



# Nafion™

*A Reliable Partner for over 50 years*

17 November 2016  
George W. Brown

# Agenda

- Overview of Nafion™
- Research and Technology Development
- Product and Innovation Pipeline
- New Membranes
  - Commercial status & Performance
  - Testing and validation
- Technical Service Support
- Questions

# Overview of Nafion™

## Inventor of Nafion™ Ion Exchange Polymers

- Nafion™ brand has more than 50 years history of proven, high quality, innovative, reliable and sustainable products used across multiple applications.
- Nafion™ has excellent chemical resistance and physical properties with the added benefit of strong ionic properties.
- Nafion™ is one of the most recognized names in Chlor-Alkali, Fuel Cells, Energy Flow Battery Storage, Industrial Catalyst, Electrolysis, and Humidifier/Drier applications.

## Reliable Supplier

- Nafion™ provides the most high-performing, safe, and durable products in the industry. This recognized leadership offers greater efficiency to the customer and a trusted and respected partner.
- Nafion™ is part of a large integrated supply chain within Chemours™ with strong access to high quality upstream raw materials.

## Innovation & Commitment

- Chemours™ is committed to a continuation of innovation of Nafion™ product offering through product development and performance, strong technical service, and extending use into new emerging applications.



# Research & Development



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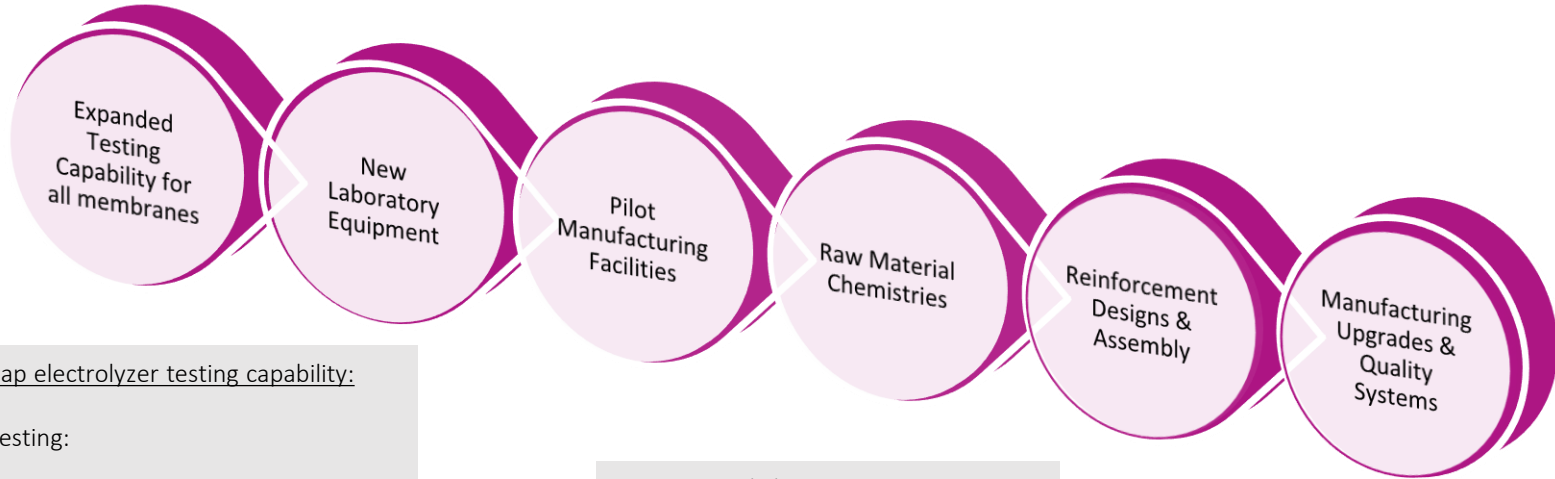
# Research & Technology Development

- Chemours™ has invested significant R&D efforts into expanding testing capability for product development and improving quality control of commercial manufacturing enabling improved high performing and high quality membranes.
- The Nafion™ Research & Development team are actively working on a broad scope of chemistry fundamentals, design concepts, and process technology enhancements for future membranes.
- New membrane NE2050 has been recently launched through the efforts of the Research and Technology teams and is performing excellent in commercial plants.



