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AMI | Events
Plastics in Electric Vehicles
6-7 June 2023 | Munich, Germany

Safety of Electric Vehicles:

How the Right Choice of Polymers and Flame Retardants Can Help?

Cefic sector group

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Franz Janson graduated in Plastics Technology in 1986 at the Kunststoffinstitute of Darmstadt.

Franz joined TE in January 1987 as Resin Engineer and has more than 26 years of experience in plastics working for company TE connectivity.

Covering several roles as global gatekeeper with link to material selection / - release, design-/ molding requirements, prototyping and sustainability with direct global interaction with strategic resin suppliers. Lecturer & External Speaker at Plastic Conferences / Student Coaching.

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Cefic sector group

Notes and references

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Actual and future requirements for connectors in electromobility

Franz Janson

Senior Principal Engineering, Global Platform Engineering

TE Connectivity

Cefic sector group

The European Chemical Industry Council, AISBL – Rue Belliard, 40 - 1040 Brussels – Belgium
Transparency Register n°64879142323-90

Plastics in Electric Vehicles

7June 2023 Munich (Germany)
14.30 - 16.30 CEST

Actual & Future Requirements for Connectors in E-mobility

F. Janson, *Senior Principal Engineering, Global Platform Engineering*
TE Connectivity (TE)

EVERY CONNECTION COUNTS

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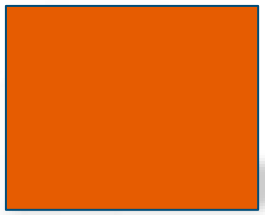
TE connectivity

1 TE - Company Introduction

2 HV & Fire Protection Requirements

3 Sustainability & Circular Economy

4 Conclusions



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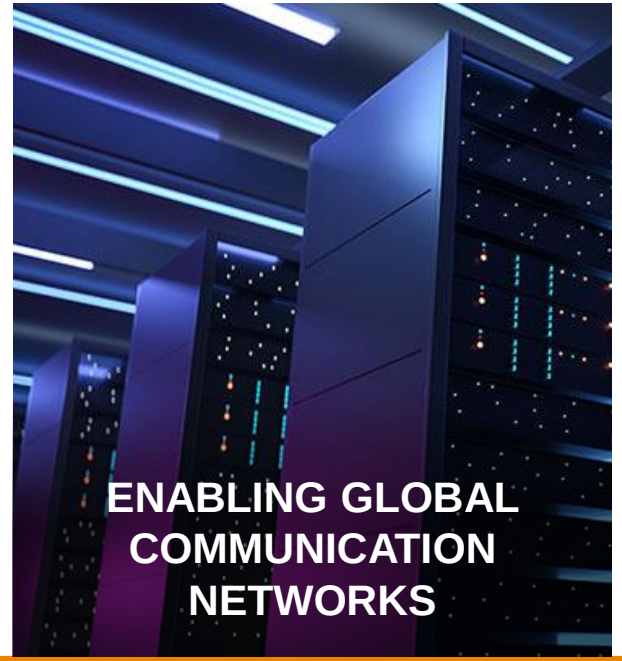
OUR PURPOSE

WE CREATE A SAFER, SUSTAINABLE, PRODUCTIVE AND CONNECTED FUTURE.

ADVANCING THE FUTURE OF TRANSPORTATION

REVOLUTIONIZING MEDICAL TECHNOLOGY



ENABLING GLOBAL COMMUNICATION NETWORKS

MAKING FACTORIES & HOMES SMARTER

Our Purpose

WE CREATE A SAFER, SUSTAINABLE, PRODUCTIVE AND CONNECTED FUTURE.

SUSTAINABLE DEVELOPMENT GOALS

INVESTOR'S BUSINESS DAILY 2021 BEST ESG COMPANIES
ENVIRONMENTAL, SOCIAL & GOVERNANCE

CDP
DISCLOSURE INSIGHT ACTION

Member of
Dow Jones Sustainability Indices
Powered by the S&P Global CSA

SCIENCE BASED TARGETS
IN PROGRESS
DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

"We've been demonstrating our commitment to sustainable business for years and our strategy is the next evolution of that.

It's proof of concept that sustainability isn't something we do, it's who we are."

