
Introducing
DuPont™
eCool
A More Sustainable and
Cost-Competitive Solution
for EV Cooling Lines
DUPONT™

About the Presenters

Claire Massy
Product Technical Specialist, High Performance Nylon – Europe
DuPont Mobility and Materials

Michele Cristanini
Senior Automotive Business Development Specialist
DuPont Mobility and Materials

Agenda

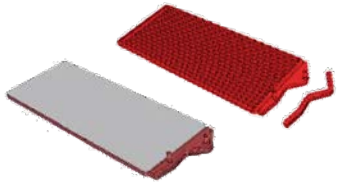
1. DuPont™ eCool Solutions for xEVs
2. Cooling Lines GWP (Global Warming Potential) Assessment
3. Services and Technical Capabilities Beyond Materials
4. DuPont Mobility & Materials Overview
5. Q&A Session

1. DuPont™ eCool Solutions for xEVs

Key solutions: Thermal Management

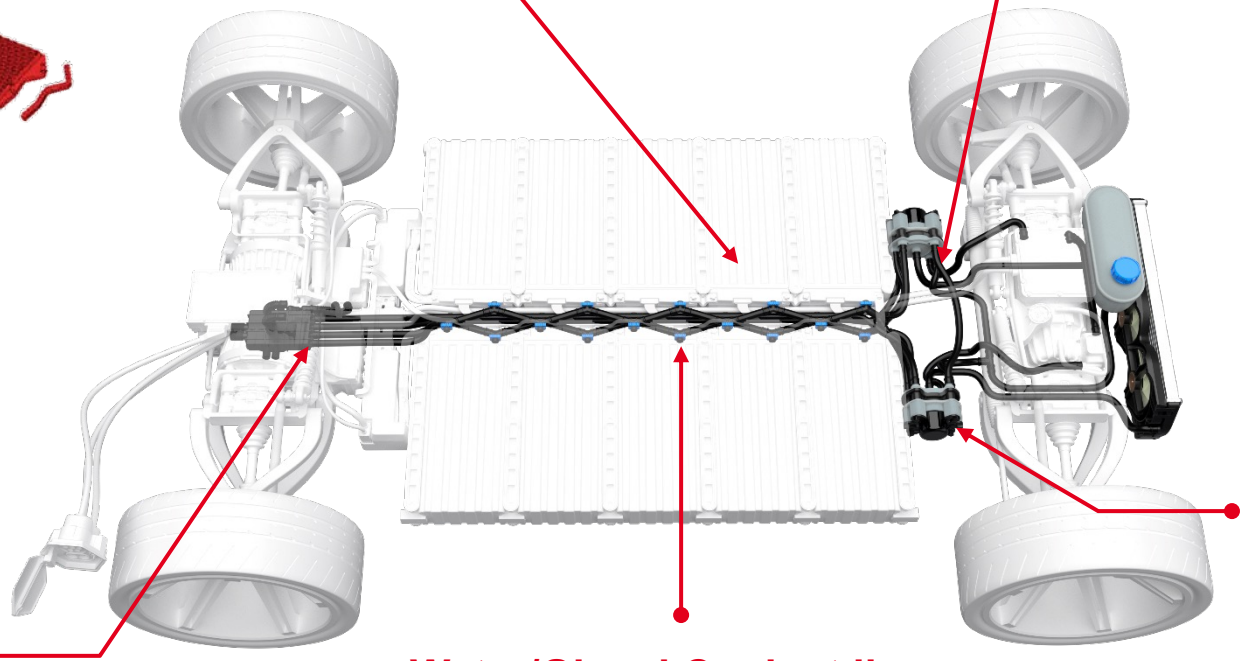
New Cooling Concepts

Zytel® HTN, Zytel ® and Sealing Technology



Sensors – Electronic Friendly Materials

- Zytel® EF (PA66 GR)
- Zytel® HTN EF (PPA GR)
- Zytel® LCPA EF (PA6.12 GR)



Water Pump, Motorized Valves, Radiator end tanks and Structural Components

- Zytel® (PA66 GR)
- Zytel® HTN (PPA GR)

Quick Connectors

- Zytel® (PA66 GR)
- Zytel® LCPA (PA6.12 GR)
- Zytel® HTN (PPA GR)

Water/Glycol Coolant lines

Temp.	Product	Material Type
< 110°C	TPO/Zytel® LCPA	TPO/PA612 TPO/6.10
<125°C	Zytel® LCPA	PA6.12CM

Long Chain Polyamides Portfolio for Cooling Tubes

LCPA Based Polymer						
Chemistry	PA612-I	CM(*)-PA612-I Plasticizer Free	PA1010-IP	CM(*)-PA610-IP	CM(*)-PA612-IP	PA1010-IP
DuPont Product	Zytel® LC6200	Zytel® LC7201	Zytel® RSLC2600	Zytel® RSLC4601 Zytel® RSLC4603	Zytel® LC7601 Zytel® LC7602 Zytel® LC7603	Zytel® RSLC1600
Stiffness	1100 MPa	1100 MPa	880 – 1150 MPa	750 MPa	670 MPa	600 MPa

= **Renewable sourced materials**

(*) CM stands for Chemical Modified (high salt resistance)

Polyamide for Quick Connector Applications

PA Based Polymer						
Chemistry	PA612-GF33	PA610-GF33	PA66-GF30	PA6T/66-GF35	PPA-I-GF35	PPA-GF30
DuPont Product	Zytel® 77G33EFT Zytel® FE5382	Zytel® RS78G33 FHS BK	Zytel® 70G30HSLR Zytel® 70G30REF Zytel® FR70G30NH	Zytel® HTN52G35EF Zytel® HTNFR52G30NH	Zytel® HTN54G35EF	Zytel® HTN42G30EF Zytel® HTNFR42G30NH

= **Renewable sourced materials**

(*) CM stands for Chemical Modified (high salt resistance)

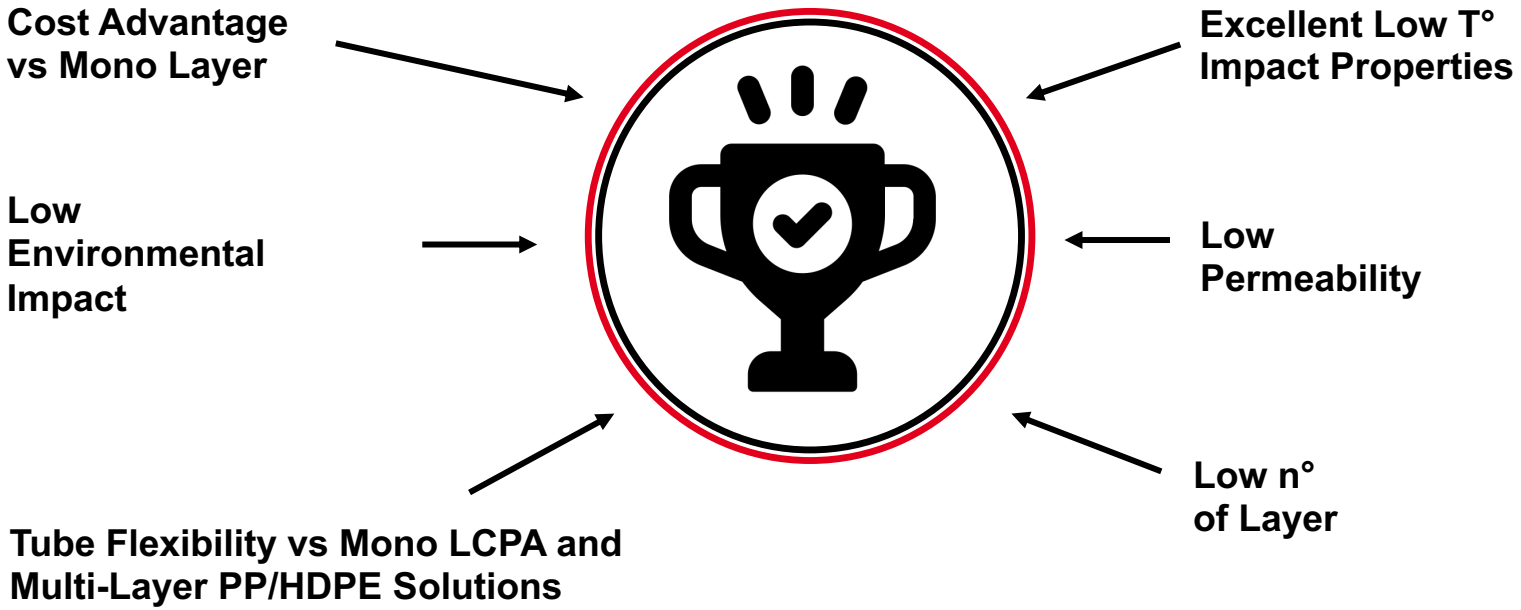
This list is not exhaustive. Other grades with different functions (such as Flame Retardant, Laser Making, Weatherable, Thermal shock improved properties) are available.