# Research & Technology

## Comprehensive Approach to New Membrane Innovation



### New zero-gap electrolyzer testing capability:

#### Lab-scale testing:

- Two different designs of zero-gap electrolyzers
- 100 cm<sup>2</sup> active area, up to 8 kA/m<sup>2</sup>
- Supplement traditional 45 cm<sup>2</sup> glass cells
- Capability for continuous feeding of special brines (impurity testing)
- Staffing for 24/7 year round operation.
- Standard conditions at 90C, 6 kA/m<sup>2</sup>

### Raw material chemistries:

Developing and evaluating new monomers and polymers to improve performance in Chlor-alkali and other applications

### Process Technology:

- Improved process control and manufacturing quality controls
- Improved coating formulations and application

### Pilot manufacturing facilities:

- Small-scale production of new monomers and polymers (for lab or plant trials)
- Small-scale membrane fabrication— from polymers and fabric through finished membrane

### Reinforcement & Assembly designs:

Developing upgrades to improve mechanical and electrical performance of Chlor-alkali membranes

# Development Pipeline

## Pipeline

**NE2050** - 50-70 mv improvement over 2030 with equivalent impurity resistance and mechanical strength

**Next Gen Plus** - 90+ mV improvement over 2030, improved CE, reduced pinholes and defects

**New Technology** - Utilizing new chemistry in overall design

Each membrane solution developed delivering improved performance and consistent quality to meet customer needs

NE2050  
Commercially available

Next Gen Plus Launch.  
New membrane structure  
Prototypes tested

Optimized membrane structure with new chemistry

# Next Generation Membrane NE2050



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# New High Performing Membrane – NE2050

Plant	Type	Vs N2030	vs Comp. Mem. 1	Vs Comp Mem. 2
1	Zero Gap 50 DOL	-60 mV		-60 mV
2	Zero Gap 60 DOL	-80 mV	-20 mV	
3	Zero Gap 70 DOL		-30 mV	
4	Near Zero Gap 6 DOL		-20 mV	

- 20,000 m<sup>2</sup> shipped to date
- Consistent CE performance to NE2030
- Good mechanical strength
- Fewer pinholes/leaks have been reported at start-up

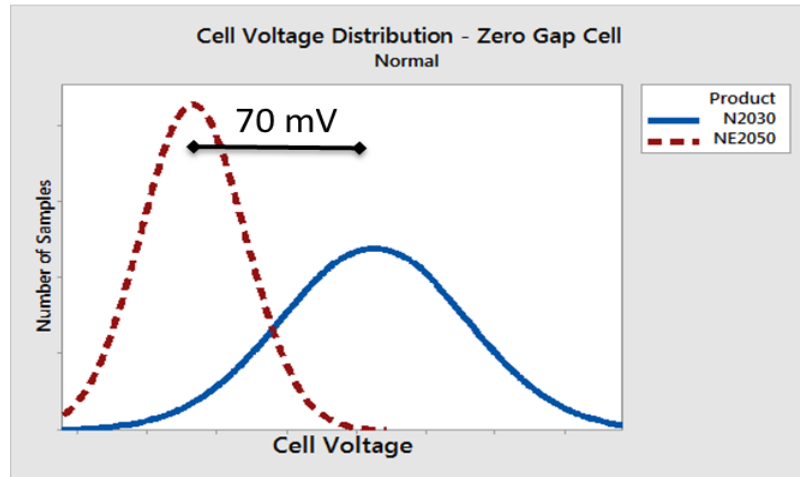
# New High Performing Membrane – NE2050

## NE2050 High Performing Membrane

- Data presented is from > 100 different lots tested from commercial production.
  - Voltage, Current Efficiency, Durability testing (Ca Spike, Brine Impurity, High Caustic, High Current Density, Mechanical Strength)
- Brine test results are internal lab tests at *extreme conditions* and based on voice of customer
- NE2050 utilizes the mechanical strength and stability of N2030 reinforcement with improved voltage for zero-gap electrolyzers