Terrence Curtin, CEO

Automotive at a Glance

A GLOBAL LEADER IN AUTOMOTIVE CONNECTIVITY & SENSOR TECHNOLOGY

>40,000
PARTS

>2,000
ENGINEERS

>$6B
REVENUES

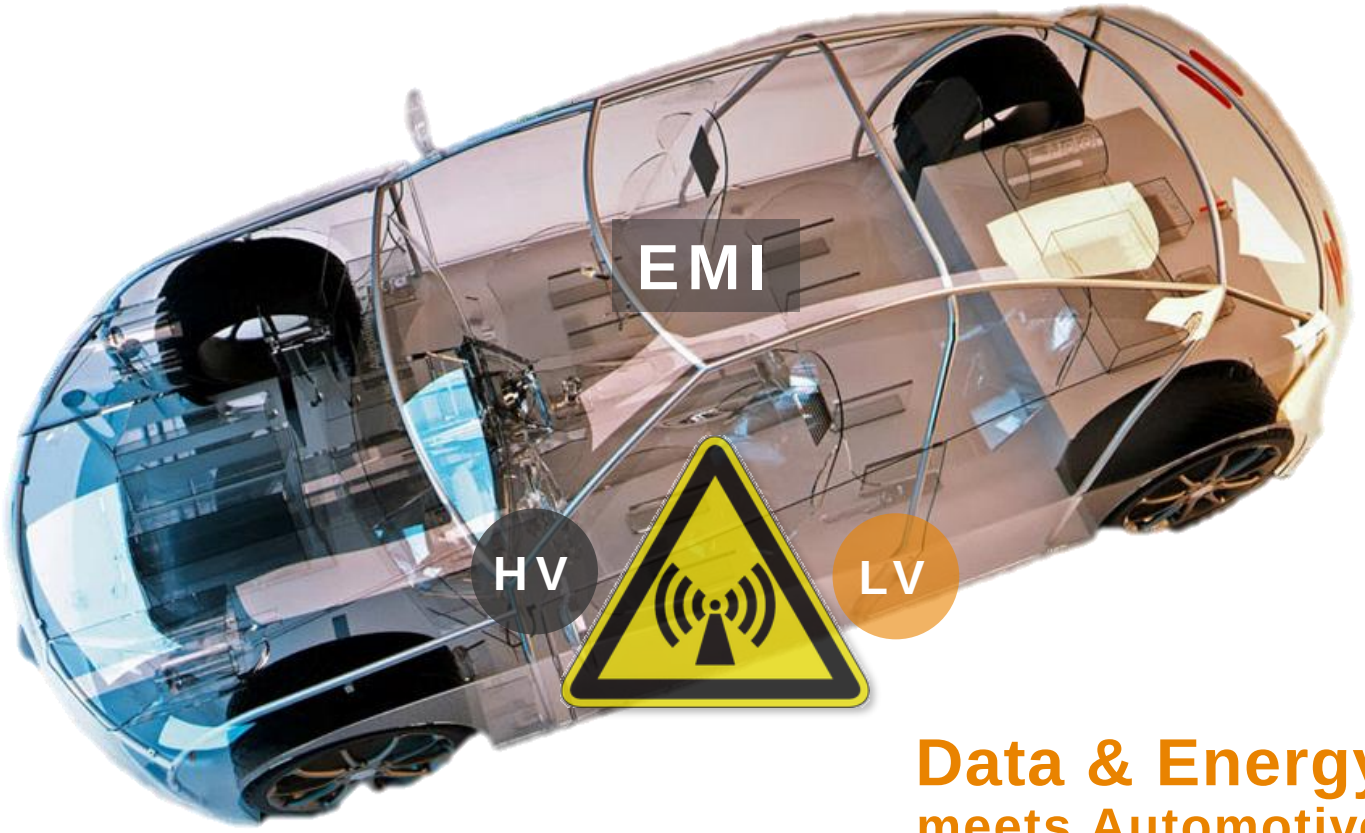
PRODUCTS

Terminals & Connectors	E-Mobility	Data	Sensors
			

FOOTPRINT

	GLOBAL
Manufacturing Sites	>20
Engineering Centers of Excellence	>20

Megatrends



Data & Energy
meets Automotive

A high reliability on the physical level is needed including HV and LV connectors

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Next-Generation Mobility

NEXT-GENERATION MOBILITY

All-Electric Vehicles + Autonomous Driving + New Transportation Models

REQUIREMENTS

ARCHITECTURAL IMPACT

- Software Driven Architectures
- High-power Drive Systems / Low Voltage Data Networks / Working in Parallel
- Wireless Connectivity to Multiple External Points

CHALLENGES

CONNECTIVITY CHALLENGES

- Connectivity for High-power Charging
- Reliable Data Connectivity in All-electric Environment
- Connectivity Software Driven Architectures
- Wireless Connectivity

SOLUTIONS

TE PRODUCTS & TECHNOLOGIES

- Advanced Thermal Modelling
- End-to-end Data Connectivity Solutions: High-speed, EMC standards compliant, Backplane Connectors
- End-to-end Antenna Portfolio for all Wireless Connectivity

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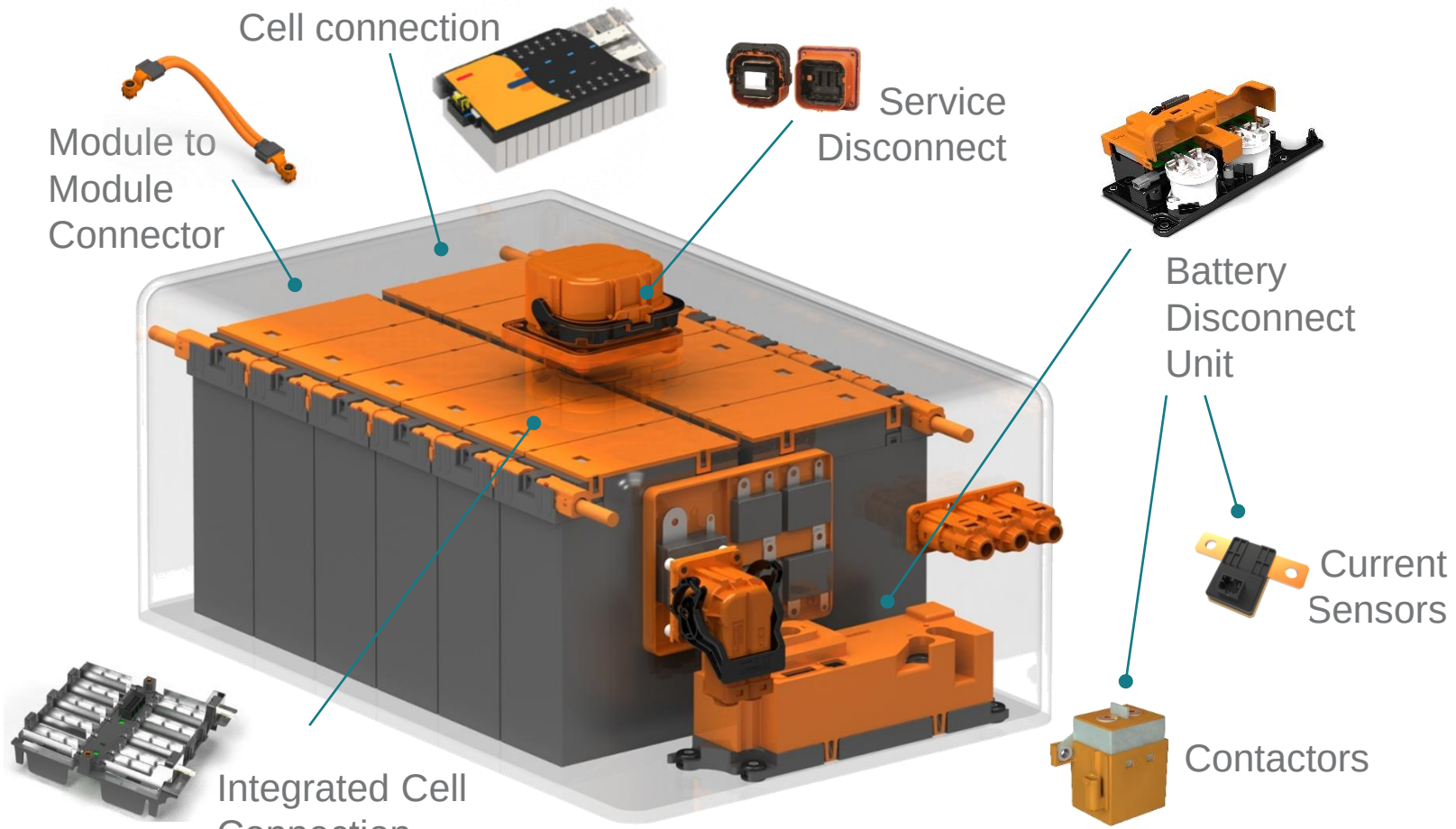
Battery Connection