DuPont™ eCool Solutions—Tube Configurations

Configuration	Internal Layer	Intermediate Layer	Outside Layer
	TPO	Tie Layer	Zytel® compounds based on PA6.12, PA6.12 CM, PA6.10 CM, PA1010
	N.A.	N.A.	Zytel® compounds based on PA 6.12, PA6.12 CM, PA6.10 CM, PA1010

DuPont™ eCool Solution

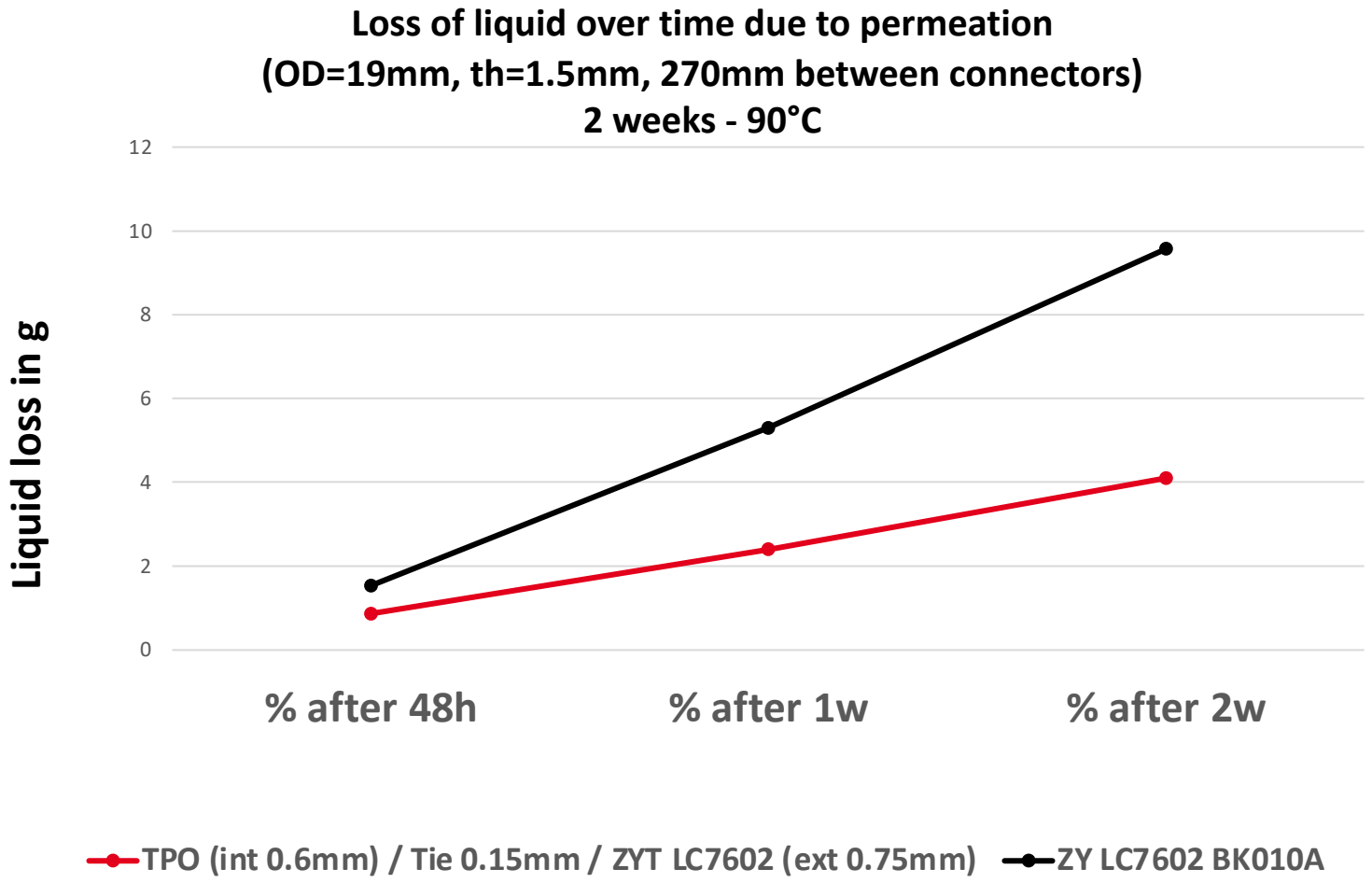
Configuration	Internal Layer	Intermediate Layer	Outside Layer
	TPO	Tie Layer	Zytel® LC6200, LC7602, LC7603, RSLC4603

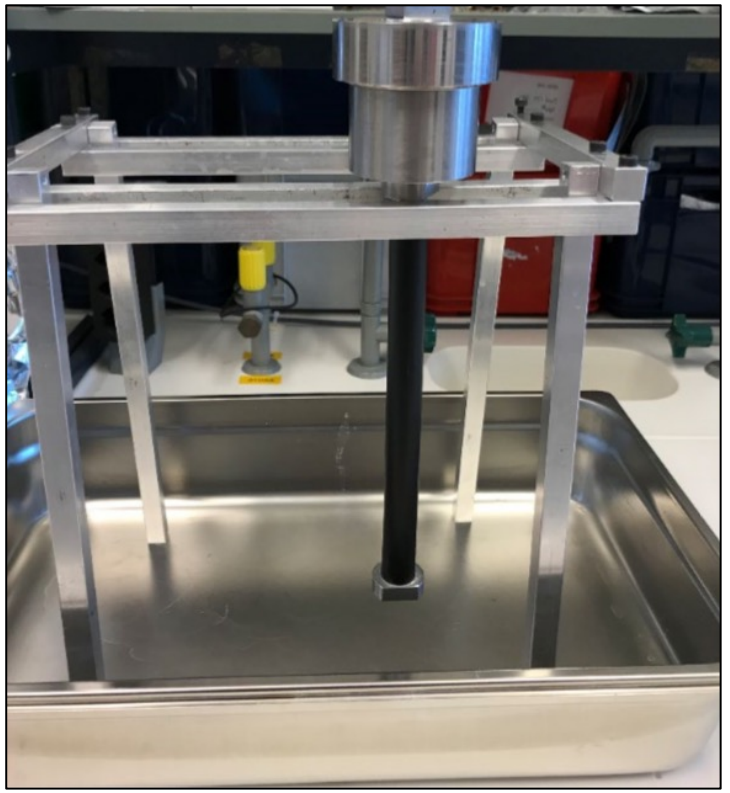


DuPont Material Candidates

Based on specific needs, other compounds can be considered for the construction. Tubes can be extruded smooth or corrugated.

