetic esters emerged in the 1970s, followed by natural esters in the 1990s to provide fire safe K class compliance and readily biodegradable status along with superior sustainability.

A synthetic ester is made from carefully selected acids and alcohols. In MIDEL 7131, there are no double bonds in the R chains between carbons (saturated bonds) which increases its oxidation resistance and thermal stability. While being a synthetic fluid, MIDEL 7131 is nevertheless readily/fully biodegradable and fire-safe. It's the premier ester transformer fluid, approved and certified by FM® and UL® - as are MIDEL natural ester fluids.

AC: On the other hand, natural ester dielectrics are produced from vegetable oils, sourced from readily available plant crops. The structure of natural esters is based on a glycerol backbone, to which is bonded 3 naturally occurring fatty acids. In the MIDEL range, there are two natural ester fluids, namely MIDEL eN 1215 (soybean) and MIDEL eN 1204 (canola/rapeseed). The properties of the natural ester, as a transformer dielectric liquid, are affected by the base vegetable oil used to make it, and this affects the oxidation stability of the natural ester as well as its cold temperature pour point. Our technical position is that all natural esters should only be used in sealed systems where there would be no direct exposure to atmospheric air for elongated periods of time.

Responses from:



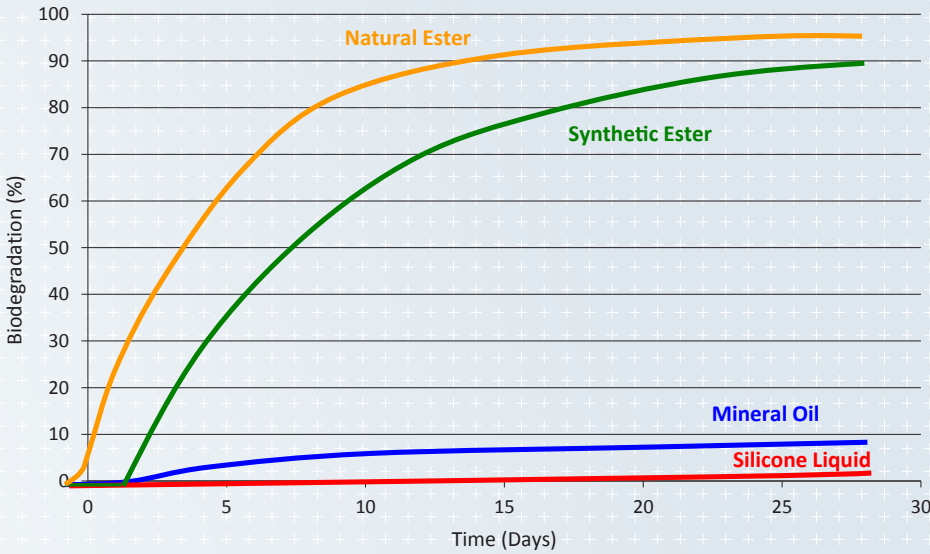
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Ester transformer fluids are now an integral part of the mainstream electrical infrastructure, and that role is only going to expand as more and more forward-thinking OEMs and utilities look to capitalize on the tangible benefits offered by MIDEL ester fluids.

In terms of biodegradability, all MIDEL fluids are fully/readily biodegradable. It's a point more easily explained with this illustration:



Cigré brochure 436, Experience in Service with New Insulating Liquids, 2010

ML: And another key difference between synthetic and natural esters is the pour point temperature. This table helps to illustrate the differences:

	MIDEL 7131 (Synthetic)	MIDEL eN 1204 (Canola)	MIDEL eN 1215 (Soybean)
Pour point	-56°C	-31°C	-18°C

You'll see that MIDEL 7131 is an ideal choice of fluid for transformers placed in cold climates to -56°C. MIDEL eN 1204 operates in temperatures as low as -31°C, and soybean-based MIDEL eN 1215 has a pour point of -18°C. These different pour points, along with an assessment of the low temperature viscosity, can help transformer OEMs and end users choose the ester fluid that will work best given the transformer's ultimate location and operating environment.

The practice of retrofitting mineral oil filled transformers is becoming more common in the US and Canada. Can you tell us how the rest of the world is handling this situation and how MIDEL is involved?

ML: Retrofitting has a long history in Europe, with large projects dating back to the 1990s and is rapidly gaining traction across the rest of the world. We are assisting utilities and other end users in retrofitting projects in the Americas and across Asia-Pacific. The initial key driver is usually a requirement for increased fire safety in an existing transformer, however the ancillary benefits of environmental protection and solid insulation protection are also acknowledged.

AC: A key consideration in asset management, especially when dealing with ageing infrastructure, is whether new solutions can complement existing substations without causing disturbances or power outages. A key benefit of our natural and synthetic esters is they can be retrofilled into existing mineral oil transformers up to 66 kV (69 kV in the Americas), including sealed and free-breathing applications without the unit needing any modifications other than new gaskets and seals. Higher voltage level transformers can be retrofilled; however, the designs would have to be investigated thoroughly for candidacy. Retrofitting is a proven solution that can be performed in situ, allowing networks to upgrade without the end user incurring Capex cost. We have many examples where retrofills were done overnight at commercial sites, with no impact on operations.

