

POWER PANEL DISCUSSIONS

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Navigating the Transformer Boom: Advanced Insulation Solutions for a High-Demand Era



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The global transformer industry is experiencing a period of unprecedented high demand, driven by electrification, the rise of AI data centers, and the urgent need to modernize an aging grid infrastructure. This surge has extended lead times for new transformers to years, not months, creating significant challenges for manufacturers and utilities alike. Against this backdrop, the selection of insulation materials—both liquid and solid—has become more critical than ever, as specifiers seek solutions that enhance reliability, safety, sustainability, and efficiency.

To explore these challenges and the advanced insulation solutions available, a panel of experts convened in the latest [Transformer Technology Power Panel](#) to share their insights.

The panel featured Bruce Forsyth, Director of Global Application Engineering for Cargill's Power Systems; Evanne Wang, Applications Development Specialist for DuPont Nomex; and Thomas Norrby, a chemist and expert from Nynas, a major supplier of transformer oils.

The State of the Transformer Market: A Sustained Boom

The panelists unanimously agreed that the current market conditions are unlike anything they have seen before.

"This is a very busy time for the transformer industry," stated **Bruce Forsyth**. *"Over my career, I've seen the business go up and down, and I've*



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never seen it quite like this. We have such a high demand, and the long-term forecast appears to be strong for an extended period of time... It's a unique challenge for manufacturers to meet the demand. It's also a challenge for the users who need the transformers and need to forecast so far in advance to be able to get orders in place depending on the size of the transformer and deal with the lead times that are present right now."

Thomas Norrby echoed this sentiment, adding that the intense demand is leading to *"unusual practices, such as the hoarding of components and even finished transformers"*.

A new transformer could be available in 2030 or even 2032," Norrby explained. *"We also see*

hoarding of finished transformers... they are sitting in a limbo after factory acceptance testing. My personal feeling is that this will run on for decades because in earnest, the electrification is just starting to bite in our industry. We see very ambitious programs for offshore wind, for example, across Europe. This will take a long time, so sustained high demand is a real total change."

Evanne Wang confirmed that the demand extends to material suppliers and pointed to other pressures facing the industry.

"We're seeing an increase of demand in materials as well, but we actually anticipated this growth," Wang noted. *"And to add to what Bruce said, we brought on additional manufacturing capacity*



several years ago to support this rising demand for solid insulation materials. Some of the challenges that we're seeing today is an increase in the cost of raw materials, particularly the metals. Steel and copper are rising significantly. Add to that, we are also looking at some geopolitical uncertainties that are impacting global supply chain, increasing the cost overall."

The Evolution of Insulating Fluids

The conversation then shifted to insulating fluids, a core component of transformer design for over a century. Mineral oil has long been the industry standard, but the landscape is now populated with alternatives designed to meet modern challenges.

Norrby provided a historical perspective on how intertwined the development of transformer oils is with the growth of the electrical grid itself. He noted the distinction between fluids for large transmission transformers and the more diverse fluids used in smaller distribution units. The design space, power loading, and winding

geometry dictate the degrees of freedom for using different fluids.

Forsyth detailed the push for alternatives, driven largely by safety concerns.

"One of the challenges with mineral oil is that we periodically, unfortunately, see that they can catch on fire," Forsyth said. "Over the years, that's been addressed in different ways; high temperature liquids were identified, and we generically refer to them as askarels. But then we realized that askarels are carcinogenic and by and large, I think they've been banned since about the 1970s. Synthetic esters were produced, I believe, in the '70s. In the '90s, natural esters were introduced."

These alternative liquids, particularly esters, offer higher fire points, reducing fire risk, and often provide environmental benefits like biodegradability.

"Most of these alternative liquids will have higher fire points, and so the risk of fire is reduced,"



Forsyth continued. *"That's probably the most common reason that customers might be interested in looking at an alternative liquid, to get something with a higher fire point and reduce that risk of fire. But as I said, there's also an environmental consideration."*

Strengths and Weaknesses: Choosing the Right Fluid

The panel agreed that no single fluid is a universal solution; the best choice depends on the specific application. Wang, representing a solid insulation manufacturer, offered her perspective on the trade-offs.

"Mineral oil is great. It's convenient, it's affordable, but it's thermally limited," she commented. "In my personal opinion, I think using some alternative fluid such as esters has a lot of benefits. Like Bruce said earlier, they're biodegradable, which as we shift towards a more sustainable energy usage, that is great. Most of your ester fluids also have a higher thermal class, which will allow you to design more compact transformers."

Wang highlighted data centers as a key application for ester fluids, where building codes and safety requirements are stringent. She also stressed the importance of viewing the solid and liquid components as an integrated system.