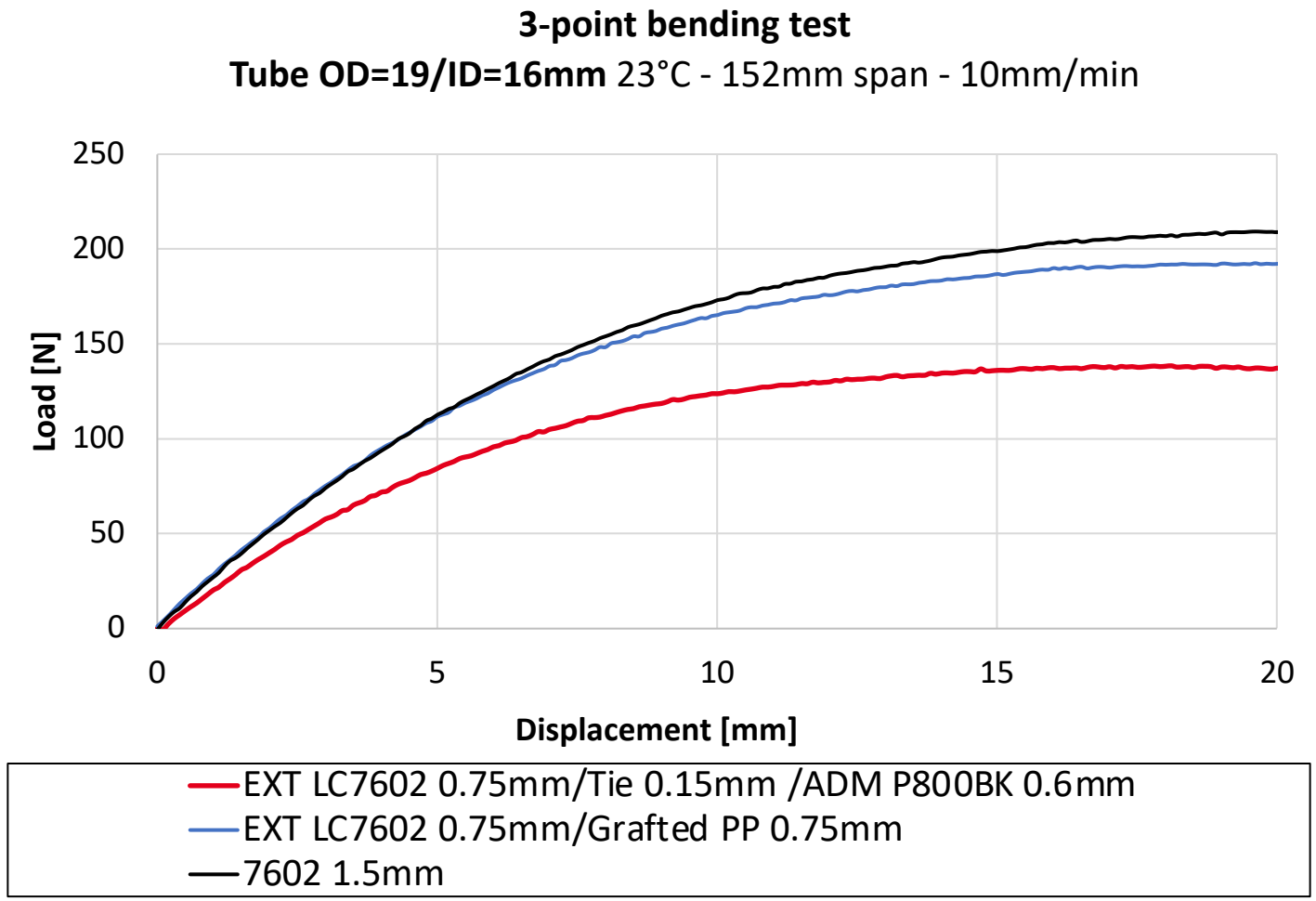
Low Permeation to Water/Glycol 50–50% at 90°C

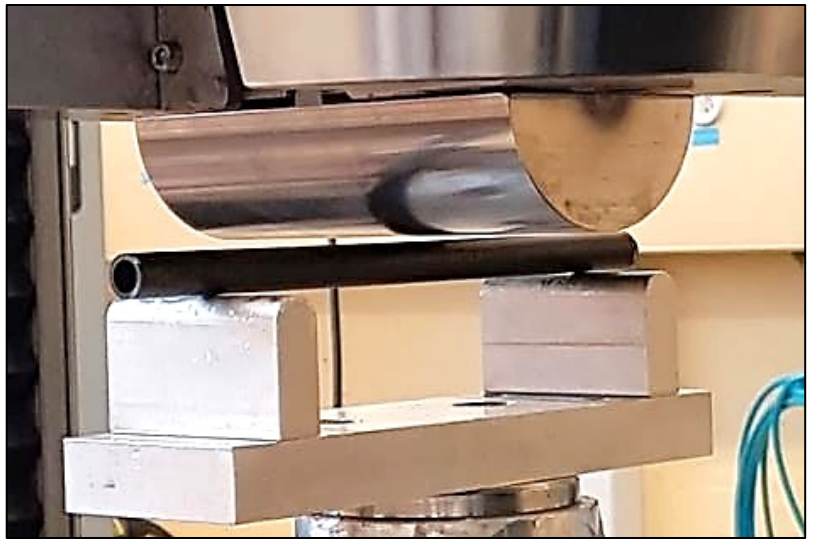


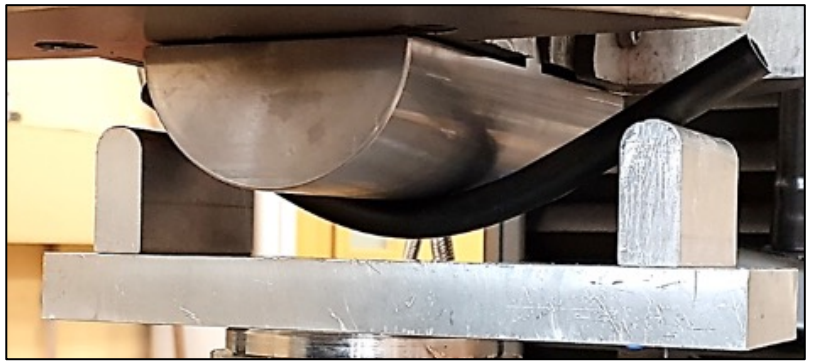


High Flexibility Multi-Layer Tubes | 3-point Bending Test

Construction Flexibility comparison—DAM condition





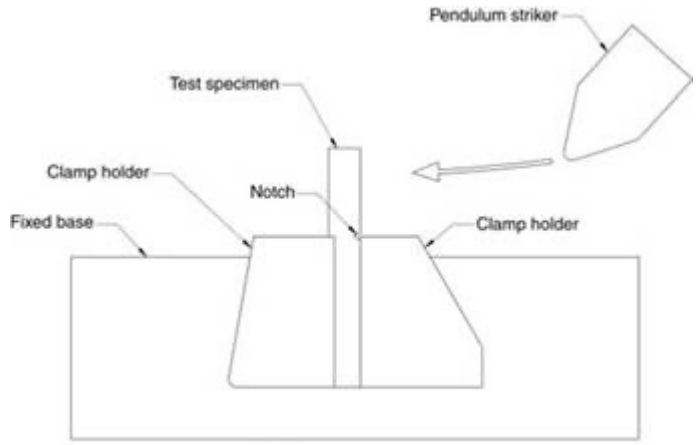


Superior Low-Temperature Impact Properties

Material Selection optimize impact properties at low temperatures

Material	Izod Notched [kJ/m2]				Charpy Notched [kJ/m2]			
	+23°C	-30°C	-40°C	-45°C	23°C	-20°C	-30°C	-40°C
Zytel® LC7602 BK010A (Dry)	84	-	13	-	105	-	-	12
TPO impact optimized	49 *	71	-	9	69*	94	80	14
PP Impact copolymer	-	-	-	-	35	6	-	-

* = No brake



Notched izod impact test

Competitive Solutions Comparison

CTQs	eCool	PP/RS LCPA Multi Layer	PA6/HDPE Multi Layer	RS LCPA Mono Layer	PP Mono Layer	Reinforced TPV
Performance Optimization	++	+	+	-	--	+
Tube Flexibility	++	-	--	+	---	+++
Connectors Installation	++	+	++	++	-	-
Cold Impact Performance	++	-	+	++	---	+++
GWP	++	++	-	+	+++	++
Production Effectiveness	++	++	-	+++	+	-
Material Cost	+	+	++	-	+++	++

2. Cooling Lines GWP Assessment

Life Cycle Assessment (LCA)

