DuPont Zytel® HTN Bio-based PPA Resins for SMT Connectors

March 3, 2020

DuPont Transportation & Industrial

About the Presenter

Nainish B. Sanghani
Global Strategic Marketing Leader, Electrical & Electronics, at DuPont Transportation & Industrial business, is responsible for driving innovation and global business development. In this position, he is focused on setting strategy and developing solutions for electrical and electronics markets, including consumer electronics, connectors, 5G networks, electrical components and wire & cable.

Since joining the company in 2005, Nainish has held several key positions in sales, business development, product line management, strategic marketing in India, Asia-Pacific and the USA.

Nainish graduated from the Saurashtra University, India with a Bachelor of Mechanical Engineering. He also holds Master of Business Administration from NMIMS, University of Mumbai, India.

Agenda

- Introduction – New DuPont and Transportation & Industrial (T&I) Business
- DuPont's Engineering Polymers Portfolio and DuPont Zytel® HTN
- Surface Mount Connectors and Key Types
- Top Criteria for Polymer Material Selection for SMT Connectors
- Introduction - Zytel® HTNFR42G30NH and Zytel® HTN42G30EF
- Q&A

New DuPont and T&I Business


We empower the
world with essential
innovations to thrive…


…by discovering
and delivering
results that matter.

Our journey to three: creating world leading companies

2017 → **2019** →

We brought together the complementary, innovative portfolios and pipelines of Dow and DuPont

With the intent to create three strong, independent companies

April

Materials Science

June

Agriculture

June

Specialty Products

Centuries of progress

The explosives era

E. I. du Pont de Nemours and Company was founded on the banks of the Brandywine River, in Wilmington, Delaware

1802

Centuries of progress

Chemistry and the polymer revolution

We established our research laboratory, the Experimental Station, the birthplace of some of our biggest innovations — including nylon, Tyvek®, Kevlar® and Sorona® polymer

1902

Welcome to a new DuPont

Specialized solutions

Essential innovations from highly engineered products and naturally sourced ingredients to shape industries and everyday life

2019

Transforming everyday lives in 70+ countries

32,000+
Colleagues

~170
Manufacturing Sites

10+
Global R&D Centers

DUPONT

Driving innovation for a diverse set of industries

$22.6B

2018 net sales

By business segment

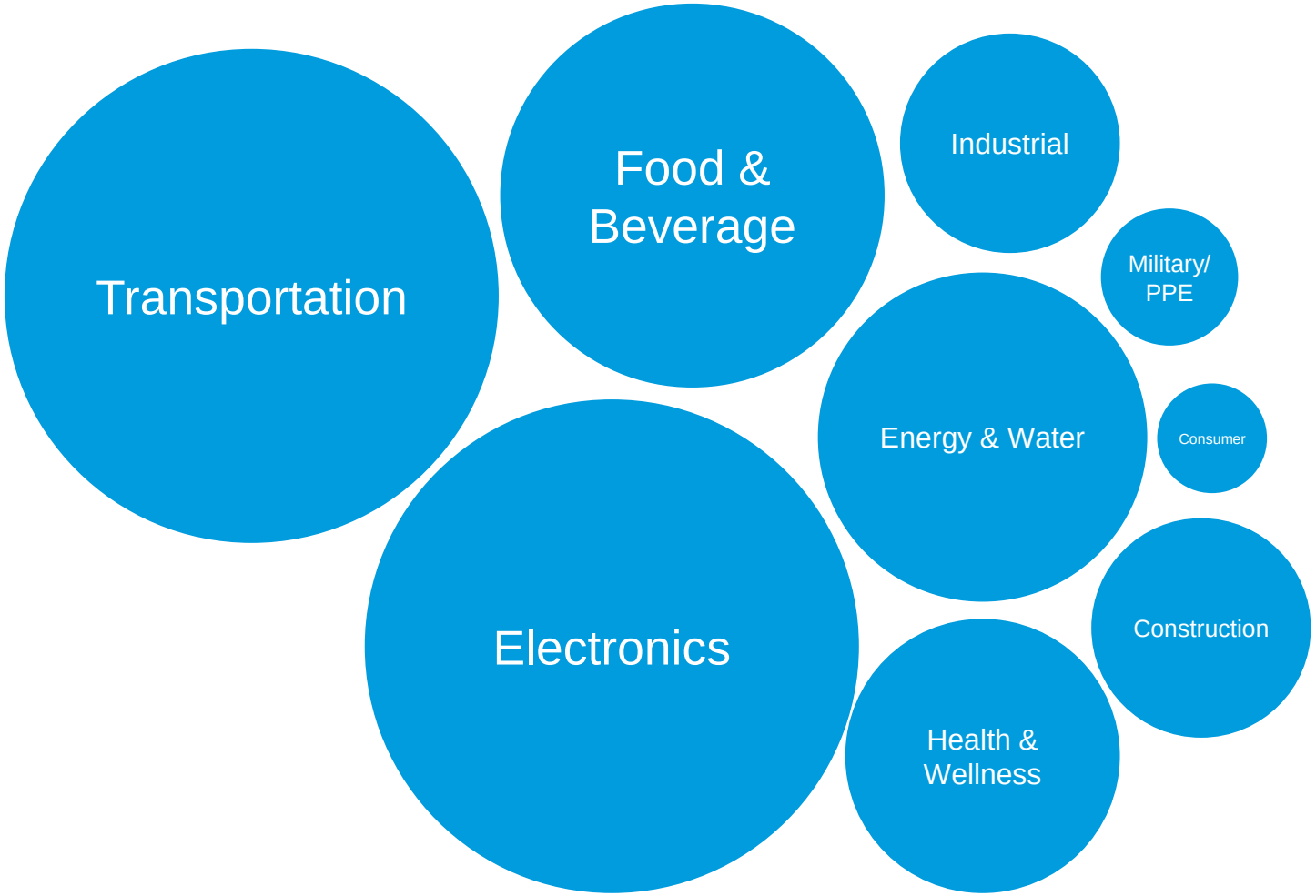
~$6.8B Nutrition & Biosciences

~$5.6B Transportation & Industrial

~$5.5B Safety & Construction

~$4.7B Electronics & Imaging

By end market



DUPONT™

Transportation & Industrial

Transforming industries and improving lives through material science

Transportation & Industrial - Our solution space

Advanced Mobility

Healthcare

Electrical/Electronics

Consumer

Industrial

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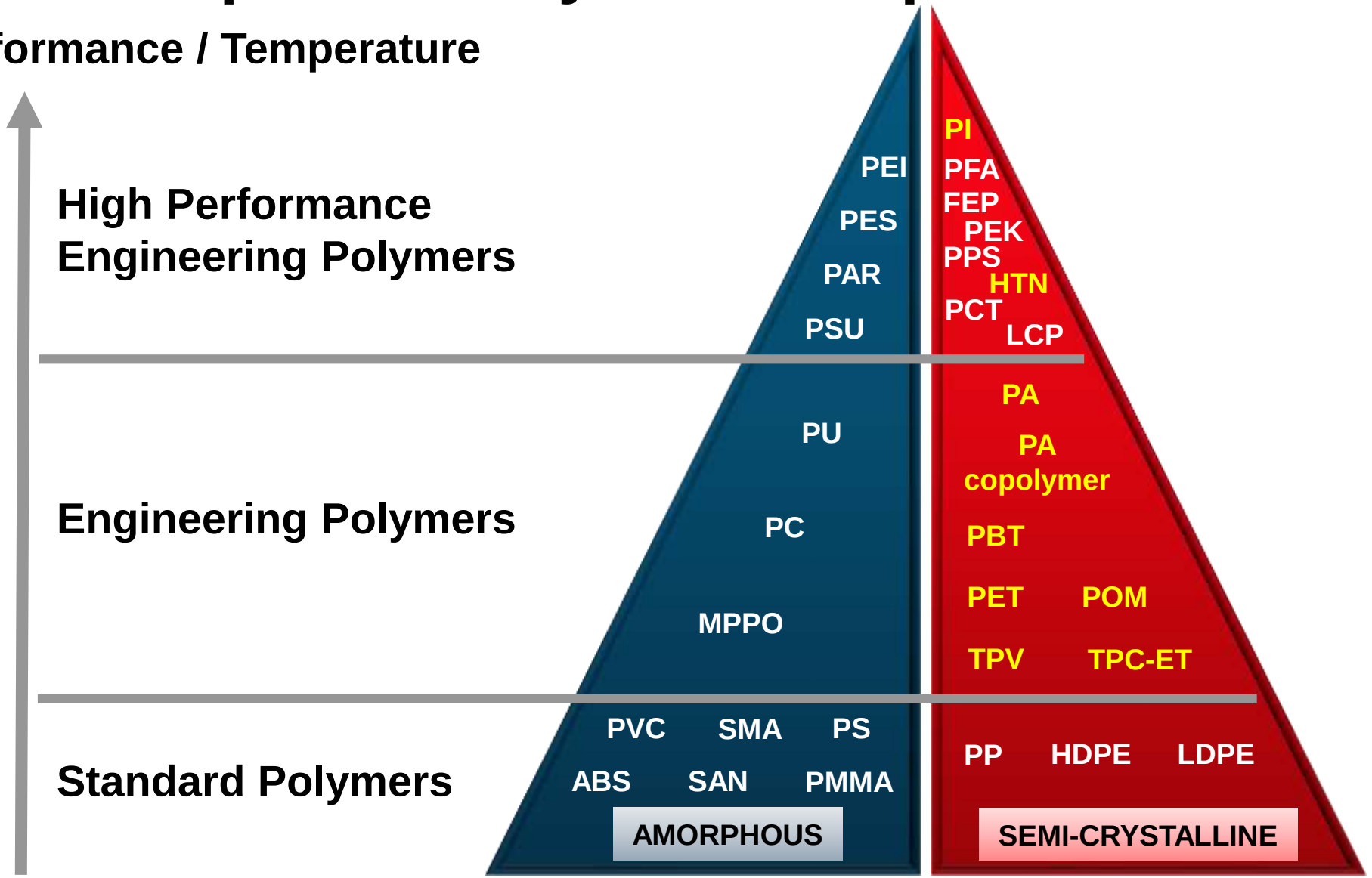
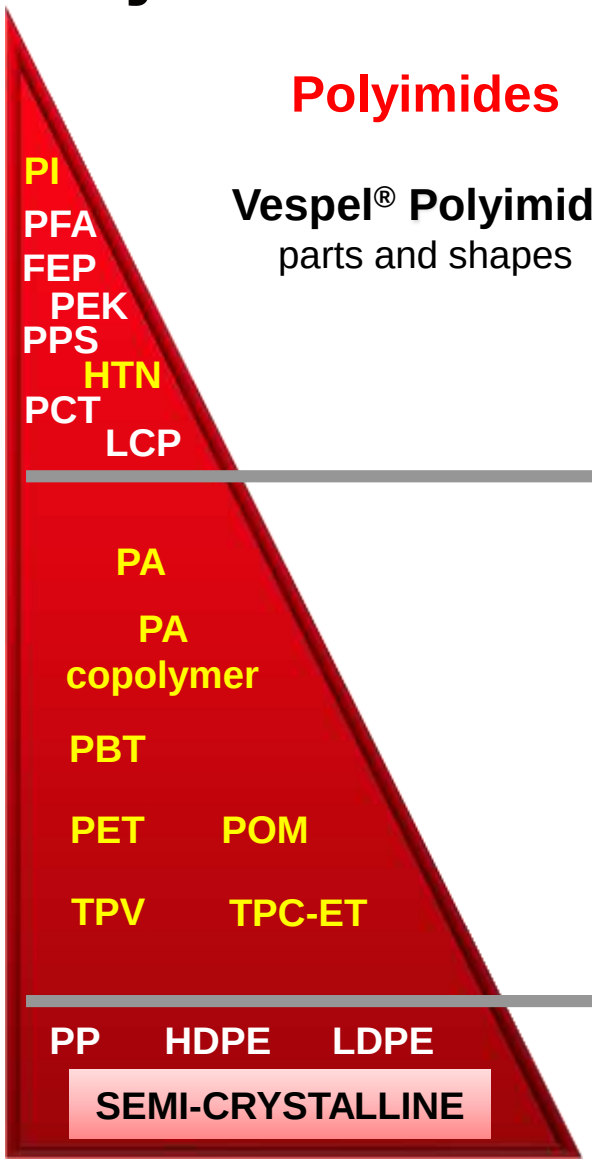
DuPont’s Engineering Polymers Portfolio and Zytel® HTN

