The demand for HV substations close to, within or even underneath places where people live and work, puts an emphasis on their safety and environmental compatibility in terms of materials, noise, and especially fire

ABSTRACT

As the pressure on substation designers grows in terms of space limitations, cost, and safety, ester filled transformers can offer a useful solution to difficult problems at transmission as well as distribution voltages.

KEYWORDS

ester liquid, low fire, compact, substations

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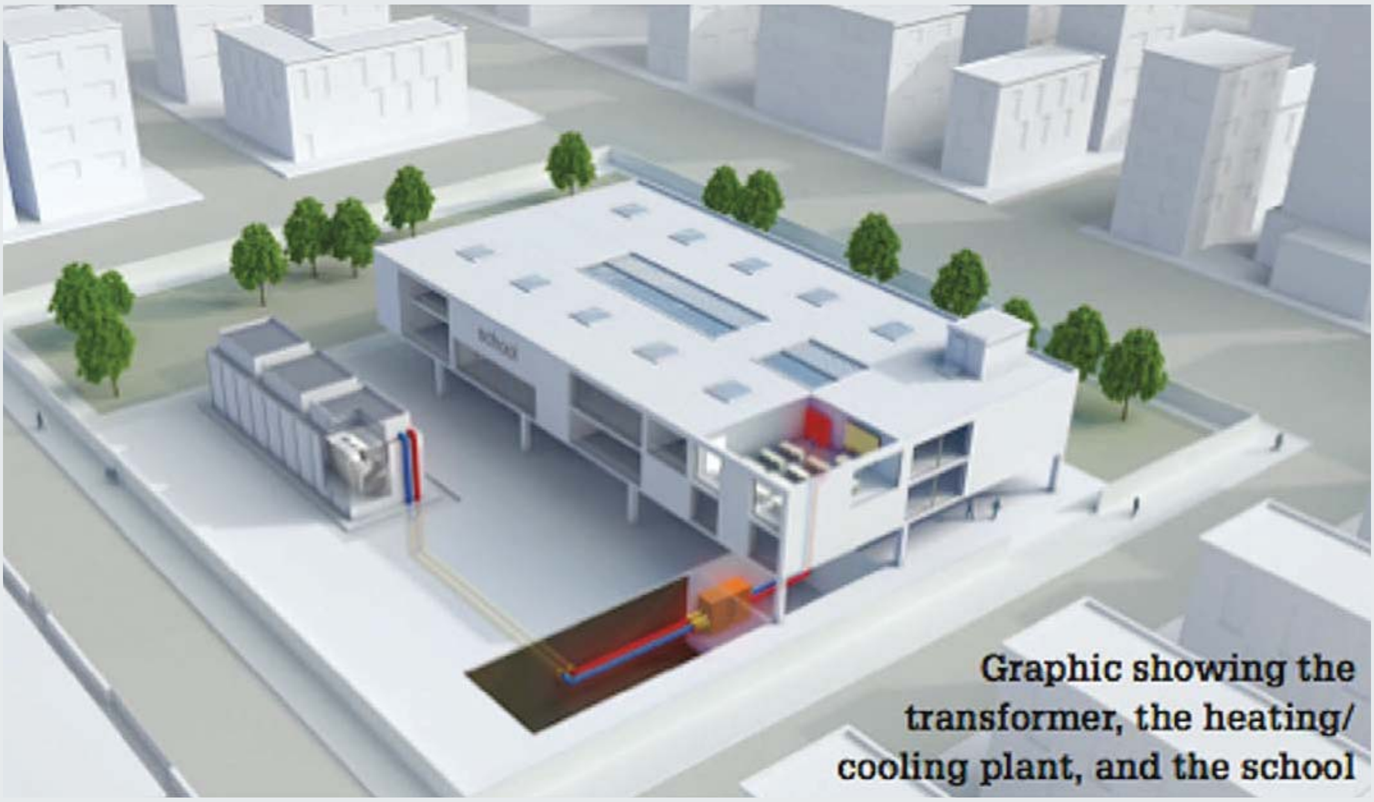
The advantages of ester liquids for substation design



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Companies and substation designers can be faced with the need to place equipment where even the small possibility of an oil fire cannot be tolerated

The global trends of increasing urban populations and the push to decarbonise heat and transport even against a background of increasing energy efficiency are creating a demand for compact high voltage substations close to, within or even underneath places where people live and work. This in turn puts an emphasis on the safety and environmental compatibility of the substation in terms of materials, noise, and especially fire.