TE Connectivity

Battery Connectivity & Protection Solutions



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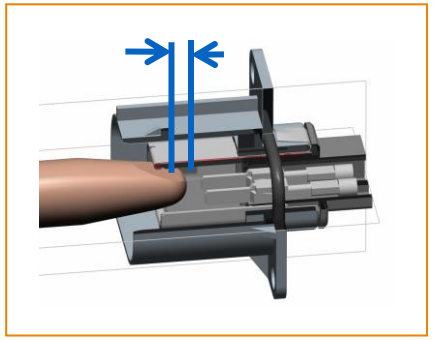
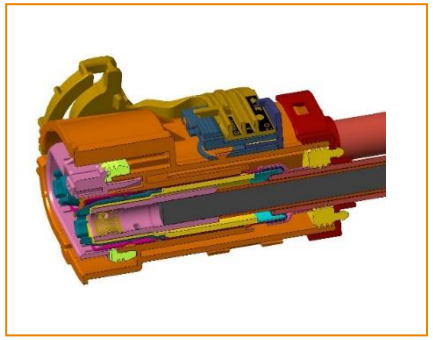
Raised requirements for HV Connectors





- Standards
- Wire
- Finger Protection
- Interlock
- Shielding
- Clearance- / Creepage Distance
- Vibration
- Assembly Process
- Validation

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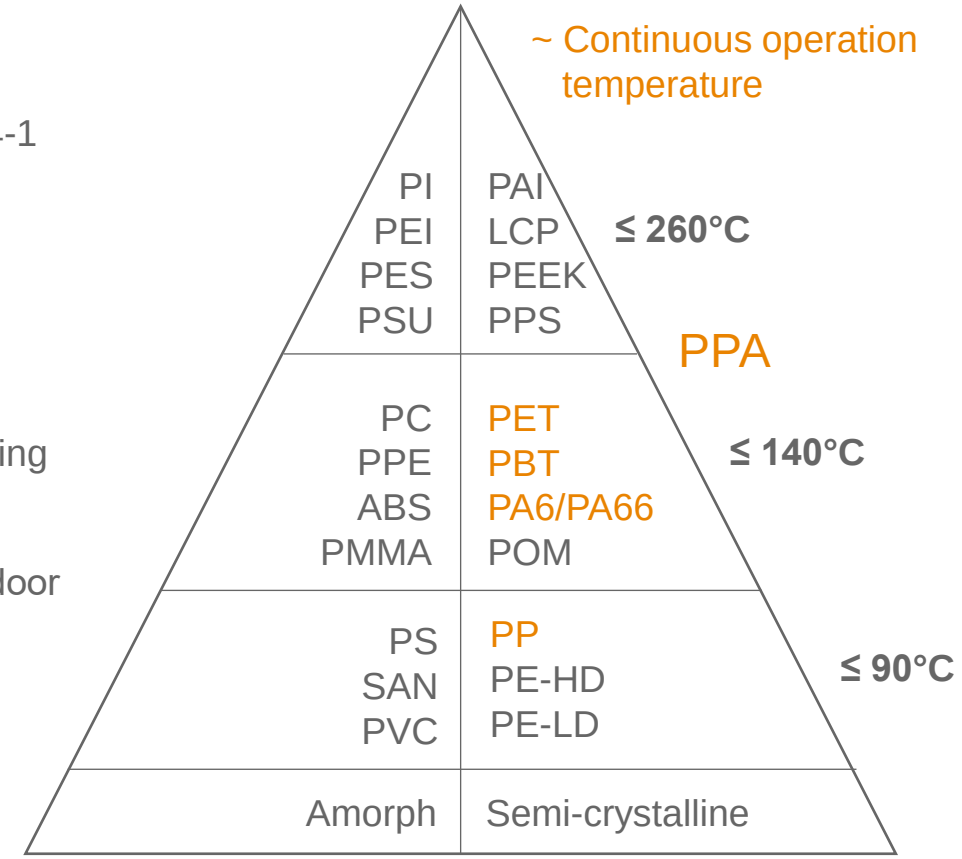
Material Trends & Technical Requirements

Clearance-
and
Creepage-
Distance

Plastics
and
Mechanical
Electrical
Thermal
Chemical

SYSTEM KNOWLEDGE REQUIRED!