# New High Performing Membrane – NE2050

## NE2050 Comparison to N2030 Cell Voltage & CE



Voltage

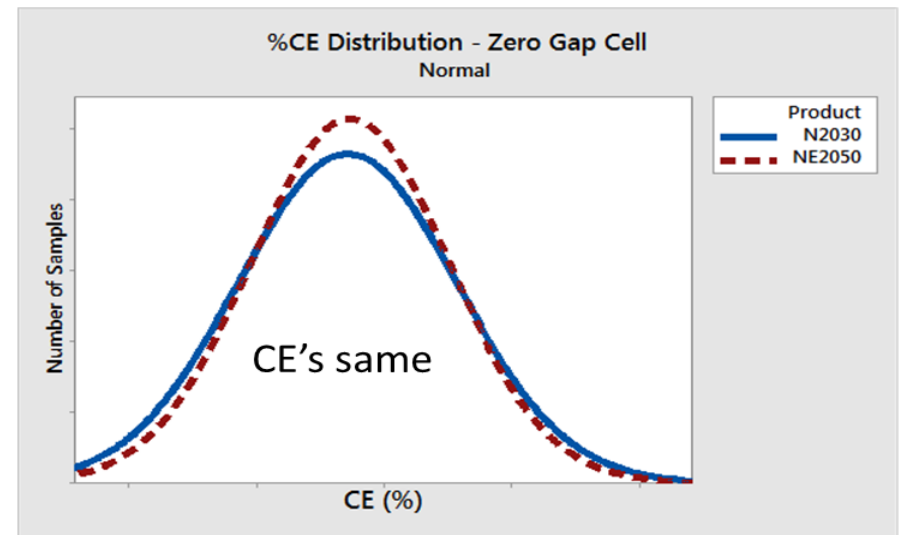
### Test Conditions

Zero-gap cells, 100 cm<sup>2</sup>  
90C; 6 kA/m<sup>2</sup>; 32% NaOH

Note: Means are relative but distributions are impacted by small cell testing.  
Cell testing data is from over 100 commercial lots of production.

NE2050 production data show 50-70 mV improvement over N2030 with comparable Current Efficiency

