HARNESSING KEY VECTORS FOR OPTIMAL FUEL CELL SYSTEM PERFORMANCE

In this edition of "Ask the Expert," product specialist Chow Mun Hoe of W. L. Gore & Associates (Gore) provides validation engineers with valuable insights into selecting the most appropriate proton exchange membranes (PEMs) for optimal fuel cell system performance.

Q: One of my challenges is validating PEM's attributes in a fuel cell system to meet customer requirements for performance and durability. How do I formulate a test method to determine the most appropriate PEM?

A: It is important to note that linking system performance and durability with PEM is a massive leap because there are many variables in between – membrane electrode assemblies (MEA), stack, and system design.

The first step is to understand how PEM impacts MEA. Gore has extensive experience characterizing PEM performance under conditions such as temperature and humidity using standard electrodes.

The next level of validation is at the stack level. As we move up the value chain, testing becomes more time-consuming and expensive. Short or full-stack tests allow customers to evaluate how the PEM impacts MEA performance at the stack level while validating different stack designs.

Finally, system-level testing considers system design, operating conditions, driving patterns, and more. This will evaluate the performance and durability of a stack.

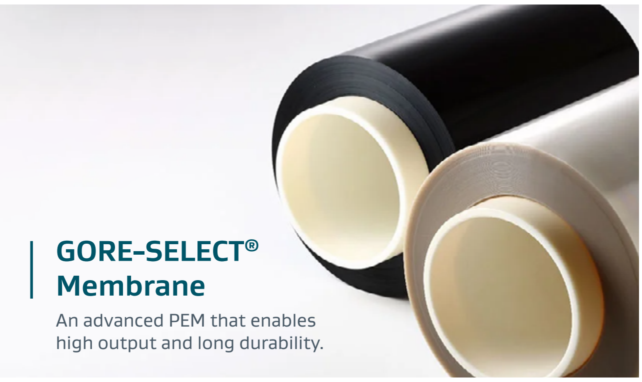
With so many variables, linking system performance to PEM requires extensive work. One way is to understand the requirements of the system. Will it be used for continuous operation over long distances driving? Or will it be operated primarily under drier conditions if the system design does not include a humidifier?

Or does it need to operate under higher temperatures to reduce the size of the radiator? The designer can decide which type of MEA/PEM is more appropriate. Working backward, we can then quantify how the PEM can impact the stack and the system's performance and durability.

This process is lengthy and tedious, so Gore is working to leverage existing empirical data from real-world cases and trying to model how a PEM impacts the various stages of the FC value chain. In time, this will help our customers better understand the relationship between PEM selection and system performance and durability.

Q My company has shifted its focus to commercial fuel cell vehicle development. To increase commercial PEM fuel cell vehicles' efficiency, what factors do I need to consider?

A Power density is the key factor determining the efficiency of a fuel cell stack or system, and a PEM significantly affects it. The type of ionomer, the structure of the membrane reinforcement, and the thickness of the PEM all affect the proton conductance and range of commercial fuel cell vehicles.



In addition, changes in relative humidity (RH) during operation will cause mechanical degradation of a PEM over time, and harsh chemical environments will cause chemical degradation. Failure to address the mechanical and chemical resistance of a PEM can result in higher levels of gas crossover, loss of efficiency over time, and even catastrophic failure of the fuel cell stack.

To prevent such occurrences, Gore's ePTFE-reinforced PEM, ionomer, and additive technologies help fuel cell stacks function more efficiently while mitigating mechanical and chemical durability risks.

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Q In mass production of PEM, quality consistency is crucial. How do the validation parameters and methods differ when I move from R&D to mass production?

A When a fuel cell project goes into mass production, a PEM supplier must consider different requirements than in the R&D phase. Volume manufacturing requires a systematic approach to ensure that manufacturing process checks and calibrations, as well as mass production audits and validations, are controlled. There are no shortcuts; only rigorous quality control processes and procedures can ensure consistent, high-quality production.

At Gore, we have proven and stable manufacturing processes to ensure a high level of lot-to-lot consistency. We also have established product specifications that are tested under appropriate sampling plans and even 100% checks to ensure a high confidence level of product quality.

Q When fuel cell stacks do not perform as expected, or their performance degrades over time, what kind of analysis can be performed to understand the failure mode?

Analyzing the MEA gives clues to potential causes of performance degradation. Gore uses several tools to perform these diagnostics.

Chronoamperometry (CA) is used to measure the amount of hydrogen crossover from the anode to the cathode. It can provide evidence of the decomposition of the PEM ionomer or the PEM mechanical defect. The causes could be the OCV holding and mechanical stresses introduced during operation, respectively.

Cyclic Voltammetry (CV) is used to measure the degradation state of the electrodes by examining the current response while the potential is swept. It can provide clues on whether there is corrosion of the electrode carbon or whether the active surface area of platinum (Pt) has reduced, indicating different causes leading to performance losses.

Electrochemical Impedance Spectroscopy (EIS) is used to understand PEM and electrode resistance, which can provide clues to performance loss.

SEM-EDX is also a common diagnostic tool to observe mechanical failure causes or contamination.

Using various diagnostic tools to understand MEA failure modes can help stack manufacturers understand potential risks, gain insight into stack performance and durability, and enable design improvements.

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Chow Mun Hoe is W. L. Gore & Associates Fuel Cell Technologies Product Specialist. He has over 20 years' experience in high volume manufacturing environments and has been working in the field of polymer electrolyte membranes for fuel cells for the last 4 years.

If you wish to learn more about Gore and its GORE-SELECT® Membrane technology, please visit https://www.gore.com/alt-energy.

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