- Orange → RAL 2003
- CTI 600 - IEC60112 → Design - DIN EN 60664-1
- Long term voltage stability → 1000VDC
- Maximum 140°C Environment Temperature
- Fire Classification V0 (HB) → 0,8 mm / 0,4 mm
- GWIT 775°C (GWFI 960°C)
- Stable Electrical Properties → Initial & After Aging
- Good chemical properties → HV Battery
- Charger Inlet → UL94/f1 Rating → Ozone/Outdoor
- Reflow Soldering (PPA)
- Processability → Low maintenance
- Sustainability → Green Materials → Regrind











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Challenging HV requirements → Design & materials impact

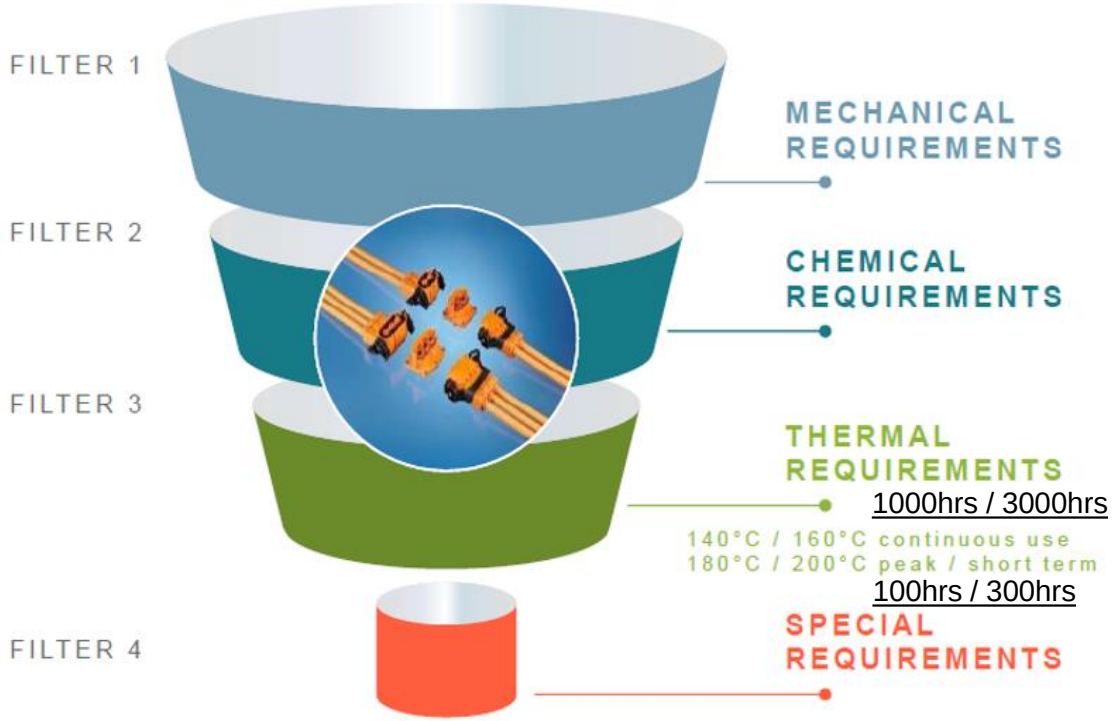
1000hrs / 3000hrs

The Challenge / Opportunity

Key requirements are:

- Move from UL94 HB → to UL94 V0 Resin
  FR compounds with UL 94 V0 at 0,8 mm → V0 at 0,4 mm
  Main Resin: PBT, PA6, PA66, HT-PPA
- CTI 600 V (IEC 60112) → Product design acc. DIN 60664-1
  Stable electrical properties → Initial & after aging
  High dielectric strength & resistivity → 150°C/1008hrs - Us car
- RAL 2003 / stable after thermal aging
  Improved laser-marking performance → DMC, data matrix code
- Sustainability –and- Circular Economy
  REGRIND up to 25% → UL746D

The Approach



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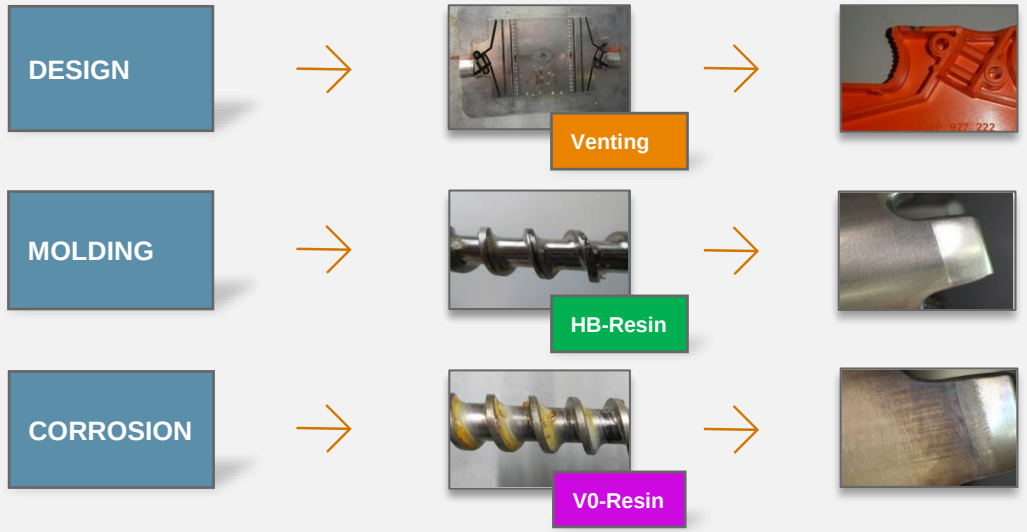
Main topics → Project headline