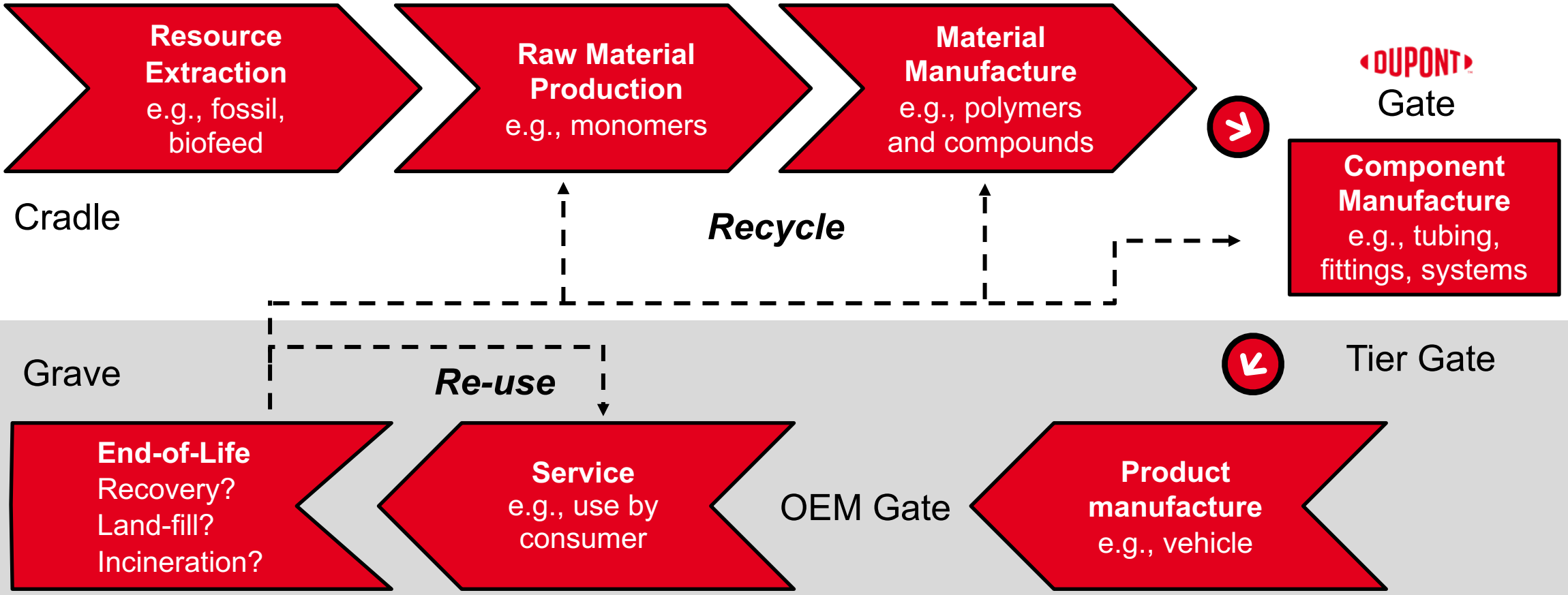
A methodology for assessing environmental impact associated with each stage in the life-cycle of a commercial product, process, or service.

- Compiling an inventory of material and energy inputs and environmental releases
- Evaluating environmental impacts associated with these inputs and releases
- Interpreting the results to make a more informed decision

GWP environmental impact is measured in terms of CO_2-equivalent emission.

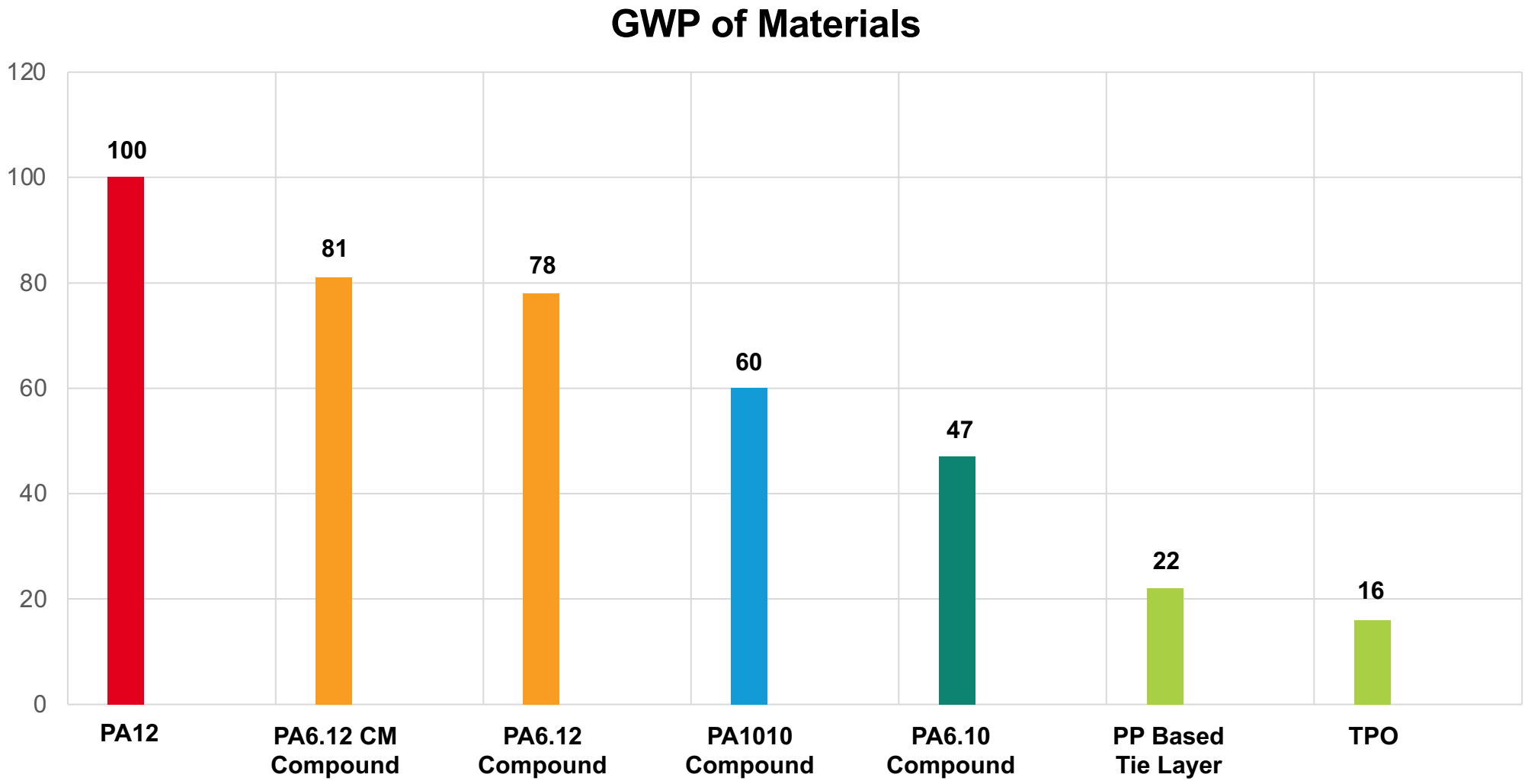
14040 – Principles and Framework
14044 – Requirements and Guidelines

Upstream Footprint for Tier Manufacturer



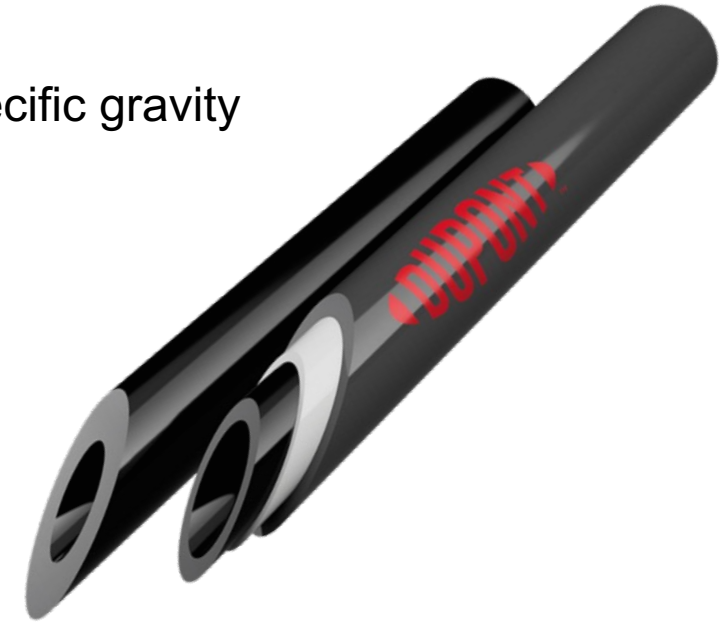
Downstream Handprint for Tier Manufacturer