"It's important to understand and to do the testing so that we know the thermal performance of an insulation system," Wang stated. "For example, like Nomex, which is the insulation that we produce, is rated at a certain temperature with mineral oil, but Nomex with an ester fluid has an increased thermal class, which may not be the case for every single solid and fluid combination."

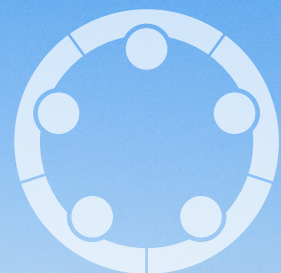
While esters offer high-temperature performance, Norrby presented a different philosophy focused on cooling efficiency.

"Our focus is on superior cooling and running a large transformer at a minimum gap above ambient," Norrby said. "The load losses are very critical, especially with the larger the transformers are and every degree above ambient is waste. A completely different philosophy is to look at



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Bruce Forsyth





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how you can make the transformer run cooler, not hotter. That's our value proposition."

Forsyth emphasized the opportunity that high-temperature materials present for transformer designers.

"One of the things I would like to see the industry move towards is more acceptance of higher temperature designs," Forsyth urged. "We have high temperature insulation solids, aramids, etc, as well as high temperature liquids that can operate at higher temperatures. That might not be the best solution for every application, but it gives an opportunity to make a smaller transformer when that is important... I think if you give the freedom to a transformer designer to operate at higher temperatures... you'll get the optimal design out of the transformer."

The Challenge of Specification in a Complex World

Today's specifiers face a dizzying array of demands, from reliability and resilience to sustainability and environmental impact, across applications ranging from traditional transmission to distributed energy resources and data centers.

Forsyth advised specifiers to start with established IEEE and IEC standards but to go

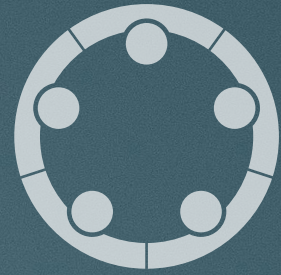
further by detailing the specific operating environment.

"I've always recommended first of all to start with those default standards. But remember that those are default standards," he explained. "It's also very important then to include the geographical issues for the user to say, this is the actual application where this transformer is going to be used'. If a transformer designer knows that the transformer is going to be in a desert or in a very cold climate, then they can factor that into their design decisions."

Norrby underscored the extremely high expectations for grid performance, noting there is little room for error.

"The requirement for uptime is all 100% relying on steady, high-quality electricity. The room for mistakes is smaller than ever, I would say," Norrby remarked. "There's no forgiveness whatsoever. You can't say, 'Oh, the other engineering was a little bad or, sorry, we picked the wrong insulation.' It is a delicate, important, critical business decision."

Wang illustrated this point with the stringent requirements for data centers, where reliability is paramount.



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Evanne Wang

"Data centers fall into tiers: The higher the level of the tier, the more reliable the data center should be," she said. "A Tier 4 data center is the highest possible rating. This is for businesses where downtime is unacceptable. A Tier 4 data center is only allowed two minutes of outage per year."

Final Thoughts from the Experts

As the discussion concluded, each panelist offered a final thought on their company's value proposition in this dynamic market.

"Nomex is paper. In particular, it's a high temperature insulation system," said Evanne Wang. "Our team will work with designers to optimize their design, whether that's with mineral oil, or whether that's with an alternative fluid. We have a global presence, so we are able to supply OEMs globally."

"Cargill's flagship product is FR3fluid," stated Bruce Forsyth. "FR3 is a sustainable alternative liquid that has a higher fire point than mineral oil. We can address the concerns about fire point, and it's biodegradable. It can also extend the life of cellulose insulation. And when we're operating with high temperature materials, like aramid insulation, we can even operate at higher temperatures and get more power density out

of the same footprint, which is, I think, the direction that the industry needs to move to."

"Our challenge is to be a provider of solutions for the transition to a sustainable society," concluded Thomas Norrby. "We have the large-scale responsibility for the very large-scale operations, volumes, transmission, main transformers, HVDC, and so on. We need to be able to grow and supply this as needed. If you can't get steel, if you can't get copper, if you can't get paper, and if you can't get insulation, then you cannot grow electricity."

The insights from this panel make it clear that the transformer industry is at a pivotal moment. The sustained high demand, coupled with increasing performance requirements, is forcing a re-evaluation of traditional design and material choices. Success in this new era will depend on a sophisticated, systems-based approach to insulation, strategic collaboration between suppliers and specifiers, and a deep understanding of the unique demands of each application.



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