The Solution

- Halogen-free Flame Retardants for PA 66, PBT and HTPA
  Low Halide content → Sealed application, over-molding design
- Further additives to booster specific polymer properties,
  Hydrolytic resistance, Influence of humidity: PBT /Polyamides
  Low pH value, Consider acid scavengers → FR resin & silicone
- Heat aging and color stability → During processing
  and final application → Orange ~ RAL 2003
- Increased CTI requirements → Stable electric properties
  Over product lifetime, Dielectric strength, Resistivity
  (above 600V up to 1000V DC)
- Low maintenance during production, tool & molding machine
- Technical alignment along value chain for transportation

The Achievements

- Optimization led to well suited solutions for all HV application
  (HV connectors, Charger inlet, Busbars, Sealing elements)
  depending on technical requirements vs. application areas



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Workstream → HV Testprogram → TE & Resin Suppliers

HV RESIN PLATFORM - AUT. ENGINEERING ACTIVITIES - 2019 *to* 2023

R & D Resin Topics	Test Standards	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023
		Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4
Comparison CTI 600V vs. Tests >600V → IEC 60112 → Proof current design standards acc. IEC60664-1	IEC60664-1	Remarks: Tests on different material types/different FR technologies				
Conclusion Materials CTI above 600V up to 1000V	IEC 60112		Test on selective materials (PA-FR &PBT-FR resin & HT-FR resin)			
Laser marking for HB and V-0 materials → DMC performance / Data Matrix Code / high contrast	TBD		Remarks: Technical solution available for PBT and Polyamide (Master Batch & Pre-colored resin)			
UV-Stress / Outdoor Exposure / Time Conditions	TBD		Test for Charger Inlett resin / PA6-GF30 V0 resin			
pH-Value / acc. actual Standards?	Ford Test		Test for technical advanced products			
Influence of FR-Resin to LSR Silicone → DVR - Compression set & 2K-molding technology	TBD		Test for 2K capable material combination			
Material definition for 2K molding & single seals	TBD			Remarks: Based on test results with Momentive and Wacker		
FR Resin: Influence on Mold desposit & Maintenenace	TBD		Remarks: Proof FR-system (corrosive/less corrosive) → Material type (PBT/PA/HT resin)			
FR Resin: Influence on Molding machine & Tool	TBD		Remarks: Proof FR-system (corrosive/less corrosive) → Material type (PBT/PA/HT resin)			
FR Resin: Corrosion influence on contacts & PCB	TBD		Remarks: Proof FR-system (corrosive/less corrosive) → Material type (PBT/PA/HT resin)			
Conclusion: Material selection → Avoid corrosion	TBD			Remarks: Proof FR-system → Impact on steel specification (Chrome content)		
specificationRecycling: Regrind - Closed Loop Process	TBD		Sustainability: Waste reduction / Regrind / Closed loop system / GWP (Global warming potential)			
Sustainability: Carbon Footprint → DIN EN ISO 14044	TBD			AMST: Improve resin selection (PP/PBT/PA/HT-PA) → Reduce energy consumption (NPD)		
Renewable Resin / Material Proposal (ECO)	TBD			NPD: Bio-based-Resin / Reduce CO_2 - Footprint → Release new materials		
Technical/Summary: Test Results & Material Selection	TBD			Overview: Design Requirements – Test Standards – Resin – Molding – HV Application Area		

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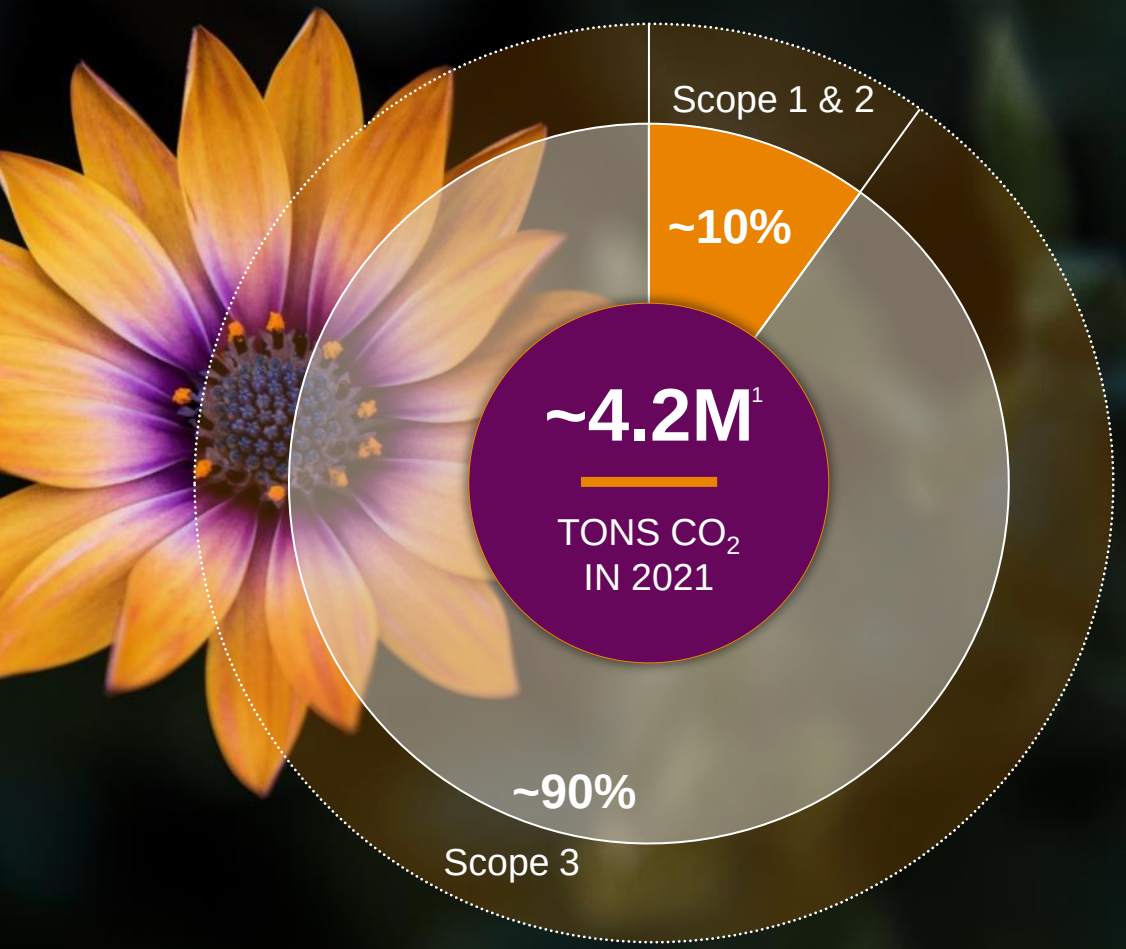
TE Connectivity Carbon Emission Overview