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[MIDEL®]
SAFETY INSIDE

There is a growing use of ester fluids in bushings. How is MIDEL involved in this area and where do you see it moving/growing in the future?

ML: MIDEL 7131 has been utilized in the world's first range of high voltage oil filled bushings from Trench. These are a major step forward in technology, allowing users to specify a fire safe ester bushing to accompany their ester filled transformer. We expect to see more developments of this type of technology in the near future and work through our research programs to support this type of innovation.

Regarding increasing urbanization and the rapid growth of cities. What do you see as the role for ester transformer fluids, both natural and synthetic, as an element of risk mitigation?

AC: There's no doubt in the Americas and globally, we are seeing a large urban population growth. City centers, pre-pandemic, are abuzz with construction of mixed use complexes that really pack in the space and the people. With that comes increased pressure on existing – and often ageing – infrastructure, resulting in widespread resource strain and higher maintenance and operating costs. With population density increasing, initiatives to save space and improve safety are now actively pursued. That's where MIDEL is making a real difference in urban substations. Densely populated areas need increased fire protection; MIDEL fluids deliver that protection with a fire point of over 300°C (compared to mineral oil at 170°C). And for some cities, the green attributes are more than just a bonus benefit as they help them address environmental issues and meet their sustainability goals.

Earlier I mentioned the business case for using esters, and here's where it gets really interesting: Esters can also help utilities providers increase network efficiency and reduce overall expenditure. How? Let's look at reducing the substation's footprint. Unlike mineral oil transformers, which require up to 15.2m of distance to the surrounding fire walls, ester fluid transformers can be installed with no fire walls, only 1.5m away from a building (with non-combustible construction). The result is a considerable reduction in both civil construction and land costs. In addition, ester transformers are increasingly being located underground and under buildings in urban areas, delivering significant cost savings and improved aesthetics.

Then there's the question of total cost of ownership. Ester-based fluids can also help to reduce overhead costs through the removal of ancillary equipment such as fire suppression systems, reduction in maintenance and allowing for shorter cable runs due to a smaller construction footprint. This can ultimately help to reduce ongoing costs as well as capital expenditure. Also, less complexity in construction helps bring substations online faster.

ML: There's an important technical aspect to point out here: Mineral oil transformers can become saturated with small amounts of moisture, coming from the external environment or ageing of cellulose insulation, reducing its effectiveness and potentially causing the transformer to fail. Because of ester fluids' superior moisture tolerance, they can absorb larger amounts of that water, without compromising their dielectric properties. The uptake of water from ageing paper by the ester can also significantly extend the life of cellulose insulation, increasing asset lifetime by an estimated 20 percent when compared with mineral oil.

How exactly does ester fluid make it possible to manufacture a smaller transformer?

ML: The high fire point of ester fluids means they can be run at higher temperatures, increasing the amount of power distributed without the need to expand the size and weight of the transformer unit. This also permits OEMs to develop smaller ester-based transformers that produce the same power output as larger mineral oil alternatives, further saving space. This characteristic makes MIDEL ester fluid an ideal component of mobile resilience transformers, when you consider that a lighter transformer with reduced dimensions will be easier to transport around a city or region than a bigger, heavier mineral oil version.



A key benefit of our natural and synthetic esters is that they can be retrofilled into existing mineral oil transformers up to 66 kV, including sealed and free-breathing applications, without the unit needing any modifications other than new gaskets and seals.

Your opinions on the future of ester fluids in the power sector?

AC: As urban populations grow, not only in the Americas but worldwide, the power sector will be challenged with guaranteeing an efficient, safe and sustainable supply of electricity across the grid. Just within the last two months, two utilities, one in the USA and one in Canada, experienced large transformer fires and they happened to be sited next to key waterways. Toxic firefighting chemicals and a deluge of water along with some of the mineral oil made their way into the rivers which are used downstream for municipal drinking water. But the high fire point of ester fluids is only one of the ways to enable transformers to be "sweated" safely. Couple that with the ability to work at an overload of up to 20 percent, and you have assets that can be run harder or for much longer, increasing the efficiency of the fleet.

And here's a new one: ester fluid power transformers can be designed to allow excess heat capture, which is then used for alternative purposes. Think of it as co-gen in a way and this process is not possible with mineral oil, as its low fire point means that retaining any heat would be problematic. For example, I recently toured a new, large inner-city substation in London where MIDEL ester fluids allowed electrical heat losses to be captured to heat water. The resulting hot water was distributed to a local district heating scheme, supplying a nearby school and residential buildings. This groundbreaking advancement enabled the power utility to convert the losses into 1 MW of power per annum and the three transformers involved are rated at 420 kV each.

The bottom line is this: specifying ester fluids in transformers allows advanced networks to be developed that can protect both people and the surrounding environment, cut expenditure on installation and maintenance, and increase transmission and distribution efficiency. Additionally, in many cases where the design includes the benefits we discussed here, the overall lifetime cost of the installation is much lower.

The drive for safer, greener, better performing transformers and substations is now a mandate for power sector planning. I see a clear direction of travel – ester transformer fluids are now an integral part of the mainstream electrical infrastructure, and that role is only going to expand as more and more forward-thinking OEMs and utilities look to capitalize on the tangible benefits offered by MIDEL ester fluids.



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