Major Thermoplastic Polymer Groups

Price / Performance / Temperature



Major Thermoplastic Polymer Groups



Polyimides	Polyamides	Polyesters	Polyoxymethylene
Vespel® Polyimide parts and shapes	**Zytel® HTN** high performance polyamide resin		
	Zytel® Plus glass reinforced	**Rynite® PET**	
	Zytel® Nylon Resins toughened, conductive, unfilled, glass reinforced	**Crastin® PBT**	**Delrin® POM**
	Minlon® mineral reinforced nylon resin	**Hytrel® TPC-ET**	
	Zytel® LCPA		

Bio-based products (in green color) are commercial today

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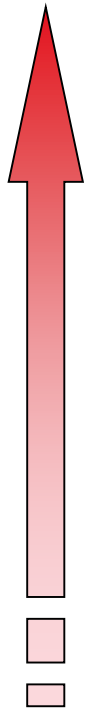
Basics of Zytel® Nylon & Zytel® HTN High Performance PPA Resins

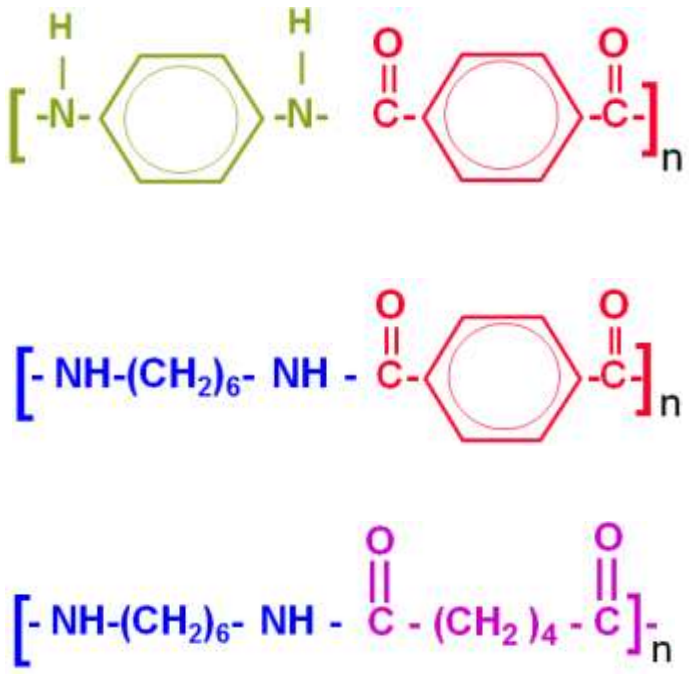
KEVLAR®
fully aromatic polyamide

Zytel® HTN
semi aromatic polyamide

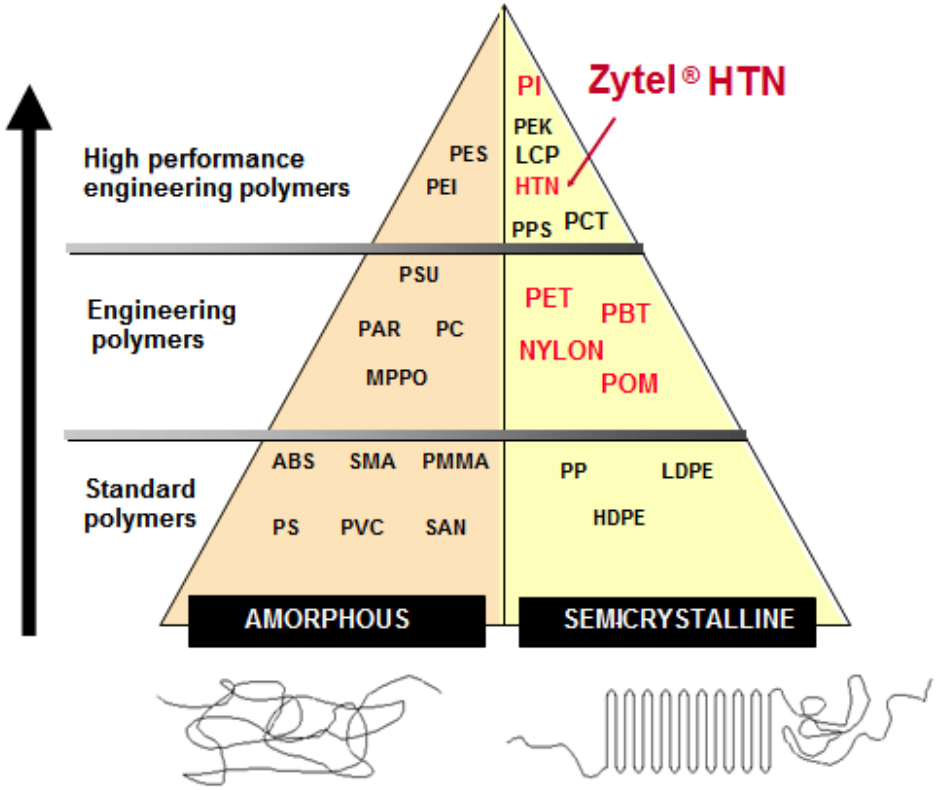
Zytel® PA66
aliphatic polyamide



Increasing melt point & properties



Amine Segment Acid Segment



Zytel® HTN: Higher Tg & melting temp., Lower moisture sensitivity vs. aliphatic nylons

Zytel® HTN 42 – New Platform for Zytel® HTN PPA

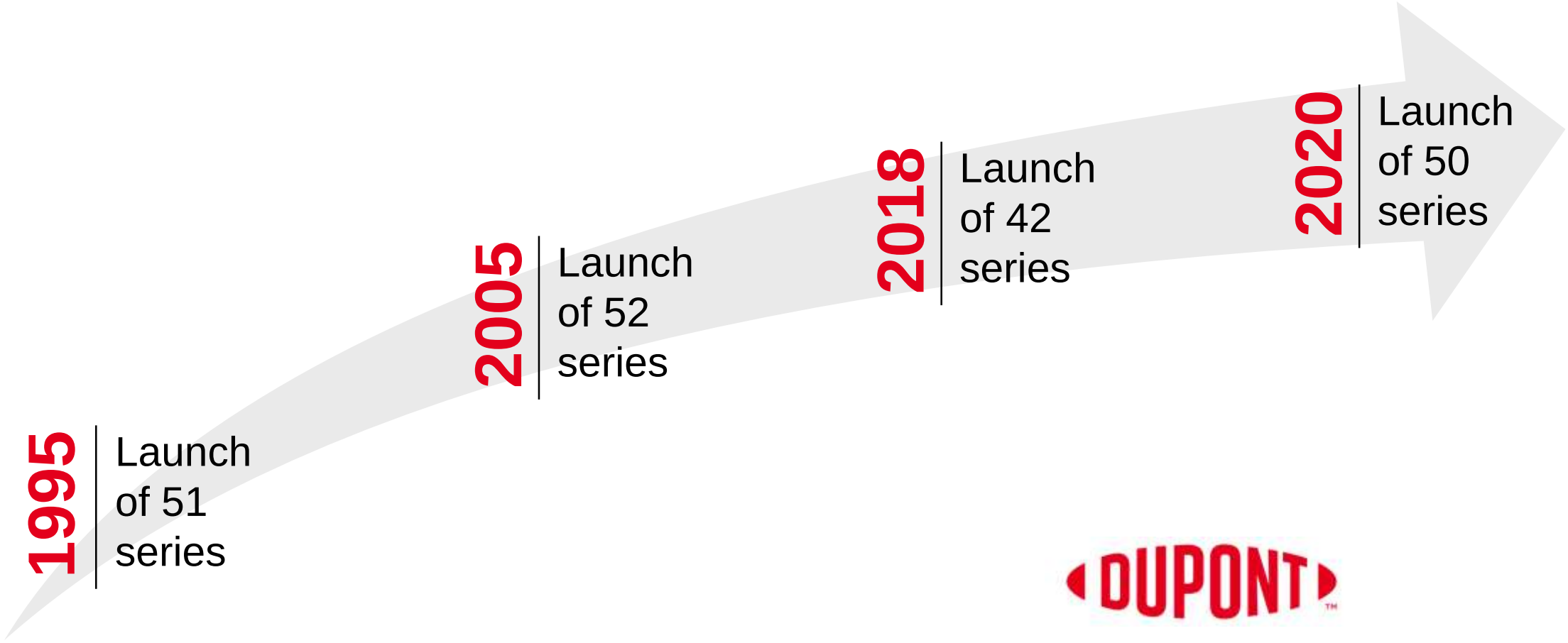
Zytel® HTN PPA bridges the performance gap between conventional engineering resins and high-end specialty polymers in a cost-effective way.

When to use Zytel® HTN (PPA)

- Zytel® HTN 50 series offers balanced mechanical and chemical/thermal resistance performance with excellent processing, knit-line strength and melt stability
- Zytel® HTN 51 series offers outstanding chemical resistance and retention of properties when exposed to moisture.
- Zytel® HTN 52 series offers a higher melting point and deflection temperature, and is moldable in water-heated tools.
- Zytel® HTN 53 series offers improved stiffness and toughness at ambient/moderate temperatures, an excellent surface appearance, and is moldable in water-heated tools.
- Zytel® HTN 54 series offers high burst pressure, retention of properties with moisture, high level of stiffness up to 110ºC, and is moldable in water-heated tools.
- Zytel® HTN 92 series, enhanced with DuPont™ SHIELD Technology, offers high performance at temperatures up to 230ºC.
- Zytel® HTN 42 series offers bio-based high performance nylon resin solutions with good balance between improved performance and cost effectiveness especially when reflow process is needed.