SCOPE 1 & 2:

Energy used in **production** and **transportation** with largest share of our carbon emissions

SCOPE 3:

Resins and metals further processed in our plants major carbon emission contributors

TARGETS

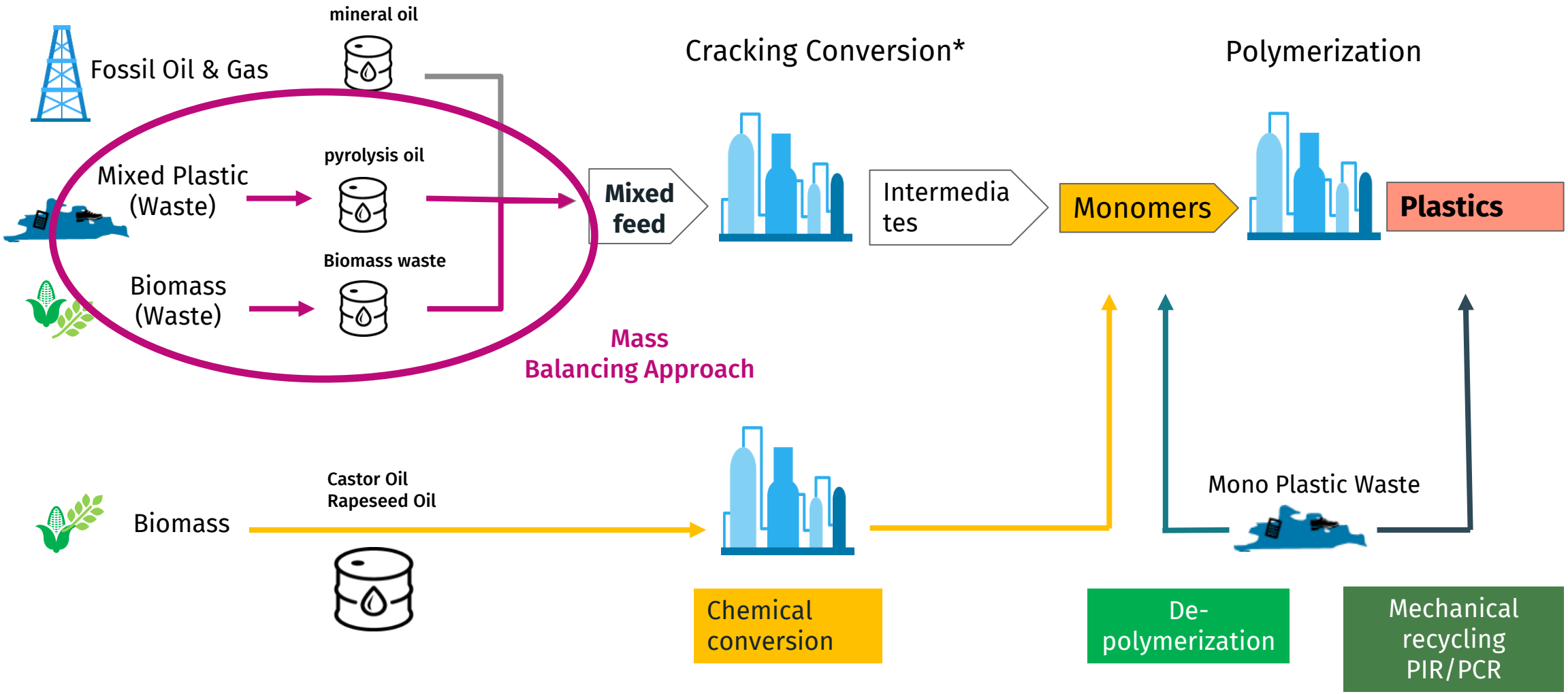
40%+ absolute reduction in **Scope 1 & 2** GHG emissions by 2030

Goal of **25%** GHG reduction in **Scope 3** by 2030 in progress

SBTi[2] **commitment decided**, but we are still in the application process

[1] Total GHG emissions Scope 1-3 of TE Connectivity (in metric tons CO_2 equivalent) [2] Science Based Targets Initiative

Recycling Trends → Circular Economy Solutions



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Regrind → Actual Automotive Engineering Activities

TE quality on part level secured over different internal & external specifications!