GWP Reduction vs PA12 Un-Plasticized

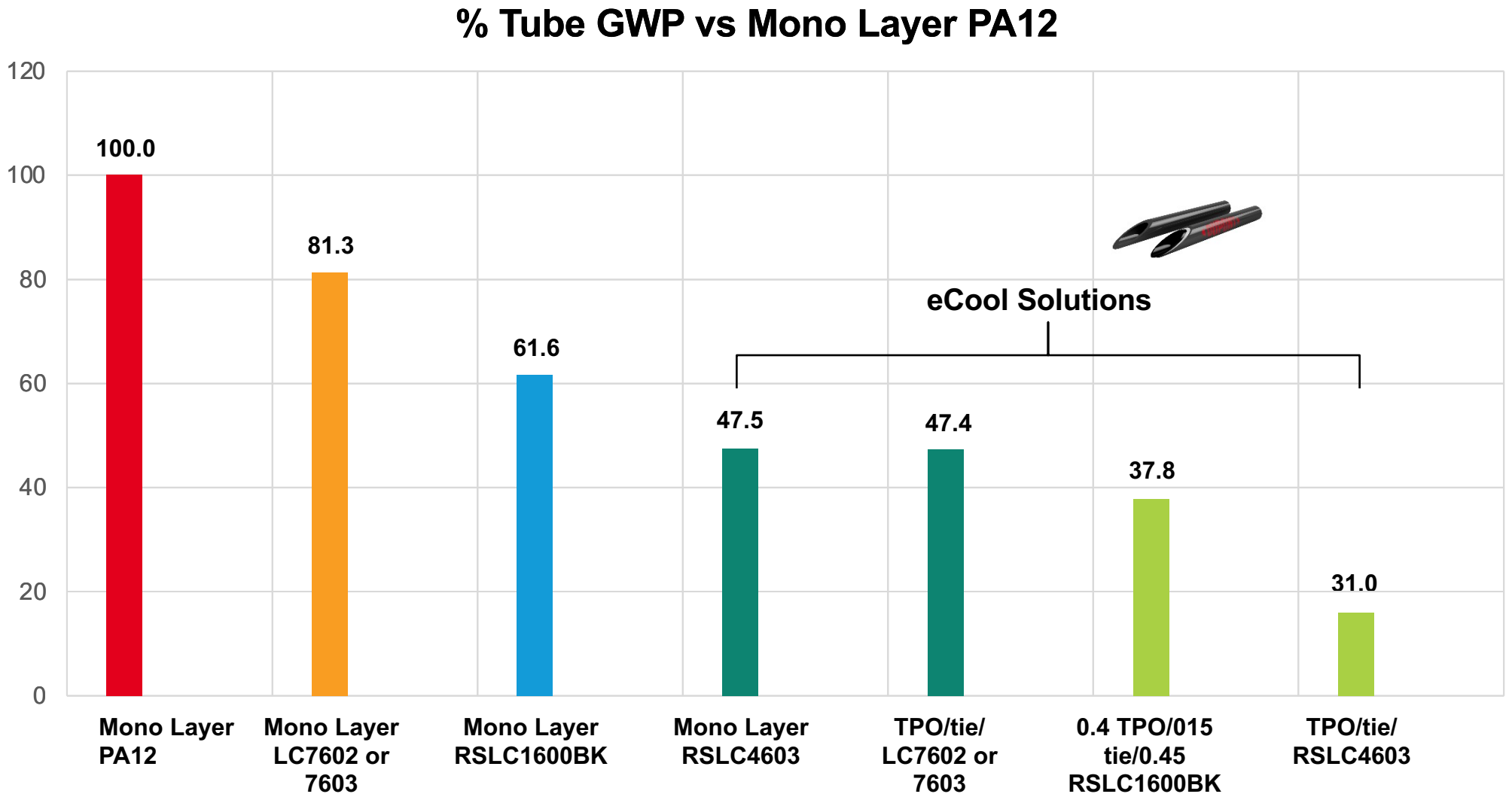


GWP Data for Tube Constructions

- 8 x 6 mm tubes
- Contribution of individual layer based on thickness and specific gravity
- Addition of contributions by all layers
- Expressed in gms CO_2e per meter length of the tube



GWP Data for Tube Constructions



3. Services and Technical Capabilities Beyond Materials

Centers of Excellence to Support Auto Electrification

Battery Safety Technical Center

Shanghai + Geneva

Objectives:
Meet safety requirements while increasing energy density, fast-charging endurance, and reducing cost

Thermal Management Technical Center

Geneva + Freienbach

Objectives:
Improve fast-charging speed and cold weather performance while keeping battery reliability at controlled cost

E-Powertrain Efficiency Technical Center

Geneva

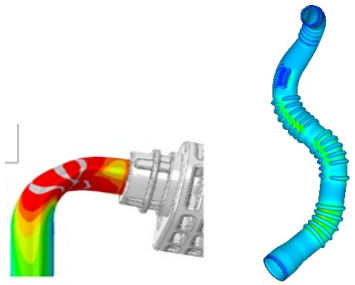
Objectives:
Improve PE and E-motors efficiency AND energy/packing density while maintaining reliability at highest levels

Global interaction between Technical Centers

ETC Geneva—COE for Extrusion Applications

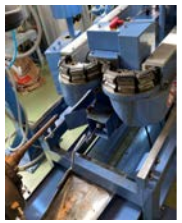
Design Expertise

CAE Design
FEA Simulation



Extrusion Process

Multi-layer Tubing Extrusion Line
Corrugation Unit
Blown Film Line
Sheeting Line
Wire and Cable
Jacketing