Zytel® HTN

25 Years of PPA based Innovation !



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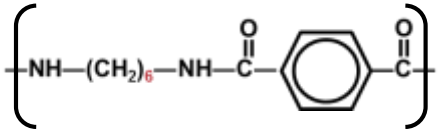
Zytel® HTN High Performance Resins



Typical Applications

Automotive Charge Air Cooler End Cap

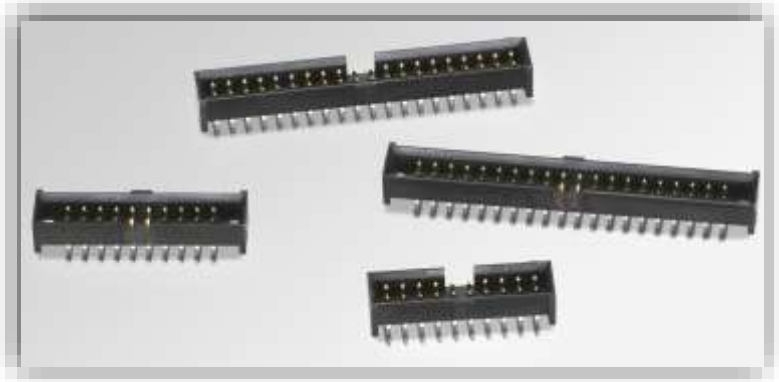
Thermostat Housings

Water Jacket Spacer

Automotive Fuel Cut-off Valve

Laptop Housings

Encapsulated Solenoids



Electronic Connectors

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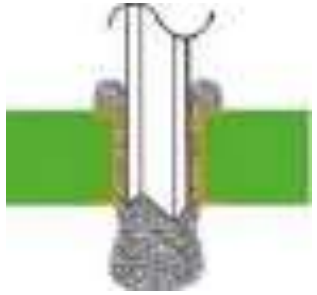
SMT Connectors & Key Types

What are Surface Mount Connectors

Surface Mount Technology (**SMT**) is a method in which the components are mounted or placed directly onto the surface of a printed circuit board (PCB) as opposed to inserting components through holes (THR) as with conventional assembly. An electronic device so made is called a **surface-mount device** (**SMD**).

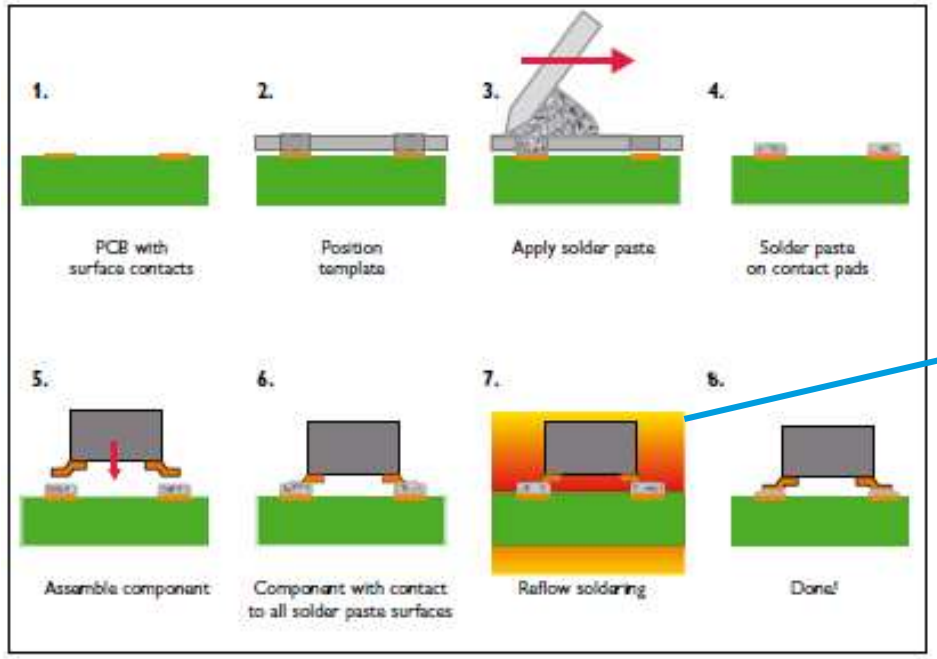
Surface Mount Technology

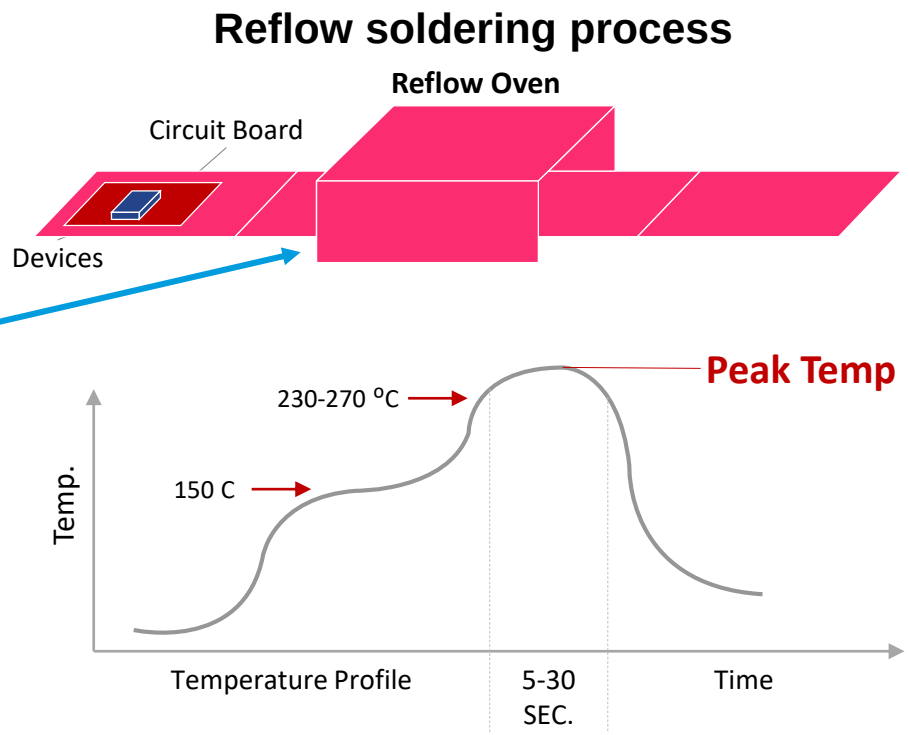


Through Hole Technology

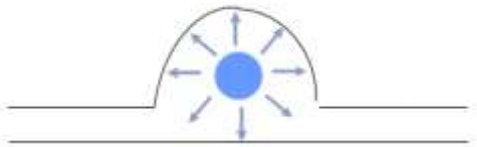
- SMT enables to build highly complex electronic circuits into smaller and smaller assemblies with good repeatability due to the higher level of automation. It is also more cost and time efficient.
- With on-going trends of designs that save space, miniaturization, increase in contact densities and market trends of connectivity, autonomous driving, surface mount connectors are continuing to be widely adopted across variety of end use markets including data & devices, automotive.

Surface Mount Process & Reflow Soldering Process





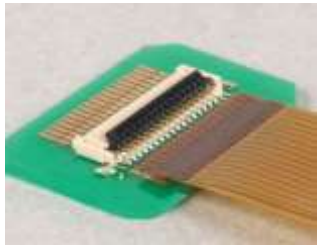
Blistering on the parts after reflow



Expansion of moisture

Surface Mount Connectors – Several Types & Form Factors

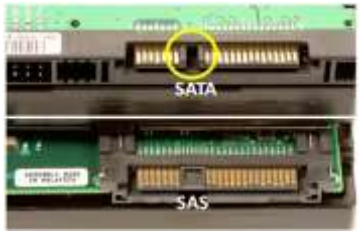
Board to Board



Flexible Printed Circuit /
Flexible Flat Cable

HDMI
Receptacle

USB 3.1
Type-C



SATA & SAS Plug

Memory Module Socket

Audio Jack

Automotive PCB and Data

Typical Specification: Product Category, Number of positions, Pitch, Mounting Angle, Current & Voltage Rating, Operating Temp, Contact materials, Compliance

Criteria for Material Selection

Key Criteria for Polymer Material Selection*

S No	Criteria	Properties/Requirements	Why It Matters
1	Thermal Properties Aging (short & long term)	Temp of deflection under load; UL 746B RTI	Stability - Withstand lead-free solder reflow process. measure of “stiffness” of the material as the temperature increases
2	Mechanical Properties	Tensile Strength, Tensile Modulus, elongation at break; Impact performance	Reliability - Balance between toughness and stiffness
3	Flammability	UL 94 V-0, HB; GWFI, GWIT	Safety. Understand risks of using material
4	Processing	Flow-ability, Viscosity, non-corrosive	Thin wall, miniaturization, less defects, higher productivity
5	Electrical Properties	Comparative Tracking Index (CTI); Dielectric Strength; Volume Resistivity Relative permittivity (Dk)	Safety & Reliability- Meet electrical voltage and current requirements. Effectiveness of insulation. Compatible with high-speed signal transfer up to 10Gb/s
6	Dimension stability (In both heat & moisture)	low thermal expansion, low hygroscopy	Reliability of performance under varying environmental conditions
7	Regulation	e.g. RoHS, Non-halogenated	Right to Operate
8	Sustainability	Bio- based, post consumer recycled, LCA	Contribute toward reducing GHG emissions
9	Color-ability & Fastness	Minimal impact on other properties	Support market needs
10	Cost, Availability & Service	Resin cost, density of resin, maintenance, Technical support, Formulation	Meet Design Requirement, Reliability
11	Qualifying Test for components	e.g. IPC/JEDEC J-STD-020 Moisture Sensitivity Level 1 to 6	Reliability – Measure of moisture absorption, under influence of temp during soldering can lead to destruction of components

*not an exhaustive list

Introduction - Zytel® HTNFR42G30NH

Broadens our Zytel® HTN PPA Offerings for SMT Connectors

Grade platform	Non Halogen FR	Bio-based	CTI (V) IEC60112	High Flow
HTNFR52G*xx*BL [1]			≤ 525	
HTNFR52G*xx*NH [1]	✓		600	✓
HTNFR42G30NH	✓	✓	600	✓ ✓

(1) HTNFR52GxxBL and HTNFR52GxxNH grades available in different glass loadings and colors; HTNFR42G30NH BK337 and NC010 are currently available product of the HTNFR42GxxNH platform.

Bio-based HTN FR42G30NH offers a unique combination of reliability, performance and productivity thanks to the UL 94 V0 flammability rating and superior flow.

Zytel® HTNFR42G30NH – UL Card

iq.ul.com

PROSPECTOR® CLICK TO CONTINUE

View additional material information including performance and processing data

The information presented on the UL Prospector datasheet was acquired by UL Prospector from the producer of the material. Ul Prospector makes substantial efforts to assure the accuracy of this data. However, UL Prospector assumes no responsibility for tl data values and strongly encourages that upon final material selection, data points are validated with the material supplier.