TEC-115-32037 Global AUT
Engineering Regrind 25% / >25%

Resin Supplier
New Regrind project
PEE & CE teams

UL746D recommends
25% Regrind for plastic molded parts

TE internal & **external**
Regrind increase
TE molding & at molders

UL94 Yellow Card
resin (HB/V0)
Regrind 25% / 50%

TE Customers
Circular Economy-
Sustainability activities

PLATFORM actualization
Regrind % each
resin specification

Network cross BUs, CTC, COE,
leading Suppliers, Institutes, Academies

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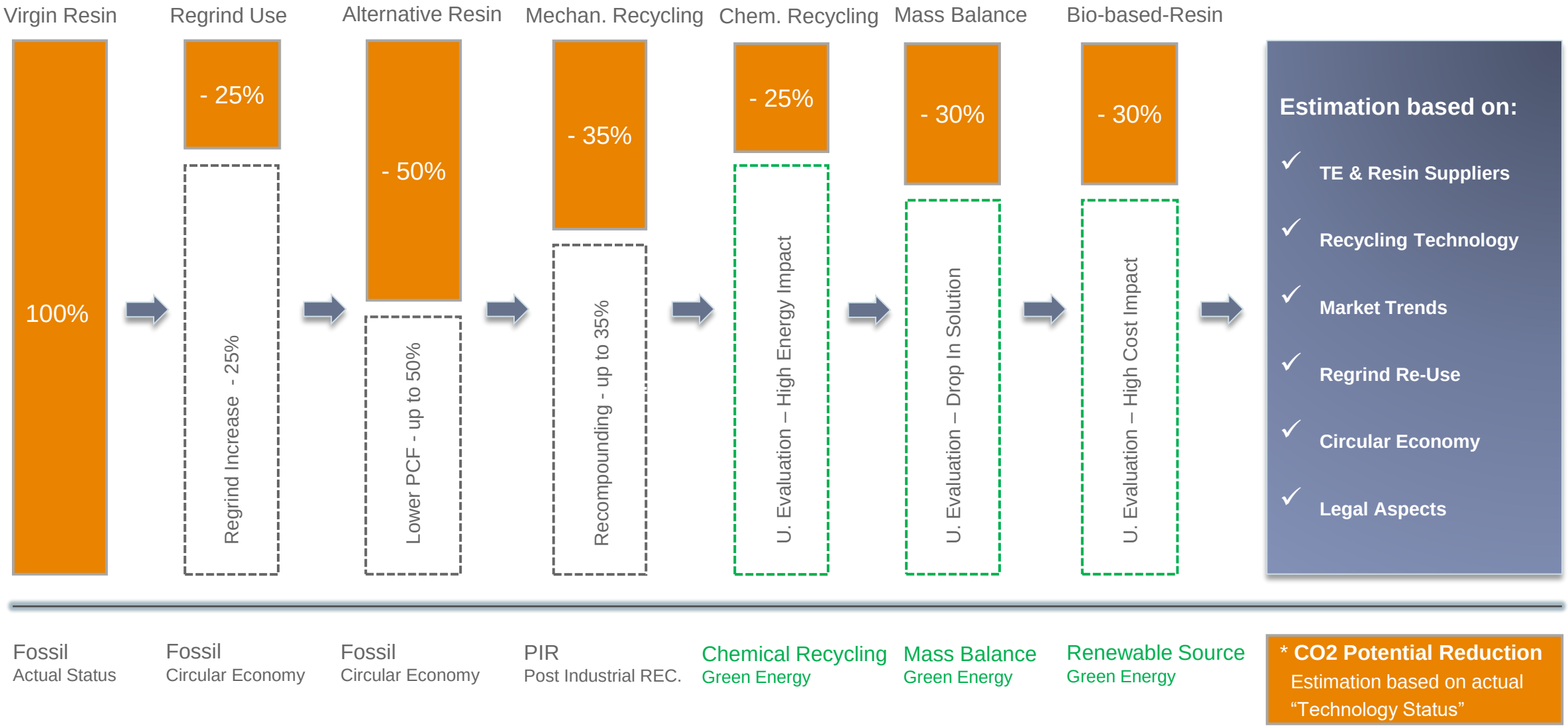
Sustainability → Impact on CO_2 Reduction



Safety of Electric Vehicles

Requirements & Conclusion

1 TE - Company Introduction

2 HV & Fire Protection Requirements

3 Sustainability & Circular Economy

4 Conclusions

EVERY CONNECTION COUNTS

Conclusions → HV & Sustainability Trends

HV - Resin Requirements

- **HV Design** → UL94 V0 requirements as main resin focus
  Main Materials: PBT, PA6, PA66, HT-PA
- **Stable resin performance** → Lifetime, initial and after aging
- **CTI 600V** IEC 60112 → Product design acc. DIN 60664-1
  Improved electrical properties → 800V DC / 1000V DC
- **Orange ~ RAL 2003** → Main color standard for HV application
  Improved laser-marking → data matrix perormance → DMC
- **Circular Economy** → UL746D, consider up to 25% REGRIND
- **Sustainability** → NPD, consider CO_2 footprint for materials

Sustainability - Recycling

(Supplier footprint differs depending on energy sources)