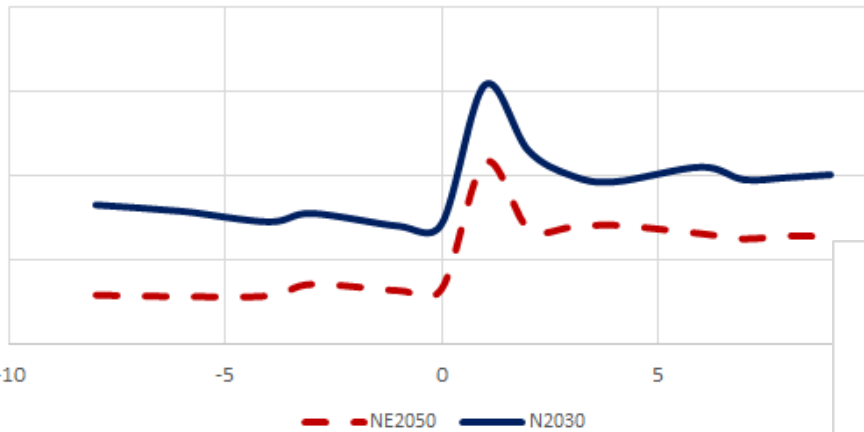
### Current Efficiency



# New High Performing Membrane – NE2050

## Accelerated Calcium Spike Test

Cell Voltage vs Days on Line Response to 20 ppm Ca<sup>++</sup>



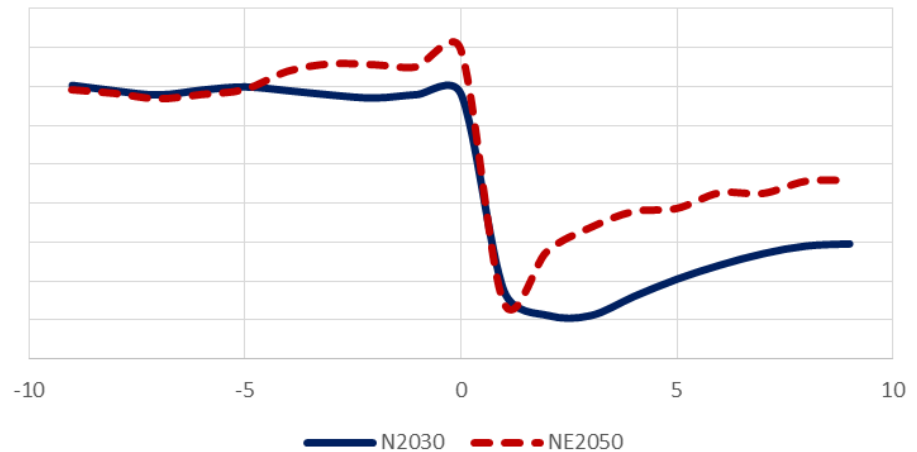
NE2050 membrane performs equivalent to N2030 to large Calcium spike, with lower voltage.

**20ppm Ca spike**

### Test Conditions

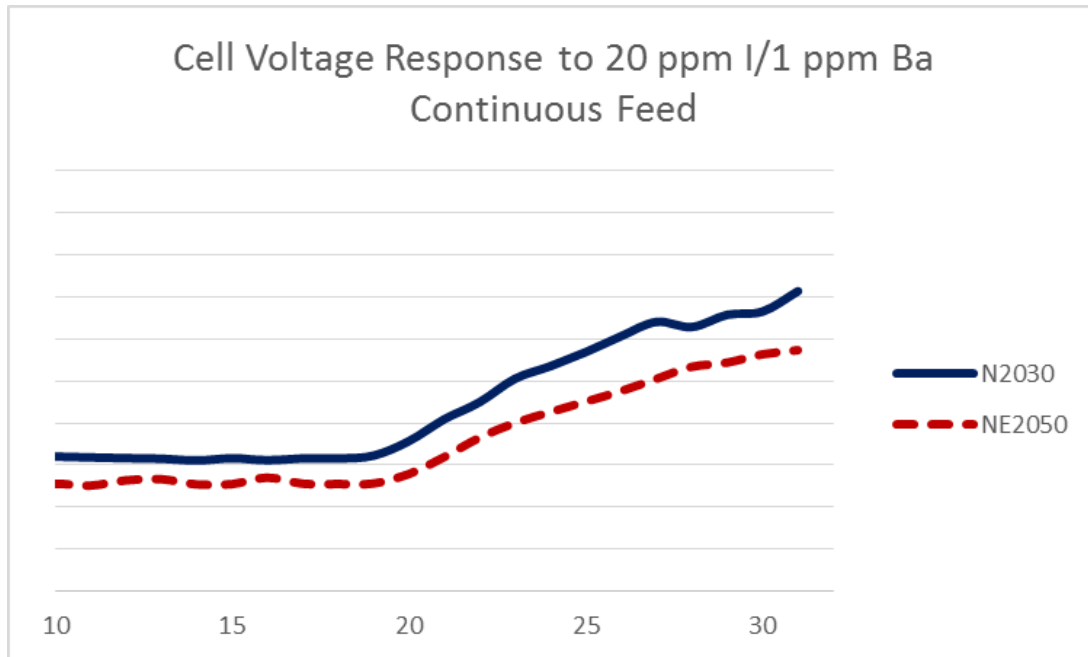
Zero-gap cells, 45 cm<sup>2</sup> glass cells.  
90 C; 4kA/m<sup>2</sup>