Component - Plastics E4193

Guide Information

E I DUPONT DE NEMOURS & CO INC

ENGINEERING POLYMERS, CHESTNUT RUN PLAZA, PO BOX 80713, WILMINGTON DE 19880-0713

HTNFR42G30NH

Polyamide (PA), glass reinforced "Zytel", furnished as pellets

Color	Min. Thk (mm)	Flame Class	HWI	HAI	RTI Elec	RTI Imp	RTI Str
BK, NC	0.4	V-0	4	0	130	115	125
	0.8	V-0	3	0	130	115	125
	1.5	V-0	0	0	130	115	125
	3.0	V-0	0	0	130	120	130

Comparative Tracking Index (CTI): 0

Dielectric Strength (kV/mm): -

High-Voltage Arc Tracking Rate (HVTR): -

Dimensional Stability (%): -

Inclined Plane Tracking (IPT) kV: -

Volume Resistivity (10^X ohm-cm): -

High Volt, Low Current Arc Resis (D495): -

UL 746H Non-Chlorine & Non-Bromine Material (color: BK, NC) view certificate

NOTE - (1) Material designations that are color pigmented may be followed by suffix letters and numbers. (2) Material designations may be prefixed by "ZYT" for Zytel or "MIN" for Minlon or "DEL" for Delrin or "CRA" for Crastin or "RYN" for Rynite or "ETPV" for ETPV or "SOR" for Sorona grades.

ANSI/UL 94 small-scale test data does not pertain to building materials, furnishings and related contents. ANSI/UL 94 small-scale test data is intended solely for determining the flammability of plastic materials used in the components and parts of end-product devices and appliances, where the acceptability of the combination is determined by UL.

Report Date: 2017-11-16

Last Revised: 2018-09-27

Improved safety thanks to UL 94 V0 rating at 0.4 mm and Tracking Resistance (CTI) of 600V

Zytel® HTNFR42G30NH – UL Card

IEC and ISO Test Methods				
Test Name	Test Method	Units	Thk (mm)	Value
Flammability	IEC 60695-11-10	Class (color)	0.4	V-0 (BK, NC)
			0.8	V-0 (BK, NC)
			1.5	V-0 (BK, NC)
			3.0	V-0 (BK, NC)
Glow-Wire Flammability (GWFI)	IEC 60695-2-12	°C	0.4	960
			0.8	960
			1.5	960
			3.0	960
Glow-Wire Ignition (GWIT)	IEC 60695-2-13	°C	0.4	750
			0.8	800
			1.5	800
			3.0	825
IEC Comparative Tracking Index	IEC 60112	Volts (Max)	-	CTI600
		Material Group		I
IEC Ball Pressure	IEC 60695-10-2	°C	-	-
ISO Heat Deflection (1.80 MPa)	ISO 75-2	°C	-	-
ISO Tensile Strength	ISO 527-2	MPa	-	-
ISO Flexural Strength	ISO 178	MPa	-	-
ISO Tensile Impact	ISO 8256	kJ/m^2	-	-
ISO Izod Impact	ISO 180	kJ/m^2	-	-
ISO Charpy Impact	ISO 179-2	kJ/m^2	-	-

Excellent GWIT allowing the utilization in Lighting and appliances

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Productivity

Our new non-halogenated, bio-based high performance nylon resin Zytel® HTNFR42G30NH meets the evolving trends for surface mount connectors by providing,

- Increased productivity, with no blistering at surface mount technology (SMT) reflow temperatures of 280 ^{O}C
- Superior flow and better weld line strength, increasing design flexibility for multi-pins, fine pitch and low height connectors

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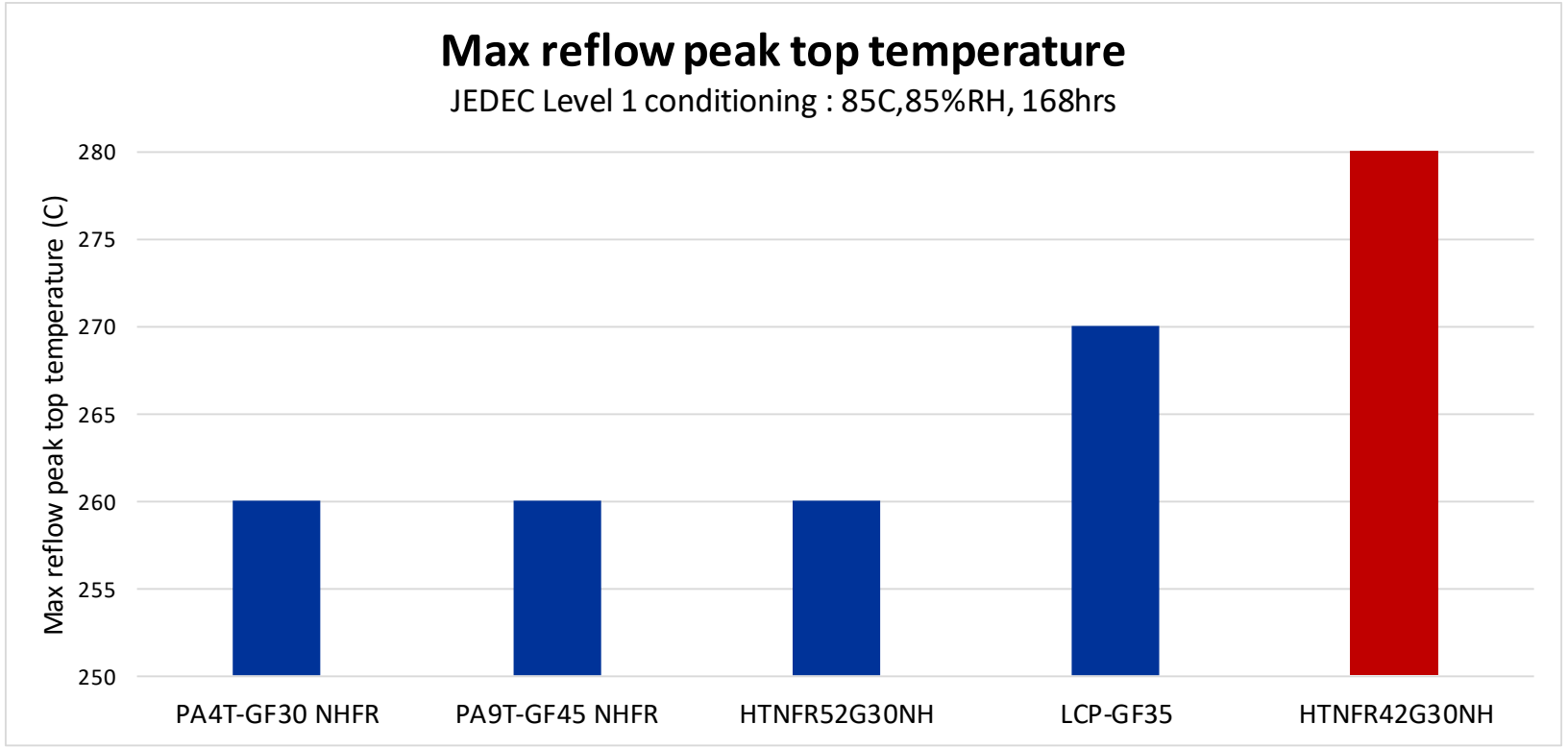
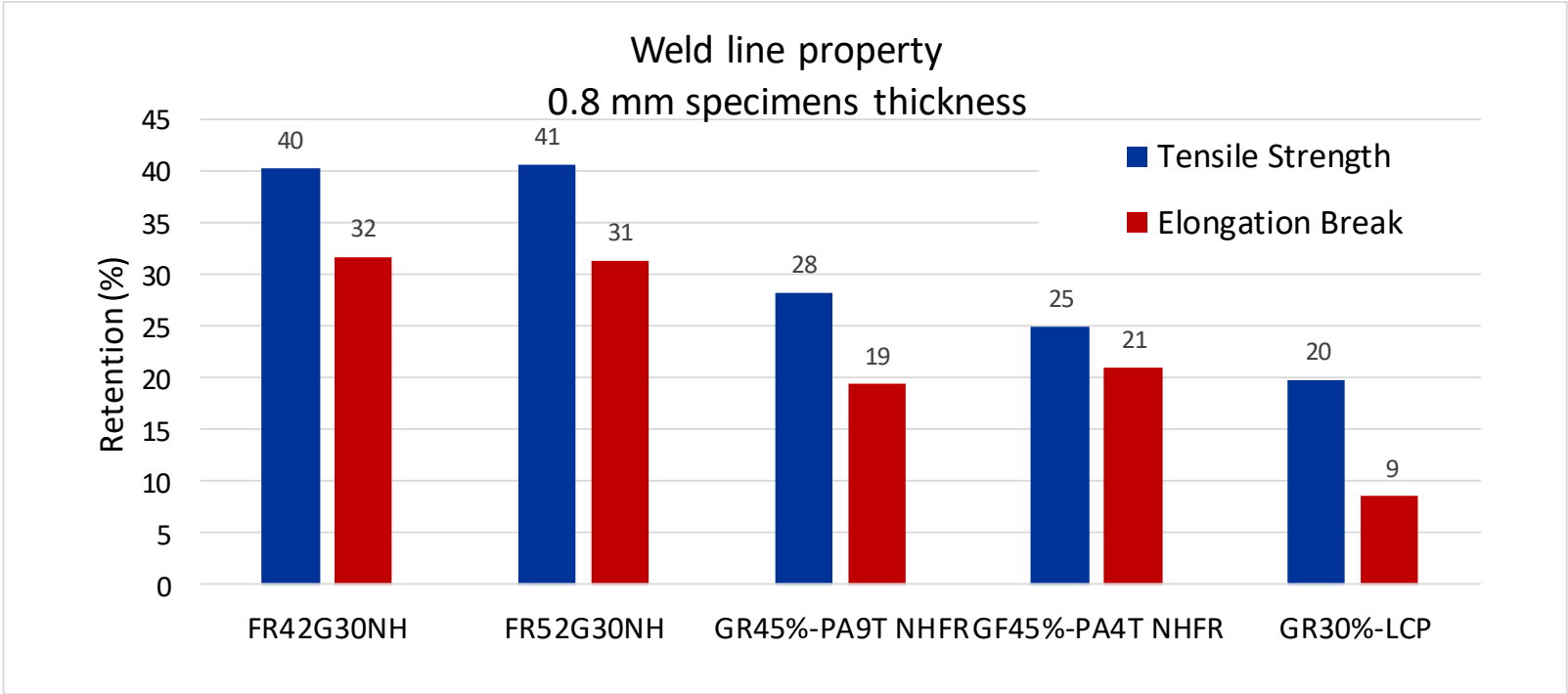
Reflow Performance