Companies and substation designers can be faced with the need to place equipment where the possibility, however small, of an oil fire cannot be tolerated. Solutions tend to be expensive, either in terms of the technology or the mitigation measures required, when compared to a conventional substation site where these issues are less important. Drastically reducing the fire risk by the use of ester liquids in otherwise fairly conventional transformers, can efficiently solve these issues for high voltage substation installations. Increasingly, utilities responsible for substations in large cities such as London, New York, and Mexico City are using this technology to capitalise on this advantage. Compact substation designs often involve switchgear and other components above or close beside the transformer with a cable basement and cable tunnels below. This is an environment where the spread of an oil fire could easily cause substantial damage making the design of containment and suppression particularly difficult, especially considering the possible energy release in a failure and that the space available for effective suppression systems is also limited. The use of a low fire liquid under these circumstances, which is now a proven option, certainly reduces the risks and has the potential to reduce the costs of mitigation.

Substantial concrete transformer bunds are often installed in substations to limit the fire pool and spread of burning oil in the unlikely, but possible case of a transformer failure, causing both a release of oil and a fire. To do the job, these bunds must be capable of retaining the full quantity of oil in the transformer plus any rainwater and fire fighting water for a significant period (sometimes hours) at temperatures high enough to melt steel. A secondary function of such

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a bund is to contain the liquid even if there is no fire. Of course, the consequences of failure to do this are to be avoided, but they are not on the scale of the losses if a fire is not contained. Ester liquids can help simplify bund design firstly because fire resistance is usually no longer a priority and secondly, the biodegradability of the liquid means that although off-site contamination must be avoided, bioremediation of small leaks and less substantial substation rather than individual transformer bunding solutions can be contemplated. Indeed, a certain change of thinking is enabled and required with ester liquids when considering containment, as the behaviour in the environment is not at all like oil, it is maybe better compared to the glycol frequently used in cooling systems.

Another trend that looks set to gather pace is the need to install additional liquid filled equipment at substations to accommodate new connections to devices such as vehicle charging stations and battery storage systems. It is often convenient to install this equipment close to existing plant. Rather than having to maintain conventional fire pool separations, the use of ester liquids can allow much closer proximity, provided of course that the loss of the new equipment, should the existing equipment catch fire, can be tolerated. This is usually the case.

A similar argument exists for the use of ester liquids in mobile and emergency transformers, where the need for temporary bunding and fire protection can be reduced or eliminated whilst significantly reducing risks. If ignited oil from a failed uncontained mobile unit were, for example, to enter cable troughs, then the consequences could be significant.

Once you have a transformer installed in a city or other situation where heat can be used nearby, heat recovery becomes an option. It is not economic to do this at the expense of the transformer life and it cannot justify using a transformer with a lower electrical efficiency, but the potential for slightly higher operating temperatures offered by ester liquids can make this viable without needing heat pumps.

Ester liquids provide some very interesting options that can make substation design feasible and economic in a variety of circumstances and deserve consideration in the early stages of planning

The low fire and biodegradability of ester liquids make them an attractive choice for offshore substation design, a significant industry as offshore wind takes an increasing share of the energy market. The reduced weight available, when fire containment is not required and liquid containment can be greatly simplified, has great value in platform design.

In short, ester liquids in transformers provide some very interesting options that can make substation design feasible and economic in a variety of circumstances and deserve consideration in the early stages of planning.

Author

Paul Jarman was born in London and graduated from Cambridge University in 1984 with a degree in Electrical Science. After 6 years in research looking at bushing condition monitoring and transformer frequency response analysis for the CEGB, on privatisation of the industry in 1990 he transferred to National Grid as a Transformer Engineer becoming Head of Transformers in 1998. From 2001 to 2018 Paul was National Grid's Technical Specialist/Manager for transformers. Paul was chairman of IEC TC14, the international committee for power transformer standards from 2009 to 2017 and was the UK regular member of CIGRE study committee A2 for transformers 2008-2016. He is a chartered electrical engineer and member of the IET. Since January 2019 Paul has taken up the position of Professor of Electrical Power Equipment and Networks at the University of Manchester on a part-time basis and is also a part-time Applications Engineering Specialist for M&I Materials manufacturers of Midel Ester liquids.