- **Mechanical recycling** → Trend requested by TE customers
  High impact in CO_2 reduction, Lowest price, PIR/PCR content becomes limited for larger volumes, Mainly BLACK colors
  Lower properties, Design & Process adaption to be verified
- **Mass Balance** → Direct drop in solution in actual design,
  Same properties as VIRGIN-fossil-based-resin, Colors possible
  Higher price vs. virgin resin, Highest impact on CO_2 reduction
- **Chemical recycling** → Depolymerization = High Energy consumption vs. Mechanical recycling, Colors possible
  Potential drop in solution, Highest price impact
- **Bio-based-Resin** → Limited volume, High price, SMD soldering

E-Mobility → Test Standards & HV Materials

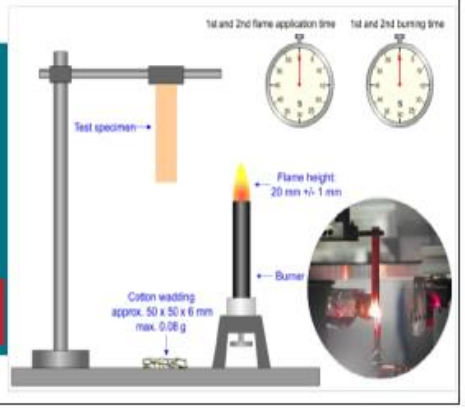
Demanding Safety Requirements / Fire Protection / Electrical Performance

Burning Behavior / UL 94 V

Traditional flame testing on injected molded specimens or samples cut from finished parts

Basis for raw material evaluation (e.g. effectivity of flame retardants for polymers in battery applications)

V0 materials do not replace smart battery cell designs



Burning Behavior / FMVSS 302

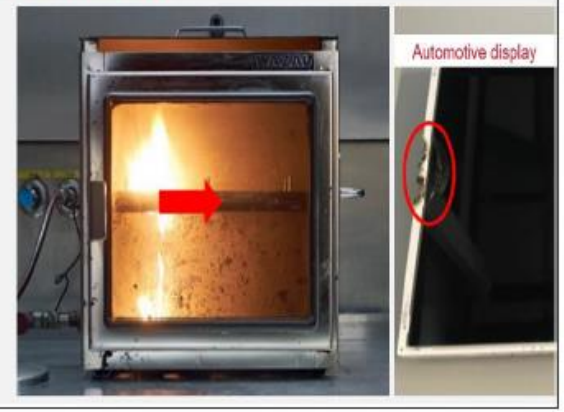
US FMVSS 302

(Federal Motor Vehicle Safety Standards)

- Burning time
- Burning path
- Burning rate

Flammability ratings (fire classes) are assigned accordingly

Expansion of test scope to electronic components (e.g. screens & displays)



Electrical Testing / Glow Wire

Test simulates an over-heated part, which then comes into contact with plastic materials

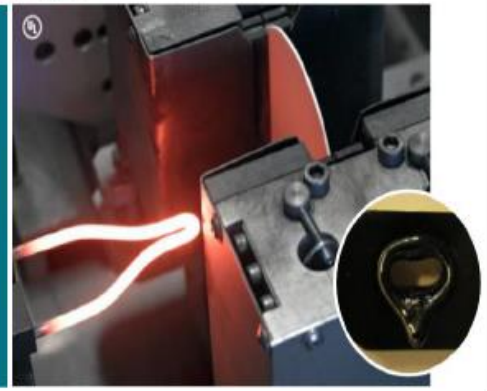
Reflects misuse, malfunction, or failure of an end product

Test temperature: increased by 50 K steps

Exposure to glow wire: 30 s

Failure criteria:

- Sample does not burn or glow 30 s after glow wire contact



Electrical Testing / Comparative tracking index (CTI)

Test initiates electrolytic corrosion on the surface of a specimen (acc. to IEC 60112 test standard)

Test voltage: 100 to 600 Volt (increased by 25 V steps)

Failure criteria:

- Sample burns
- Current exceeds 0.5 Ampere (>2 s)

Many clients request CTI testing up to 800 V; requires new test setup!

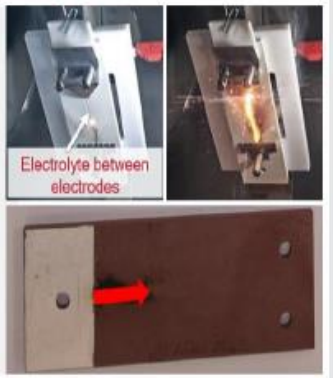
Electrical Testing / Inclined Plane Tracking (IPT)

Test "simulates" isolation behavior of materials exposed to humidity & contamination

Test voltage: 1 kV to 7 kV (increased by 250 V steps)

Failure criteria:

- Sample burns
- Formation of hole(s)
- Tracking path reaches 25 mm
- Current exceeds 60 mA



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ANY CONNECTION CAN CHANGE THE WORLD

EVERY CONNECTION COUNTS

TE connectivity

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«HV-requirements & Sustainability impacts your material selection for future requirements reflecting connectors in electromobility.»

Franz Janson,

Senior Principal Product Development Engineer

Global Automotive Resin Platform

TE Connectivity

Cefic sector group

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Transparency Register n°64879142323-90

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Thank you.

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Specialty Chemicals
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About Cefic

Cefic, the European Chemical Industry Council, founded in 1972, is the voice of large, medium and small chemical companies across Europe, which provide 1.2 million jobs and account for 15% of world chemicals production. Cefic members form one of the most active networks of the business community, complemented by partnerships with industry associations representing various sectors in the value chain. A full list of our members is available on the Cefic website.
Cefic is an active member of the International Council of Chemical Associations (ICCA), which represents
chemical manufacturers and producers all over the world and seeks to strengthen existing cooperation with global organisations such as UNEP and the OECD to improve chemicals management worldwide

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