Moisture (wt %)	2.9	0.9	2.1	0.09	1.6

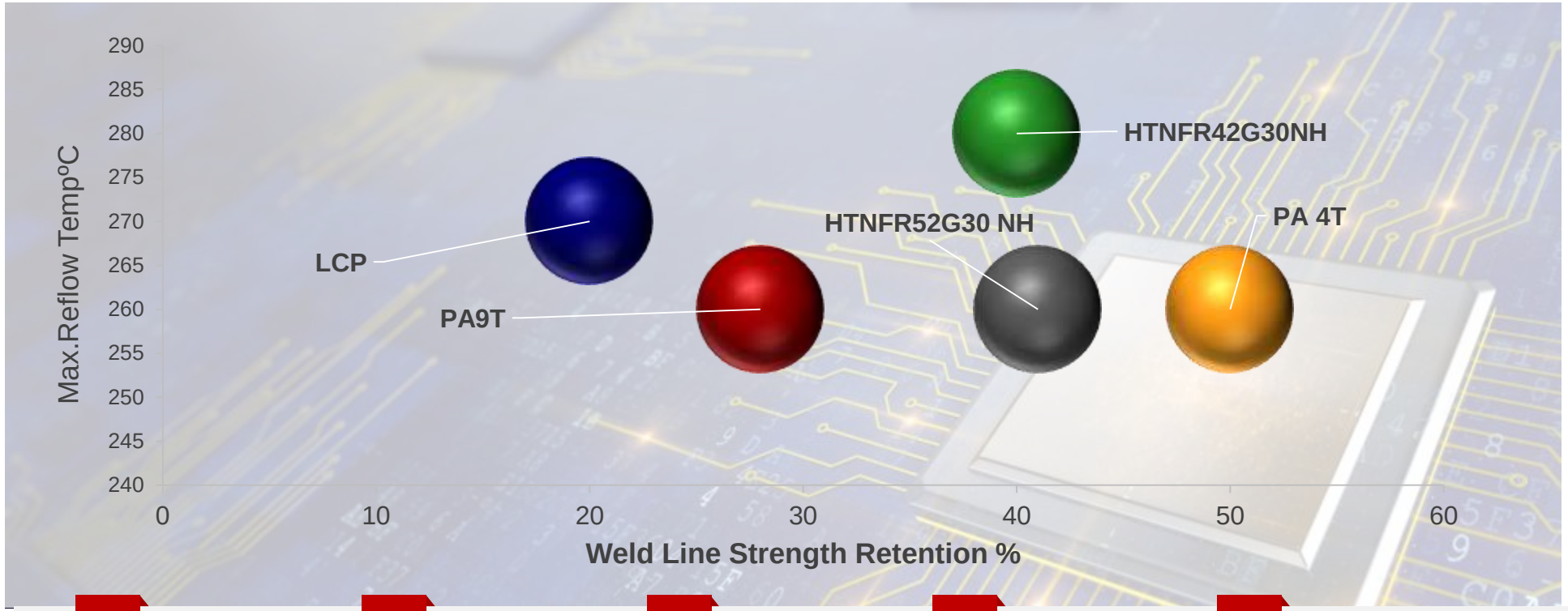
HTNFR42G30NH has much better reflow temperature performance than other competitive products resulting in increased productivity

Weld Line Strength



Better weld line strength than PA9T, PA4T and LCP leading to lower reject rate and higher productivity

HTNFR42G30NH has Better Reflow Performance as well as Higher Weld Line Strength



Existing PA6T grades may have gas issue at customers' production sites .

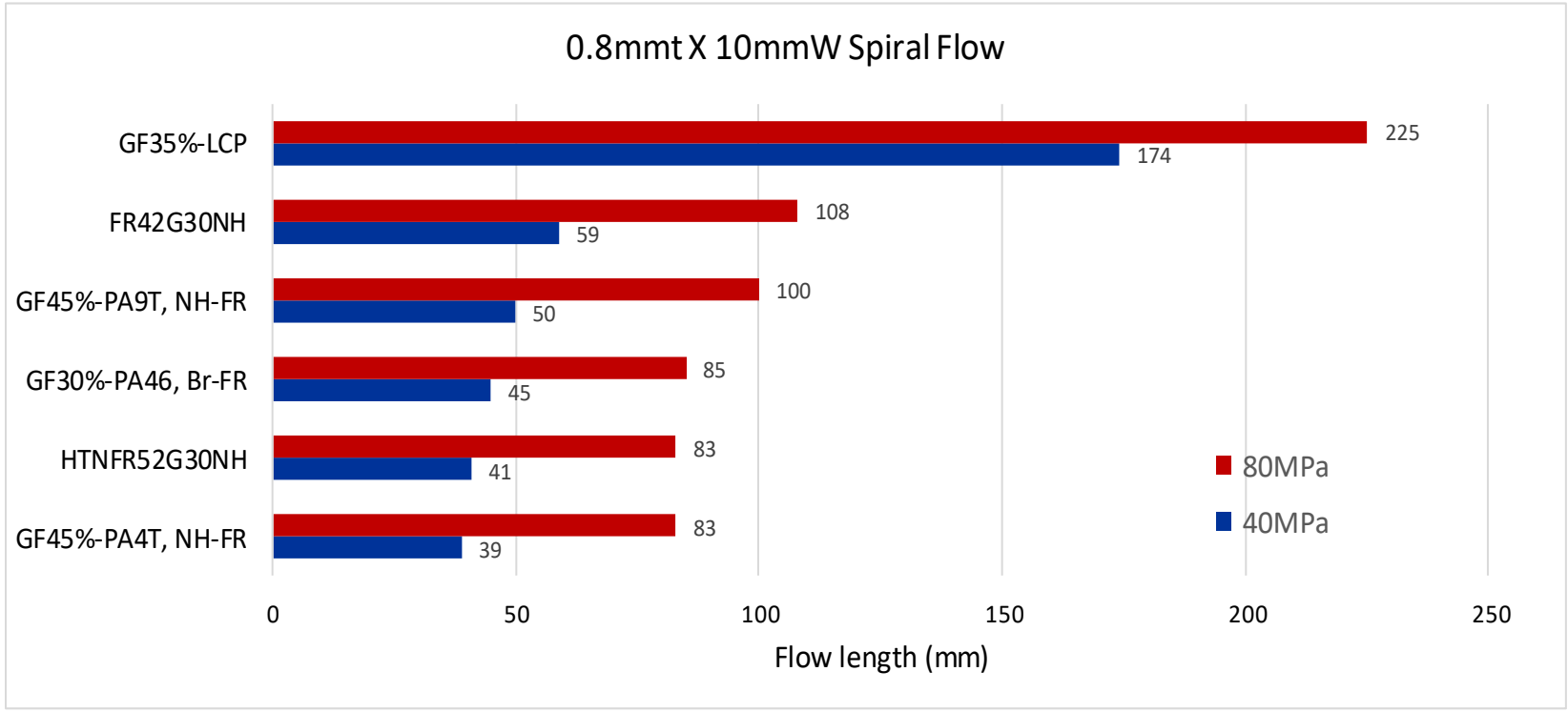
PA9T and LCP reported to give less mold deposit but some issue on brittleness (especially on weld-line area).

PA4T may cause productivity issues (blistering and corrosion)

PPS/LCP may limit design flexibility because of poor Comparative Tracking Index and weld line strength

HTNFR42G30NH has better reflow performance as well as higher weld line strength.

Key Properties for Processing



Melt temp : PA46 310°C, FR52G30NH 325°C , PA4T 330°C, PA9T 330°C , FR42G30NH 330°C , LCP 350°C
Mold temp : LCP 80°C , Others 130°C

Superior flow and better weld line strength making material suitable for miniaturization in applications such as Multi-pins, fine pitch and low height connectors

Cost Effectiveness

Our New non-halogenated bio based high performance nylon resin Zytel® HTNFR42G30NH meets the evolving trends for surface mount connectors while proposing,

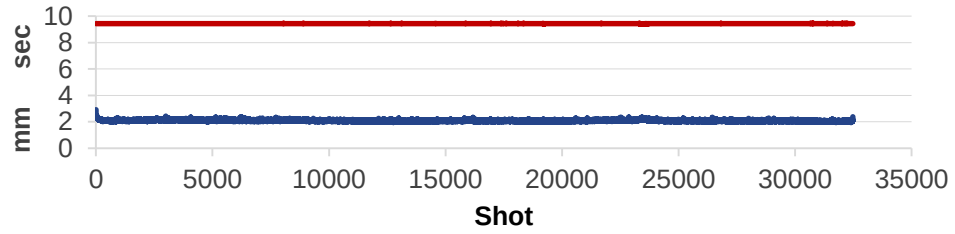
- Improved productivity of injection unit components thanks to reduced corrosion compared to PA 9T and PA4-T based grades
- Reduced tool maintenance thanks to very low mold deposit
- Above benefits are maximized by applying below conditions

  - Melting Temperature : 325-330 ℃ (actual)
  - Mold Temperature : 110 - 130 ℃ for maximum reflow performance
  - HUT : <7min is recommended
  - Drying condition : 100℃ x 6-8 hrs
  - Moisture at molding : <0.1%

Reduced Corrosion on Injection Unit Component

120h Corrosion test

Melt temp : 330 ºC , Mold temp : 120 ºC



After 120Hr

Molding condition	
Melt	Mold temp
330℃	120℃

Dimension	(medium)
Before	24.97
After	24.97
Difference	0

No visible corrosion on check ring after 120 h continuous molding

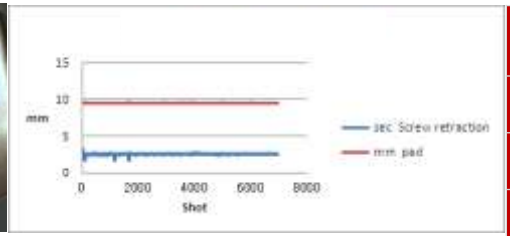
Comparative Corrosion Tests on Injection Units Corrosion

24 h Corrosion test

Melt temp : 329°C, Mold temp : 105C

45% glass filled PA9T NH-FR

Significant corrosion

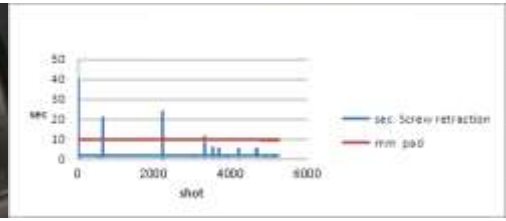


Dimension	(medium)
Before	24.957
After	24.943
Difference	−0.014

Melt temp : 320°C, Mold temp : 100C

45% glass filled PA4T NH-FR

Significant corrosion



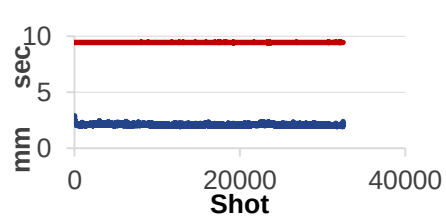
Dimension	(medium)
Before	24.962
After	24.954
Difference	−0.008