CE vs Days on Line Response to 20 ppm Ca<sup>++</sup>



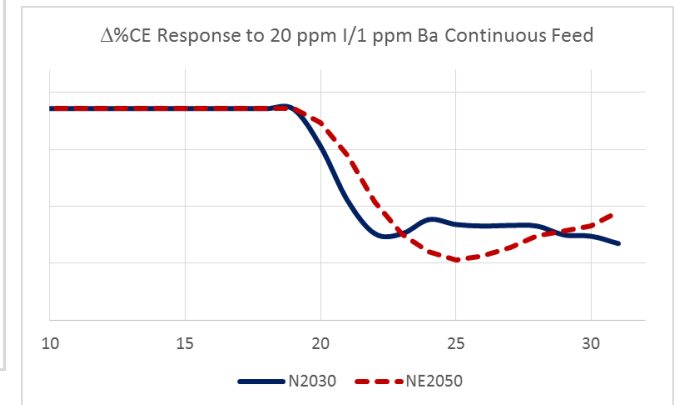
# New High Performing Membrane – NE2050

## Accelerated Durability Cell Testing: Ba/I Impurity Feed Test



### Test Conditions

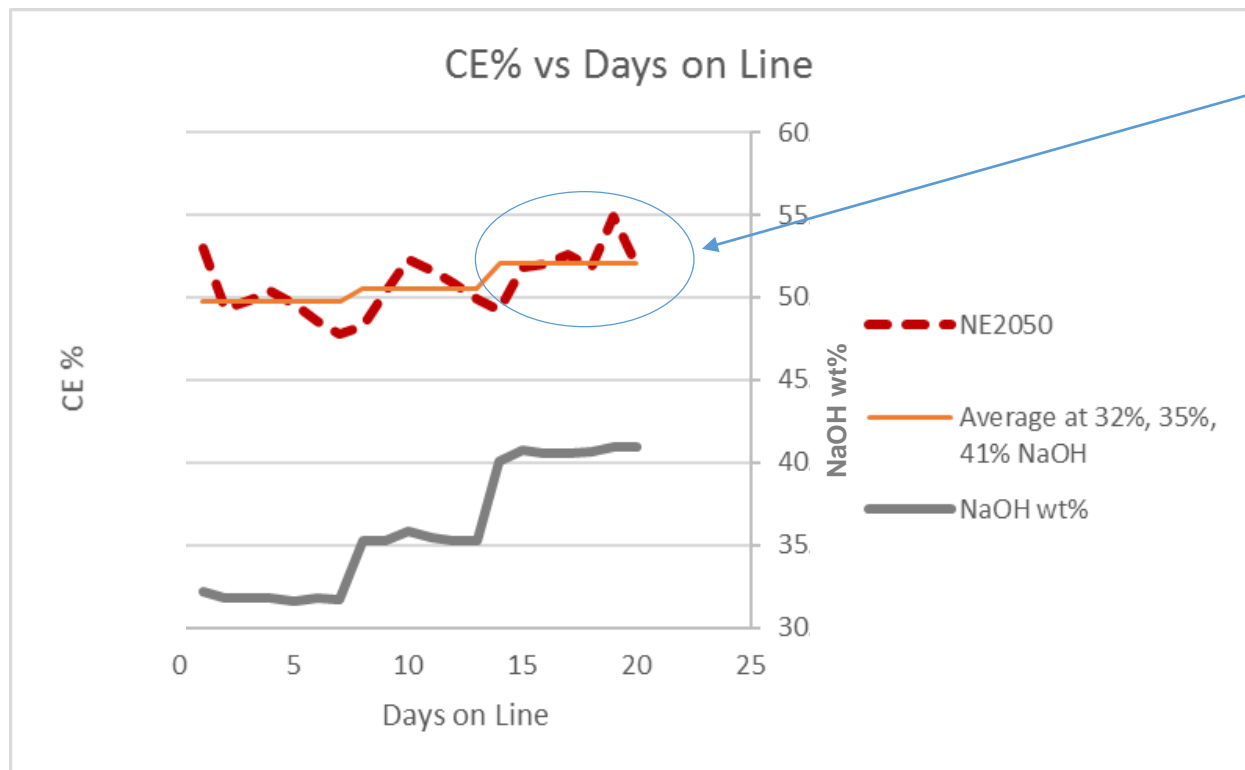
Zero-gap cells, 100 cm<sup>2</sup>  
90C; 6 kA/m<sup>2</sup>; 20 ppm I, 1  
ppm Ba continuous feed  
from DOL 18



NE2050 product performs equivalent to N2030 with lower voltage

# New High Performing Membrane – NE2050

## High Caustic CE Response



Nafion™ structures resist CE at >40% NaOH.