Post Process

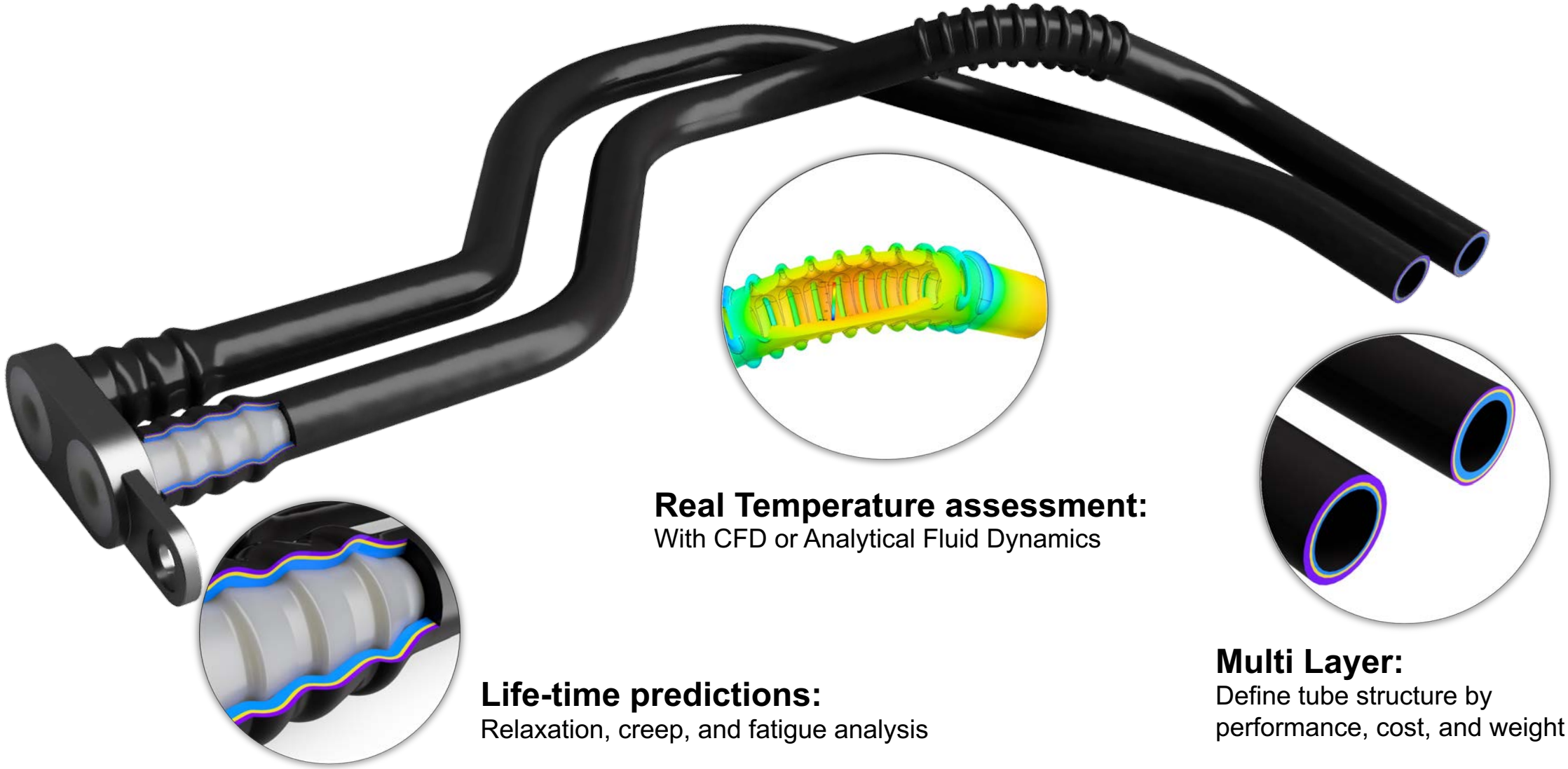
Welding
Connectors
Thermoforming



Testing

Burst Pressure
Tensile on Tubes and Rings
Air and Chemical Aging
Stress Cracking
Bend Test


Advanced Technical Services



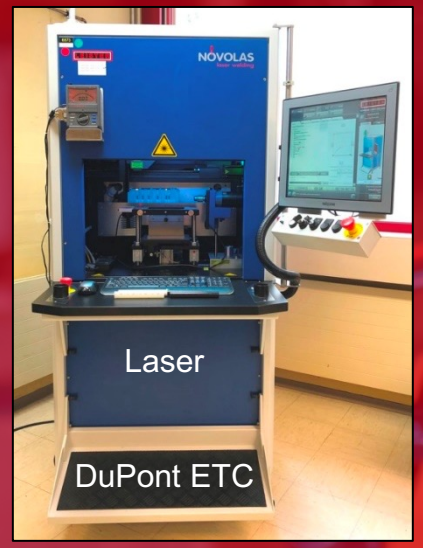
Real Temperature assessment:
With CFD or Analytical Fluid Dynamics

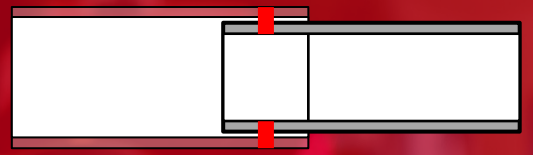
Life-time predictions:
Relaxation, creep, and fatigue analysis

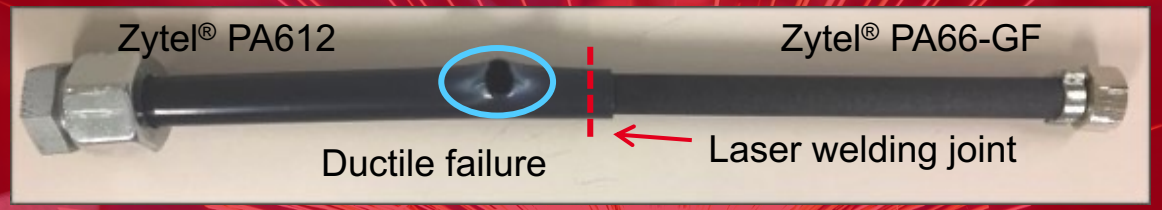
Multi Layer:
Define tube structure by performance, cost, and weight

Assembly Technologies COE

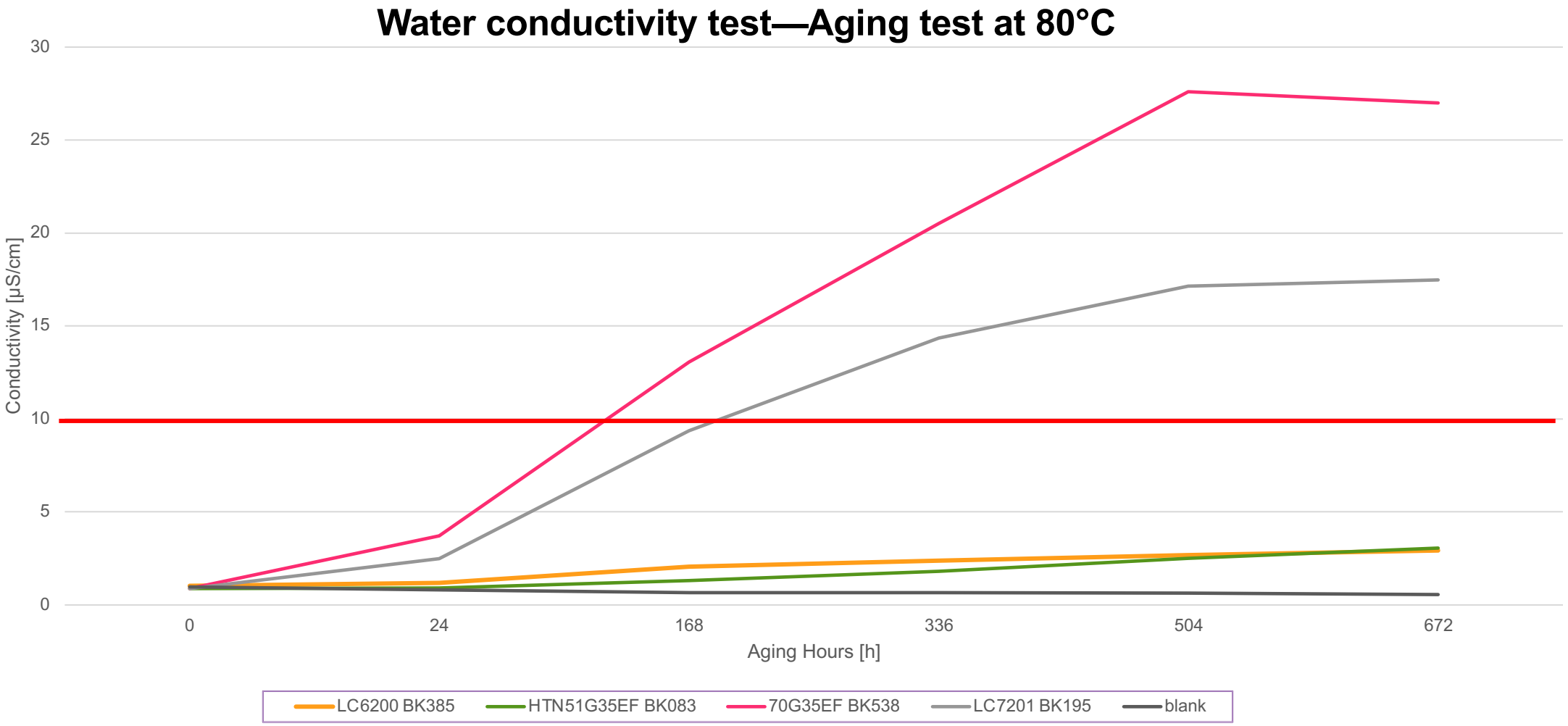
- Area of expertise—Industrial welding techniques
- >30 years of experience in welding technologies
- Application development support for injection moulded, blow moulded, and extruded parts in Zytel®, Crastin®, Rynite®, Hytrel®, and Delrin®
- State-of-the-art welding machines that represent 90% of the technologies seen in the marketplace