120 h Corrosion test

Melt temp : 330°C, Mold temp : 120C

Zytel HTN FR42G30NH

No Visible corrosion after 120 hrs



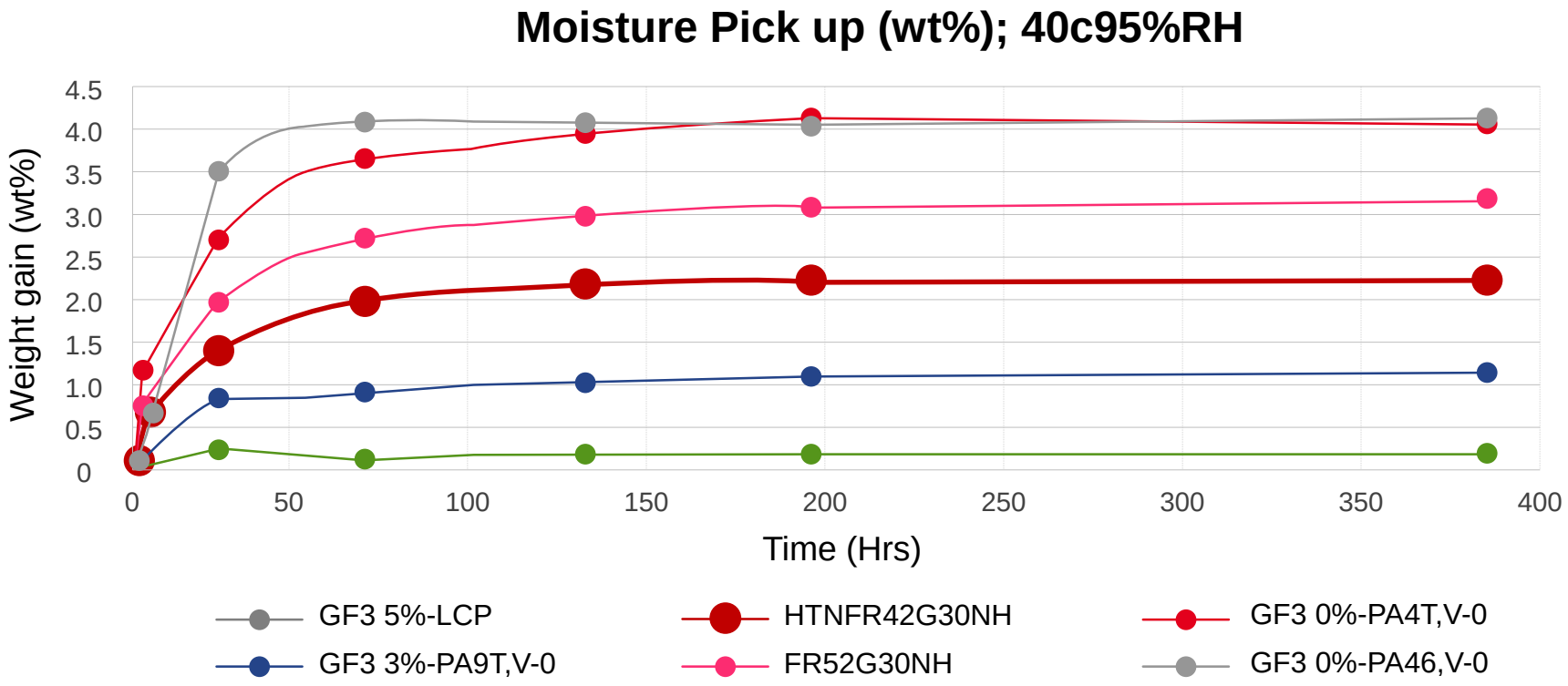
Dimension	(medium)
Before	24.957
After	24.957
Difference	0.000

Reduced Tool Maintenance Thanks to Very Low Mold Deposit

Appearance of mold after 120h continuous molding.

- Completed 120h continuous molding without stopping
- Molding was very stable
- No visible mold corrosion.
- No visible mold deposit
- ..leading to higher productivity !

Moisture Pick-up

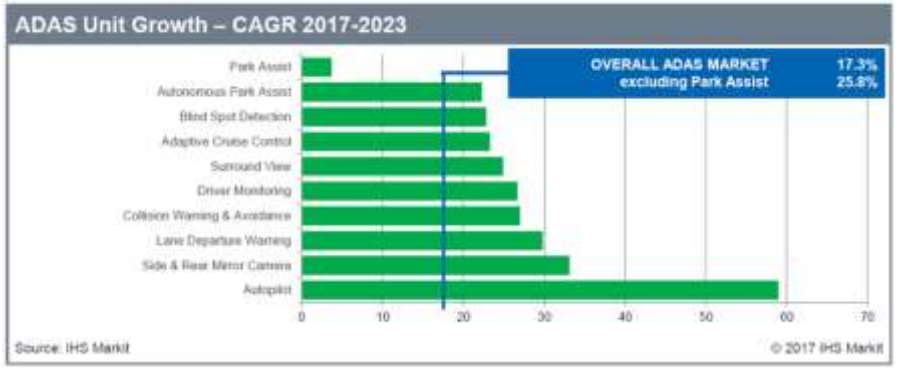


Sample : test connector

Moisture pick-up : PA46(NH)>PA4T(NH)>HTNFR52G30NH>**HTNFR42G30NH**>PA9T(Hal)>LCP

Introduction - Zytel® HTN42G30EF

Rise of Electronics in Automotive



1. HSD (High Speed Data) connectors

- A high-speed signal transmission connector for in-vehicle LAN
- Color 14 color (12 colors are common with Fakra)

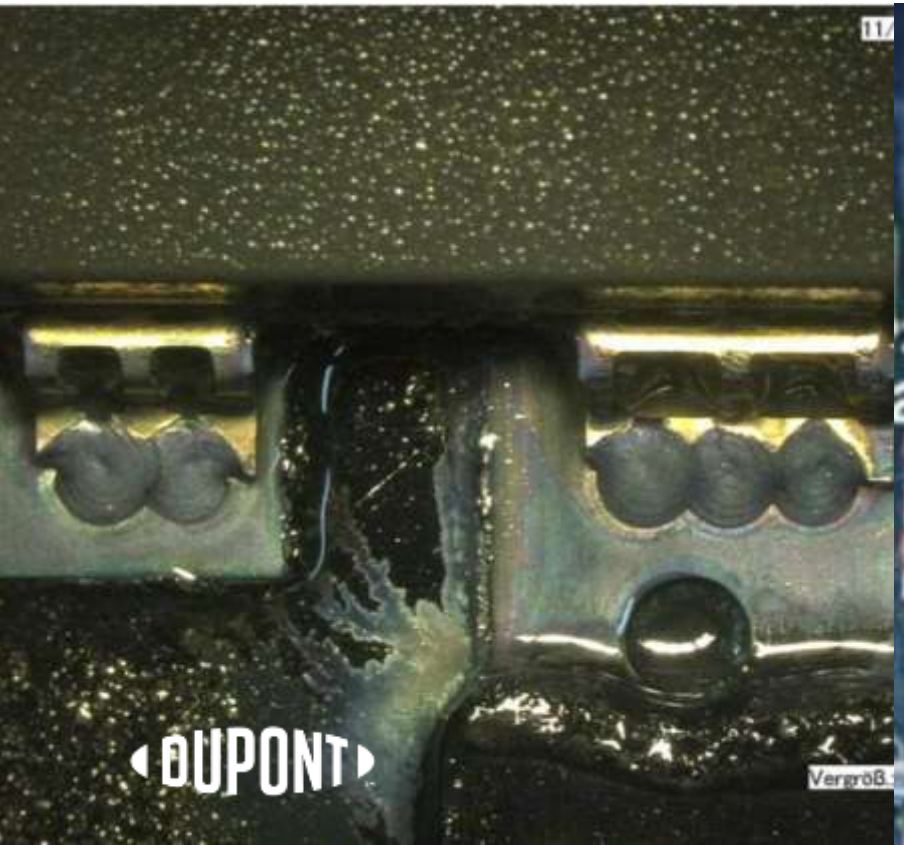
2. Fakra(Fachkreis Automobil, a German standard) connectors

- A high-speed signal transmission connector compliant with FAKRA, a standard for automotive coaxial connectors in Europe and the United States.
- Major applications are auto instrument module or antenna cable such as GPS , Digital Satellite Broadcasting .
- Color : 14 color (12 colors are common as HSD)

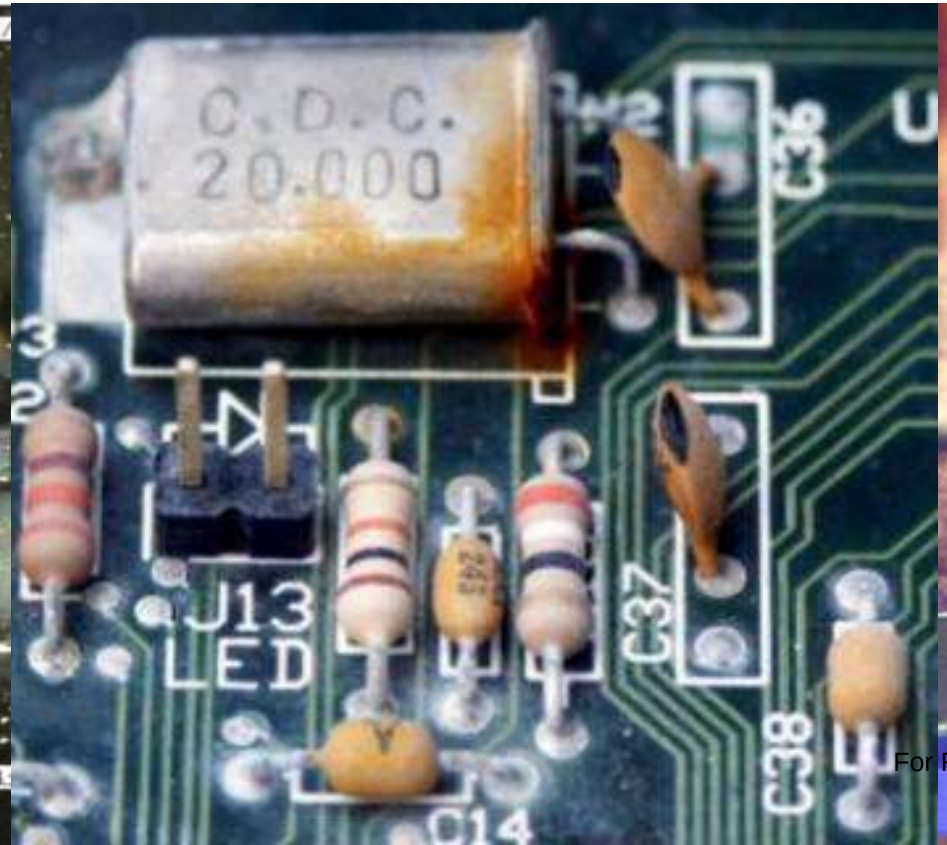
3. Other auto infotainment connectors / Auto SMT connectors