**NE2050 membrane performs equivalent to N2030 in high caustic excursions**

**41% caustic produced with no water addition. Maximum caustic at cathode surface**

### Test Conditions

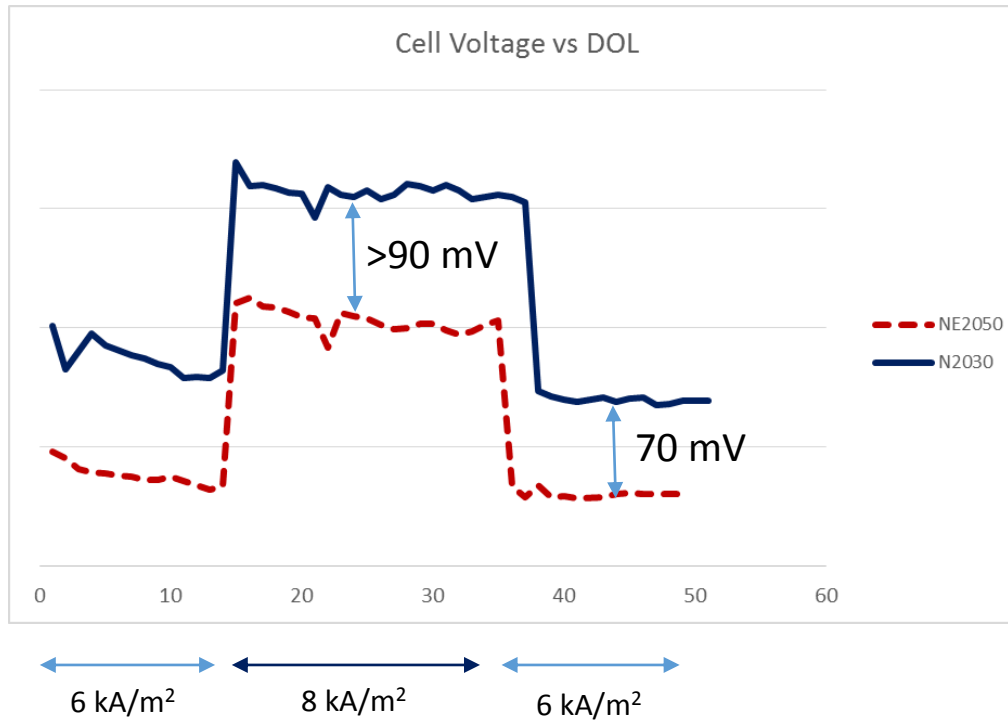
Zero-gap cells, 100 cm<sup>2</sup>  
90C; 6 kA/m<sup>2</sup>

**Note: Membrane was inspected after high current density operation via microscopy without any notable or visible damage; however, Chemours™ recommendations in our User's Guide remain the same.**