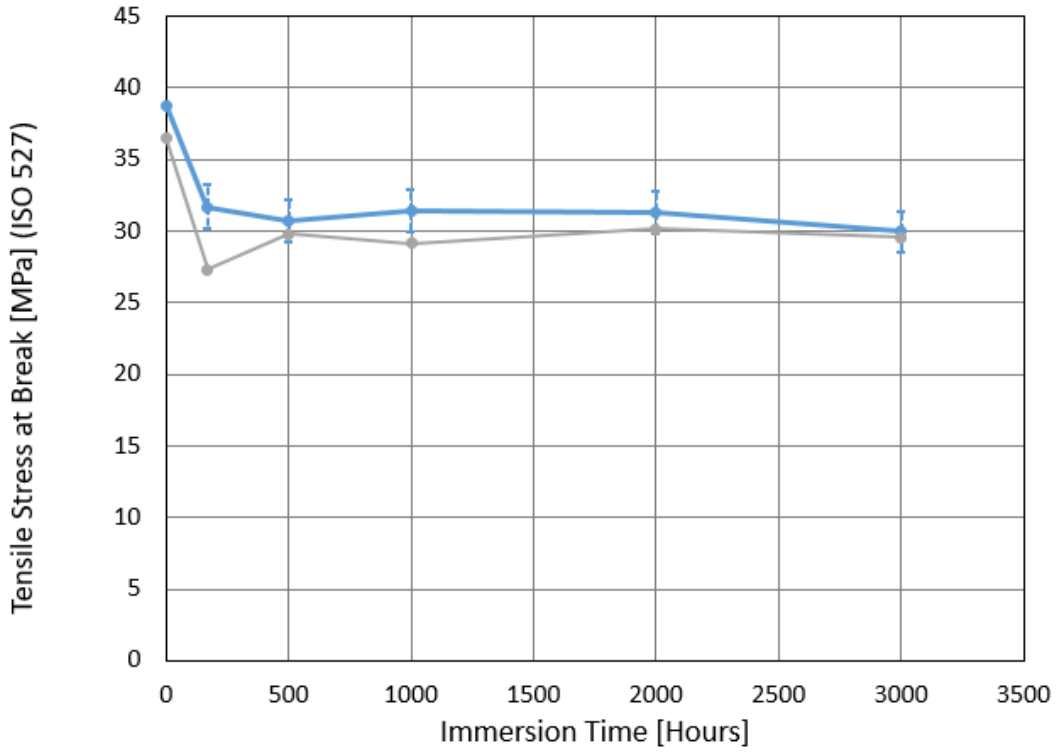


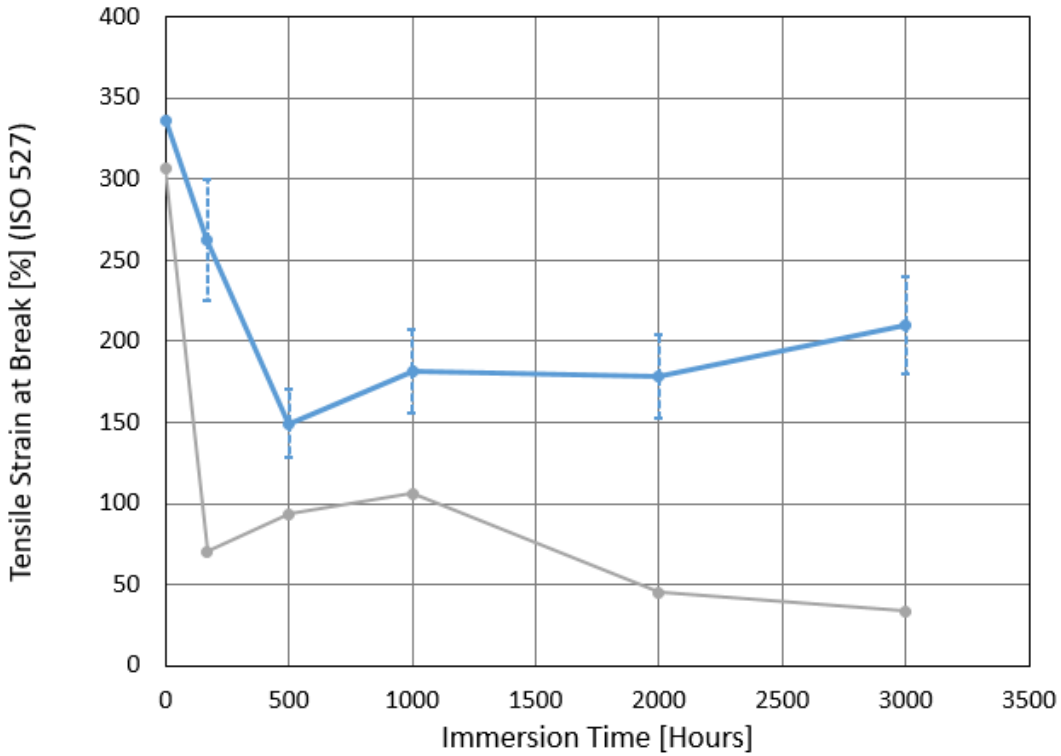
Cooling Circuit Special Properties for FCEV



New E-Fluid Performance—Immersion Cooling

Novec 7300–100°C





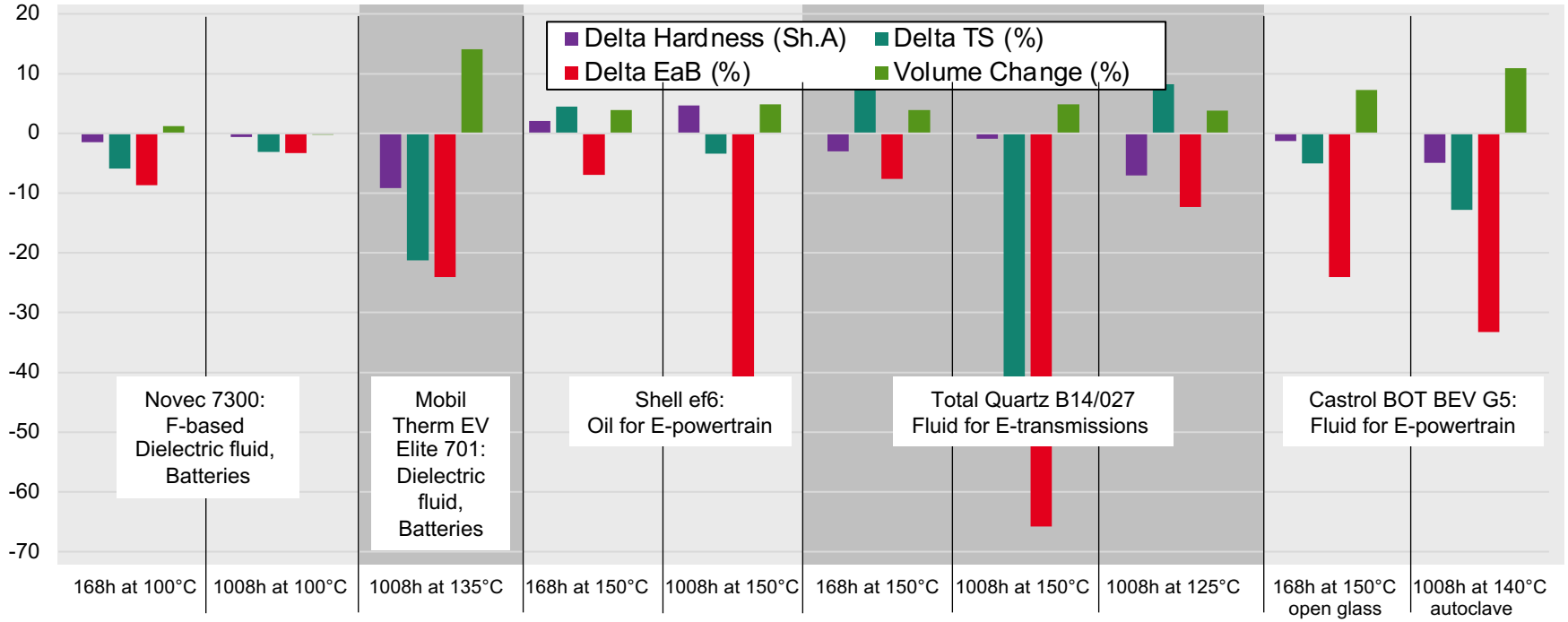
Zytel® LC6200 BK385 Zytel® LC7602 BK010A

New E-Fluid performance – Vamac® Elastomers

Elastomers will be necessary for sealing and hose applications, to get tight systems and to reduce noise and vibrations. Vamac® Ethylene Acrylic Elastomers provide good resistance to a variety of fluids (oils AND water) used in BEVs between -40 and +175°C.