Some examples of failures due to electrochemical corrosion

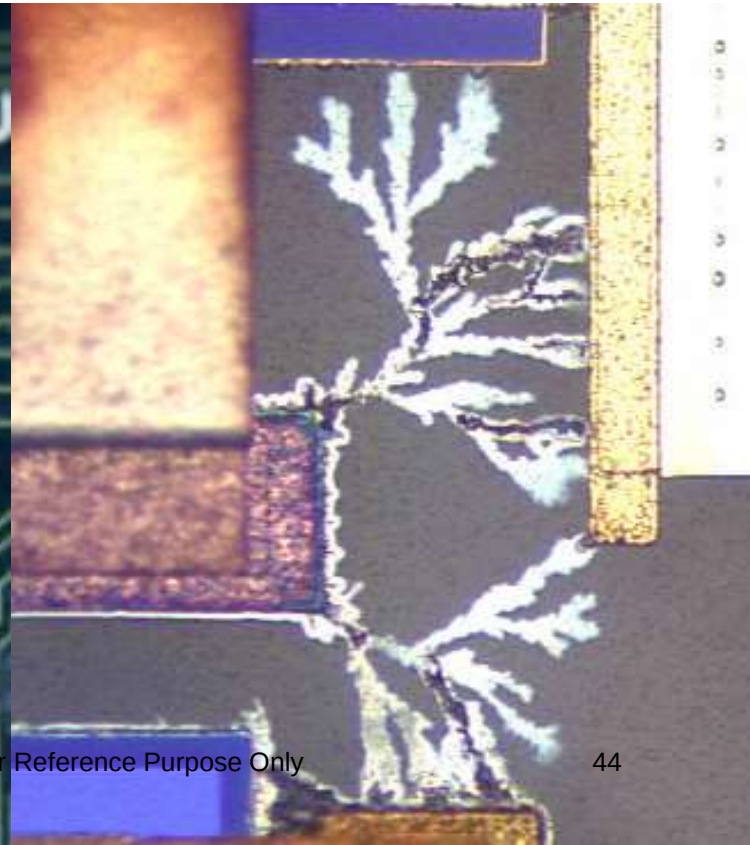
Metal dendrites growing in the space between the contacts. Short circuit can occur



In ICs, positively biased aluminum metallization is susceptible to corrosion



Silver dendrite resulting from 1000 hours of aging at 85°C/85%RH and 2.5 Volts DC bias of silver epoxy.



Zytel® HTN42G30EF Vs. Conventional Grades

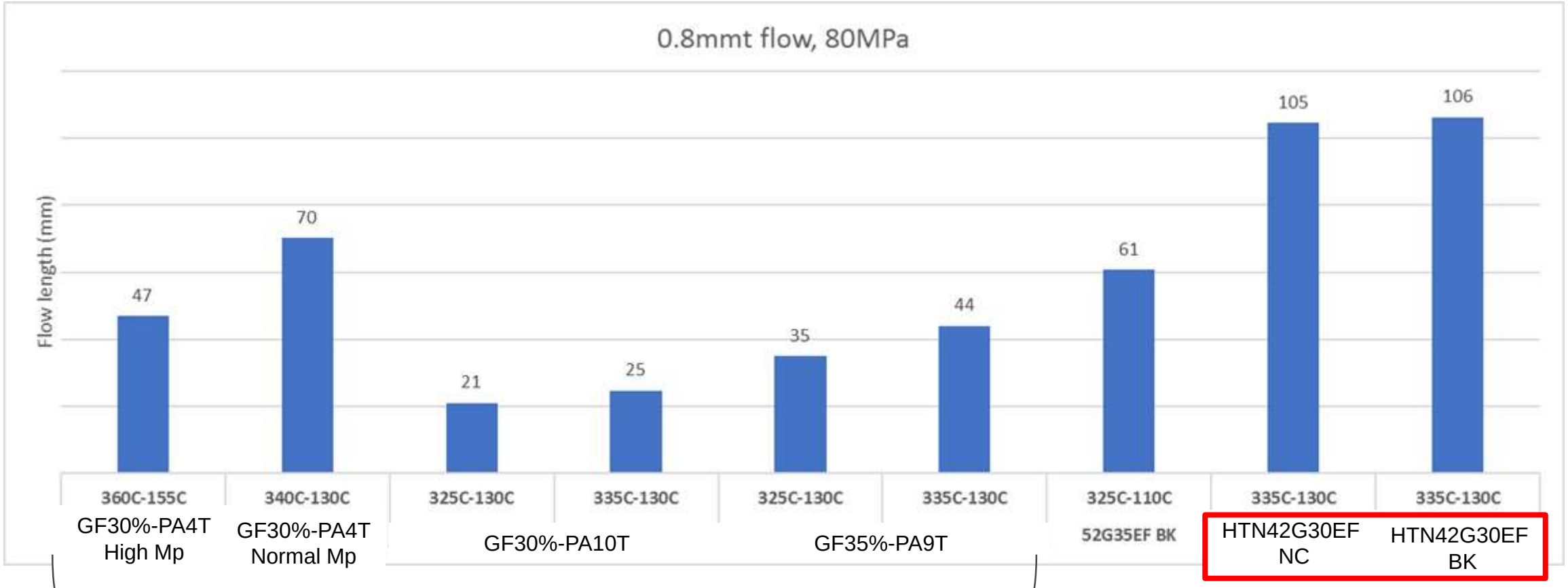
Properties	Unit	HTN42G30EF BK	HTN51G35EF	HTN52G35EF	HTN54G35EF
Tensile Strength*	MPa	175	215	199	170
Elongation at break*	%	2.7	2.4	2.2	2.5
Tensile Modulus	Mpa	9400	11700	12000	10500
UN-Charpy Impact	KJ/m2	80	57	45	82
N-Charpy Impact	KJ/m2	13	10	10	11
Reflow Performance** w/o blistering (85C85%RH 168hrs)	Deg C	>280	250	-	250
Density	Kg/m3	1350	1470	1450	1420
Melt Viscosity (Melt Temp)	Pa-Sec	88 (335C)	166 (325C)	161 (325C)	157 (325C)
CTI	V	600	525	600	600
Dk@5.1GHz		3.47	-	3.8	-
Df@5.1GHz		0.0105	-	0.0117	-

*4mmt ISO Bar
0.8mmt UL Bar

HTN42G30EF offers (1) Higher toughness (2) Higher flow and (3) Better reflow performance