# New High Performing Membrane – NE2050

## High Current Density Test



**NE2050 membrane performs equivalent to N2030, with lower voltage and stable CE**

**SEM analysis after test shows no difference in membrane types. Membrane structure and CE stable**

Test Conditions  
Zero-gap cells, 100 cm<sup>2</sup>  
90C; 6 kA/m<sup>2</sup>

# New High Performing Membrane – NE2050

## Mechanical Properties

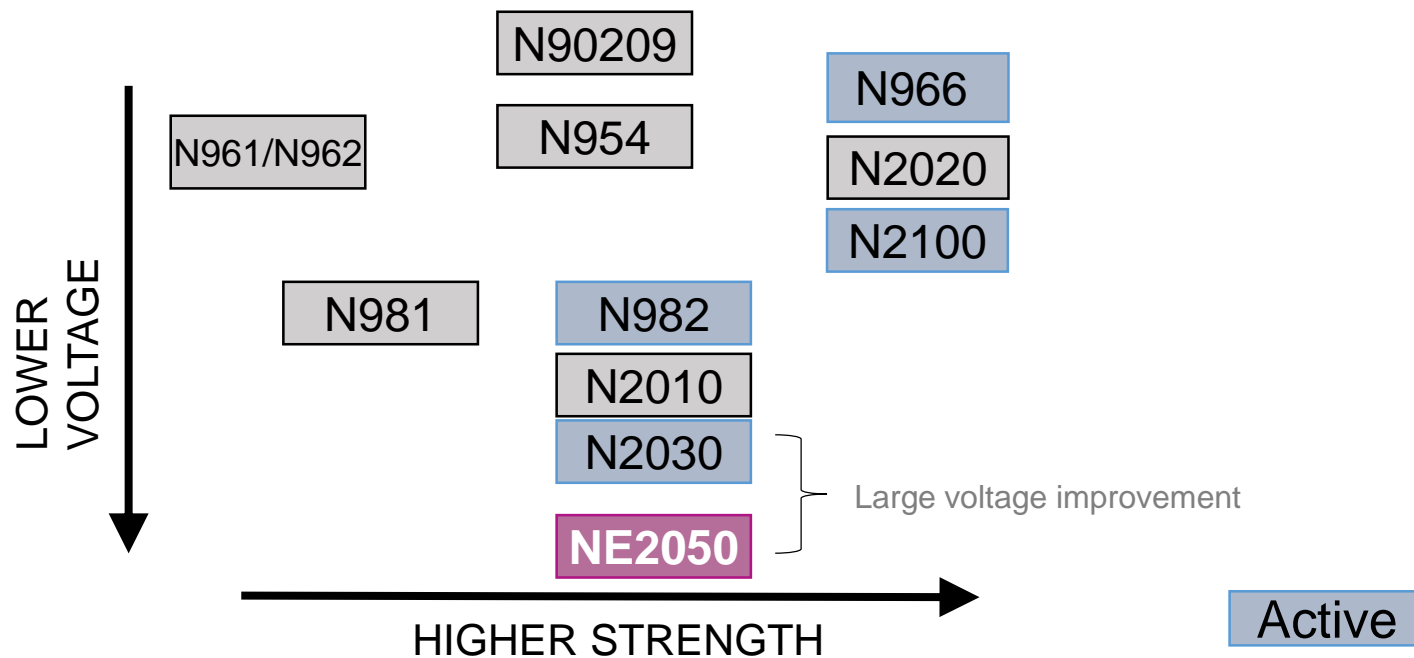
	<b>N2030</b>	<b>NE2050</b>
Force Constant at Yield (kgf/cm)	3.8	4.0
Tensile Strength (kgf/cm)	36	36
Strain at yield (%)	12	11
Load at Yield (kgf)	19	19

\*TD Data; MD Data is similar

NE2050 has equivalent mechanical strength to N2030 (same reinforcement)



# Nafion™ Product Performance Map Legacy



Beyond NE2050, the R&D pipeline continues on future membrane developments to further enhance voltage and CE performance, utilizing the strong technology of Chemours™ chemistries and operating capabilities

# Summary

- Nafion™ has a new high performing membrane, NE2050 which is performing very well in the market and commercially available in all size and quantities for any replacement or project need
- New membrane has significantly improved voltage, comparable CE and equivalent mechanical strength relative to N2030
- Beyond NE2050, the R&D pipeline continues with future membrane developments to further enhance voltage and CE performance, utilizing the strong technology of Chemours™ chemistries and operating capabilities.
  - The new membrane prototypes being developed and successfully made at the factory reduce voltage 30-40mV further and increase CE by 0.5%



# Global Technical Service



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# Global Technical Service

Value of Nafion™ strong local technical & sales team

## We provide:

- Analysis of customer membranes, brine and salt
- Consultation on membrane selection based on our years of experience in a wide variety of applications with analytical data
- Consultation on plant operating conditions using Nafion™ membranes
- Deliver training on membrane handling and installation

## Renewal of Laboratory Facilities:

- Upgraded SEM/XRF
- Surface Profilometry, Surface Tension
- Improved Membrane Resistance Measurement capability
- Improved and more detailed Membrane Mechanical Physical Property Measurement
- New zero-gap lab cell testing capability with improved voltage measurement and current density to 8 kA/m<sup>2</sup> (with future capable to 10 kA/m<sup>2</sup>)



# Global Technical Service Team

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- Rita Bolton
- Bob Theobald
- Chase Perry

- Europe, Middle East and Africa

- Replacement to be named soon

- China, Taiwan and ASEAN






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	<b>Bob Theobald</b> Technical Service Consultant North America and Latin America
	<b>Chase Perry</b> Technical Service Specialist

	<b>Martin Yu</b> Technical Service Lead China, Taiwan and ASEAN
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	<b>Ryo Iwata</b> Technical Service Consultant Japan and Korea
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## Questions ?

Thank you

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