Below chart shall give an overview on the performance of a standard 70 Shore A Vamac® compound after aging in different E-Fluids under varying conditions. Values obtained are in general very good, compound modifications can be easily made to optimize performance.

Detailed Technical Documentation available.

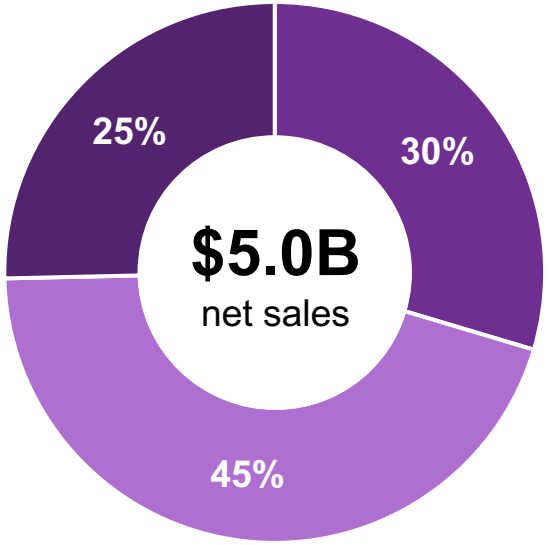


4. DuPont Mobility & Materials Overview

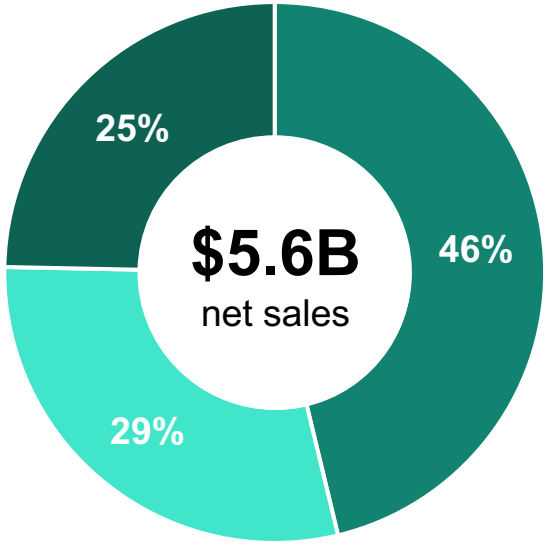
Premier Multi-Industrial with Market-Leading Businesses

2021 Financial Data[1]

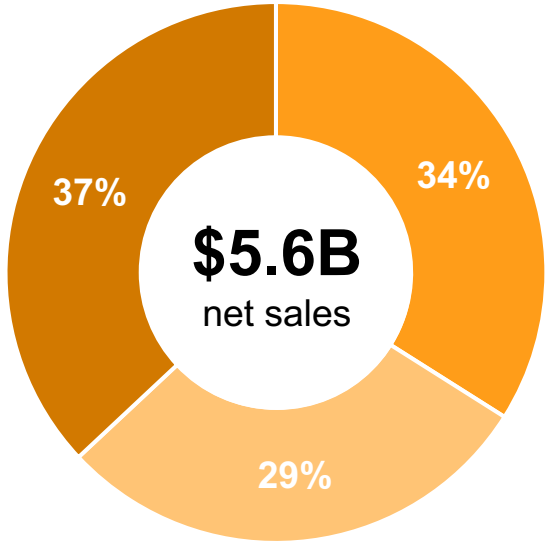
Mobility & Materials[2]



Water & Protection



Electronics & Industrial



[1] Excludes net sales related to the following businesses reflected in Corporate: Solamet® which was divested on June 30, 2021, Clean Technologies which was divested on December 31, 2021, and Biomaterials which the Company has signed a definitive agreement to divest.

[2] On February 18, 2022, the Company announced Board approval and definitive agreements to divest certain businesses within the M&M segment. See Overview for further explanation.

At a Glance: M&M Business [1]

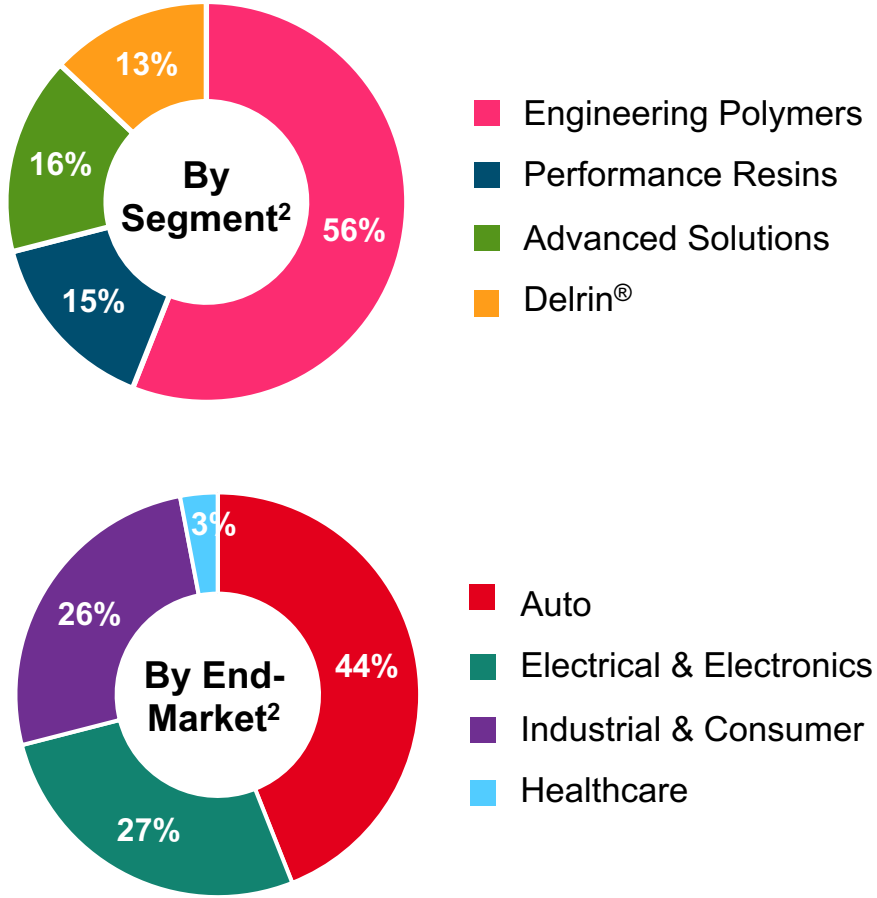
$4.1B

Sales by Geography[2]

30
Manufacturing sites[3]

~3,500
Customers

Net sales (2021 Actuals):



[1] Includes Businesses expected to be divested to Celanese plus Delrin®.
[2] Segment, end-market, and geographic breakdowns based on 2021 annual net sales prior to the application of discontinued operations accounting.
[3] Includes DuPont Teijin Films™ JV sites.

Automotive

Our broad portfolio of mobility solutions innovates to meet the evolving needs of industry today and tomorrow

- Automotive Electrification
- Chassis, Interiors, and Exteriors
- Powertrain and Thermal
- Connectivity and Sensors

Long industry experience and presence

OEMs	**Tier 1-2- Molders**
Testing Institutes	**Regulators**

Our leadership position in auto

ICE Powertrain	Chassis, Interior, Exterior	Connectivity and Sensors	Auto Electrification
Lightweight, Durability	**Lightweight-Safety-NVH**	**Signal Electronics**	**Safety, Efficiency, Durability**
			
#2 market position	**#3 market position**	**#2 market position**	**Emerging market**
Air management ,Oil Management, Transmission, Cooling - **Zytel® HTN, Zytel® PA , Hytrel® TPC, Vamac® AEM**	Anti-vibration, Suspension Systems, Boots and Bellows, Brake and Steering **Zytel® HTN, Zytel® PA , Hytrel® TPC Crastin® PBT, Delrin® POM**	Automotive sensors and connectors **Zytel® HTN, Zytel® PA and Crastin® PBT**	**Wide portfolio** covering all critical applications: Battery, Power Electronics, Motors, Thermal, Sealing


DUPONT
TM


Q&A Session

Thank you!

dupont.com