Zytel® HTN42G30EF BK / NC

0.8mmt Spiral Flow

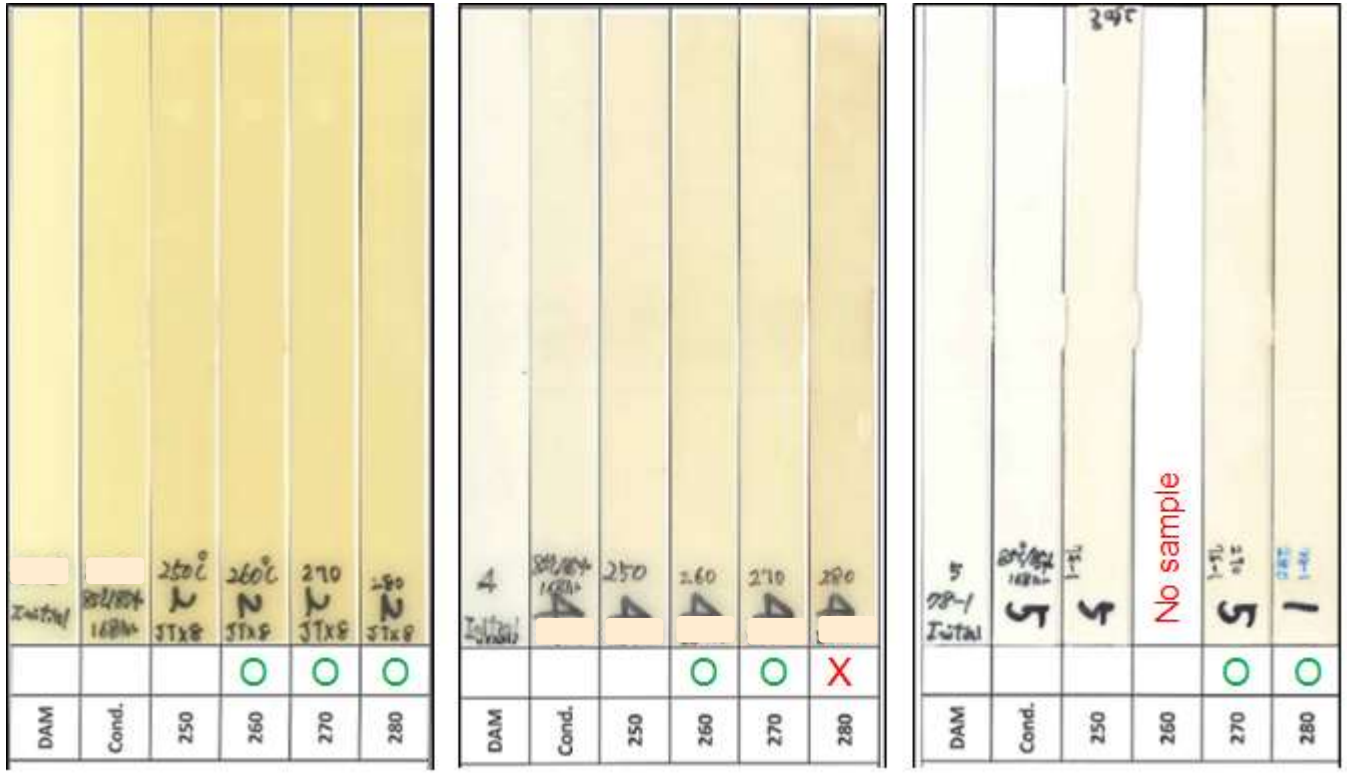


Major exiting grades for HSD/Fakra connectors

Zytel® HTN42G30EF NC

Color change after reflow

GF30%-PA4T High Mp	GF30%-PA10T	HTN42G30EF NC

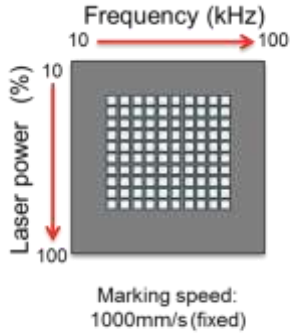


Conditioning：
85C85%RH,168Hrs

X Had blistering
O No Blistering

Zytel® HTN42G30EF BK

Good laser mark-ability

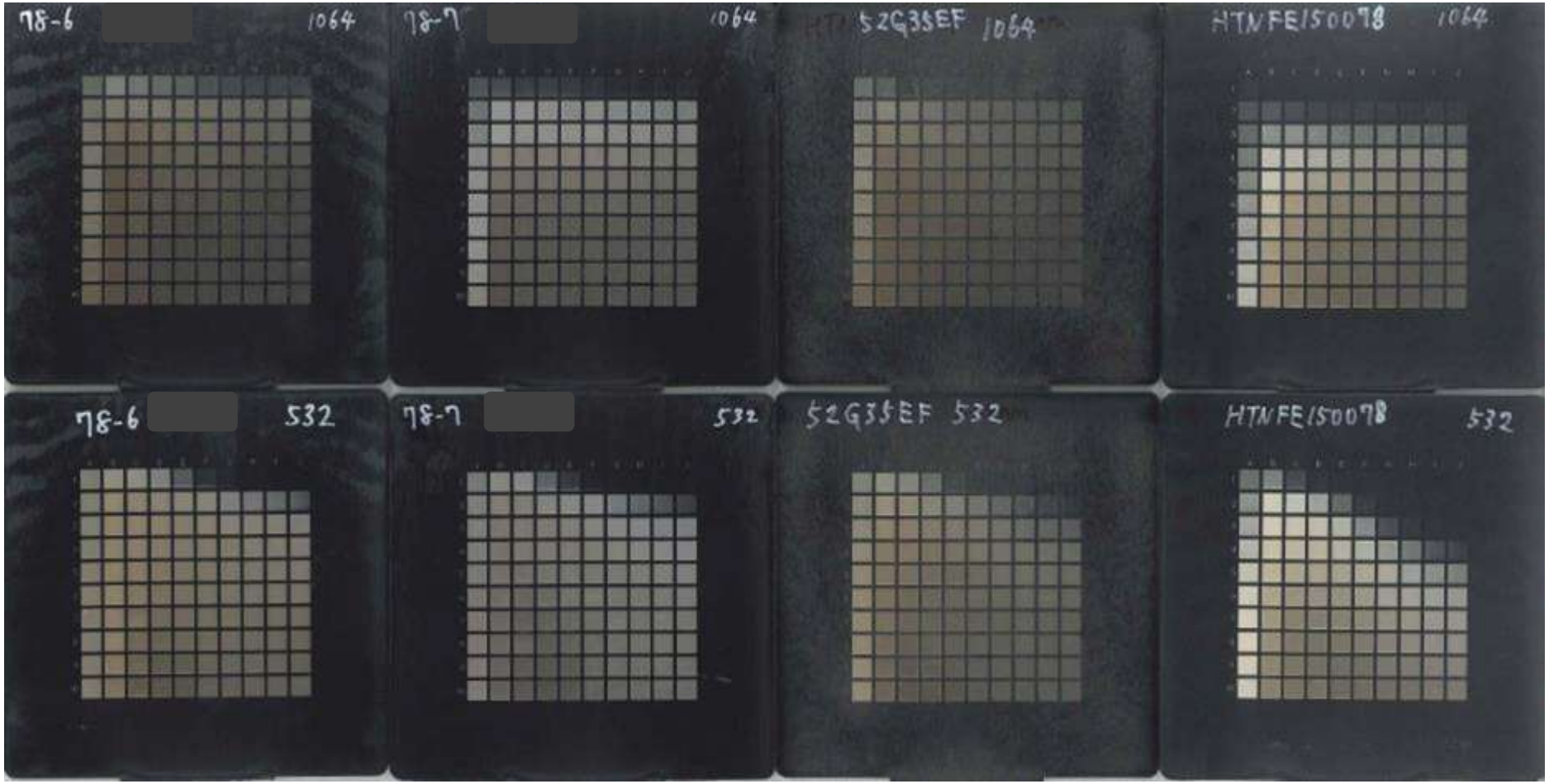


100x100 plate, DAM

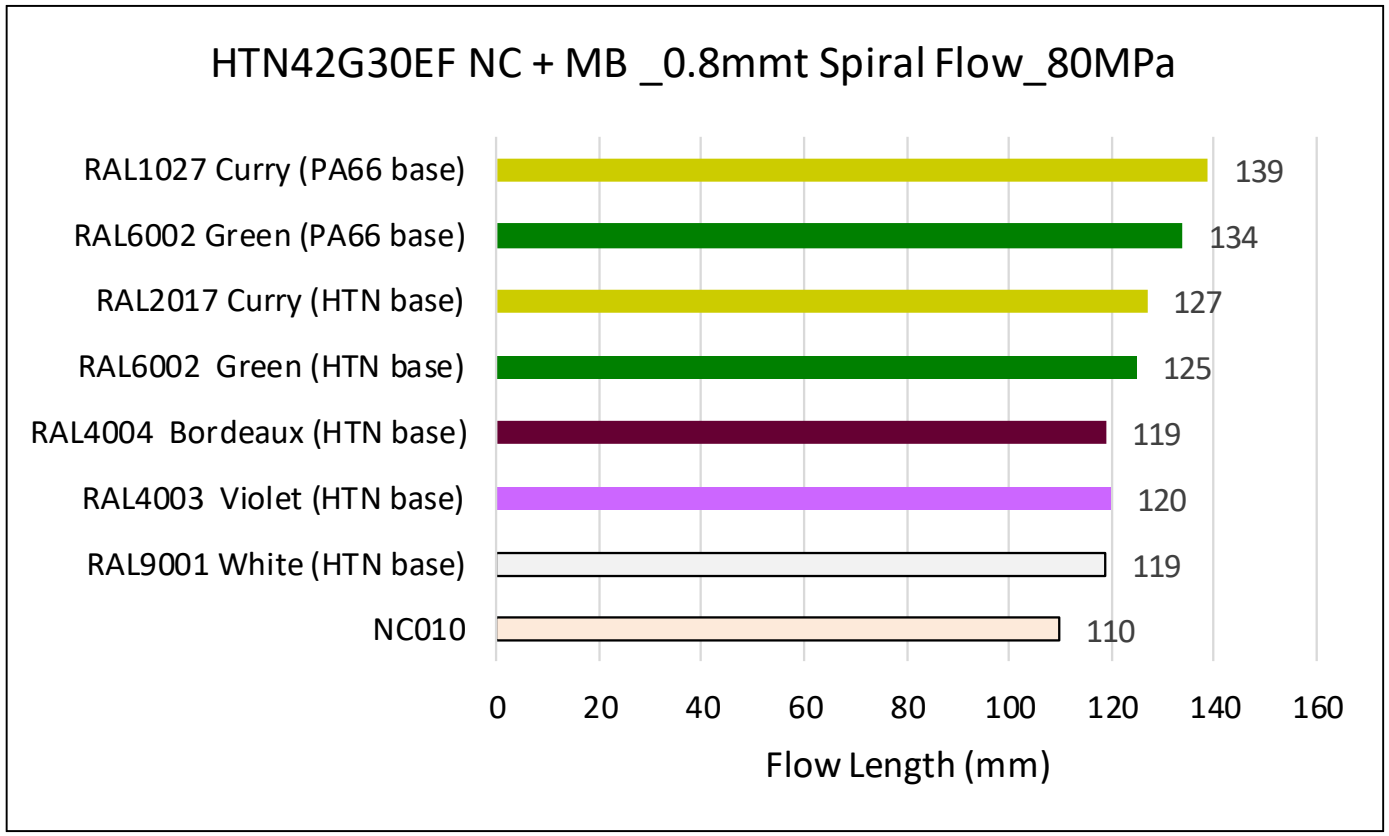
GF30%-PA4T BK	GF35%-PA9T BK	52G35EF BK	HTN42G30EF BK

1064nm (Infra-red)

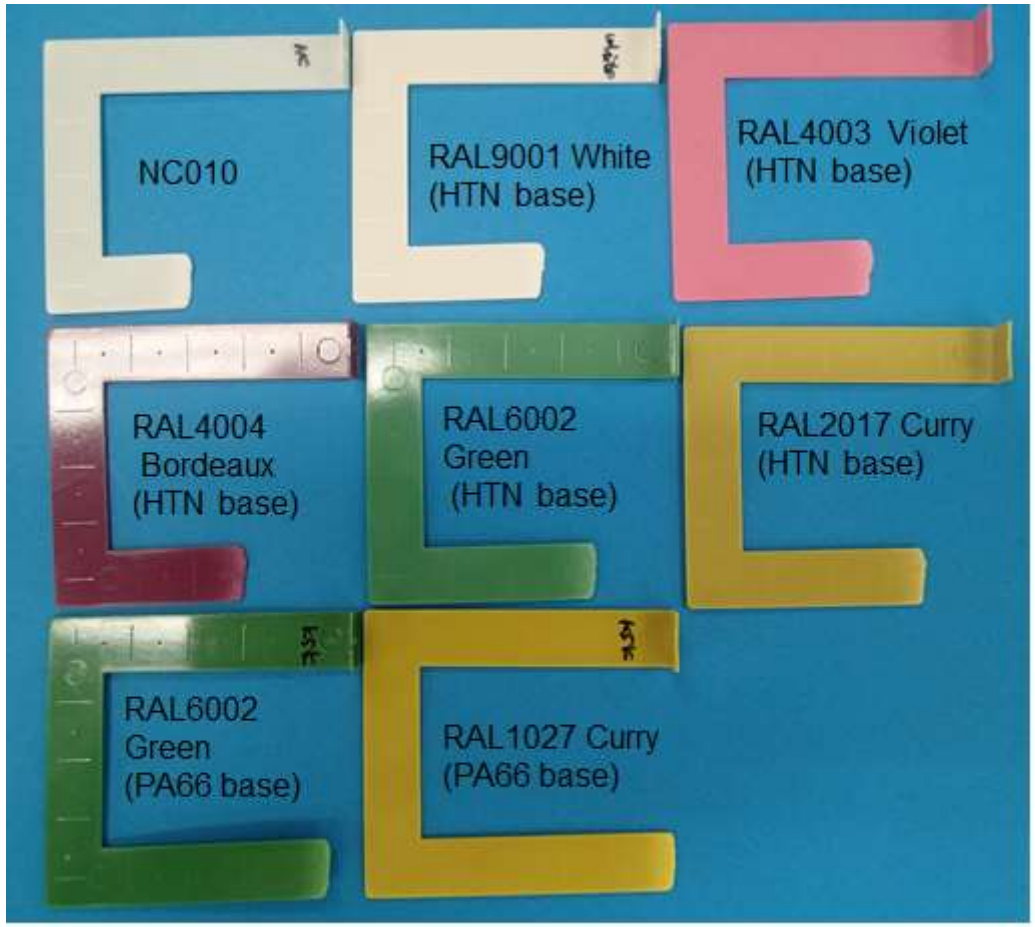
532nm (Green)



0.8mmt Spiral Flow



Color grades show better flow -ability than NC grade



HTN42G30EF NC + MB

Summary

Our new non-halogenated, bio-based high performance nylon resin, Zytel® HTNFR42G30NH and Zytel® HTN42G30EF meet the evolving trends for surface mount connectors while providing the optimal balance of :

Improved safety

thanks to excellent UL-94 V0 flammability rating and Tracking Resistance (CTI)

Increased productivity

with no blistering at surface mount technology (SMT) reflow temperatures of 280 °C, superior flow in the tooling and improved weld line strength

Cost effectiveness

from reduced corrosion in the injection unit and very low mold deposits

➢ **Consult your DuPont representative for the sample quantity and technical support!**

Questions!!

https://dupont.materialdatacenter.com/

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