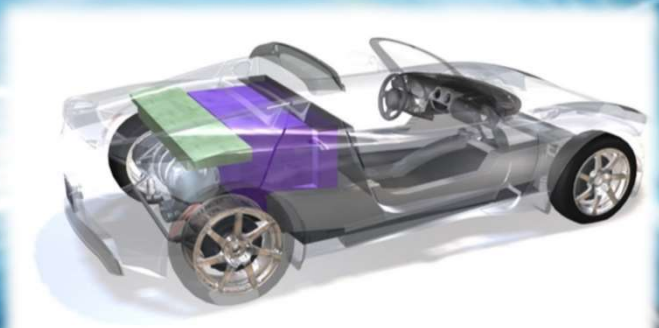
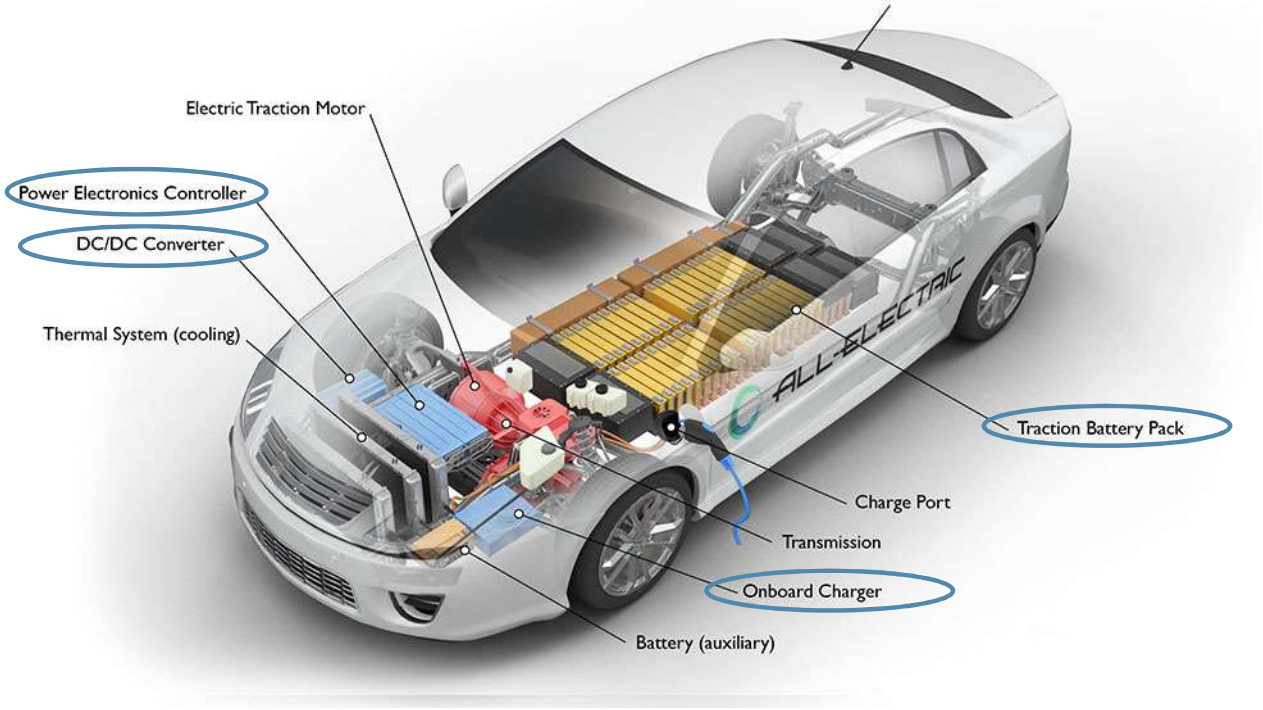
ITW

EV Power Insulation Solutions



Power System Components

All-Electric Vehicle



Charging Station

Battery Management System

EV Power

ITW Insulation Solutions Overview

ITW Formex®

Functional Solutions

- Dielectric insulation
- Flame retardance – UL 94 V-0
- Temperature tolerance – RTI up to 130°c
- Water proofing – H2O absorption as low as 0.06%
- Chemical resistance - polypropylene
- UV proofing – UL f1 listing
- Static dissipative ESD protection
- EMI shielding
- Surface contamination resistance - CTI 0 （600V)

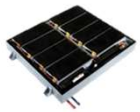
Structural Solutions

- Structural design – 3D score & fold
- Light weight – 1.035 gm/cc
- 3D thermal forming

Battery Pack

Application Examples

Chevrolet Volt

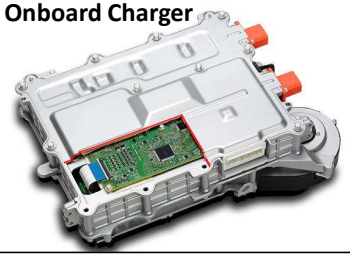
Battery Cell	Battery Module	Battery Pack
		
		
1 cell	Assembled by cells	Assembled by modules

Formex Solution Examples

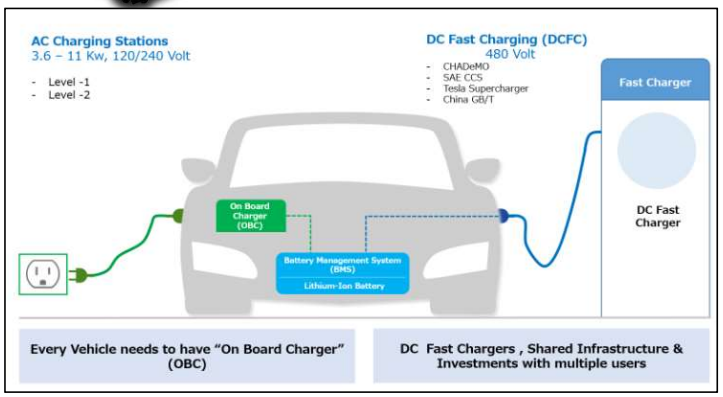
Onboard Charger + DC/DC Converter

Application Examples

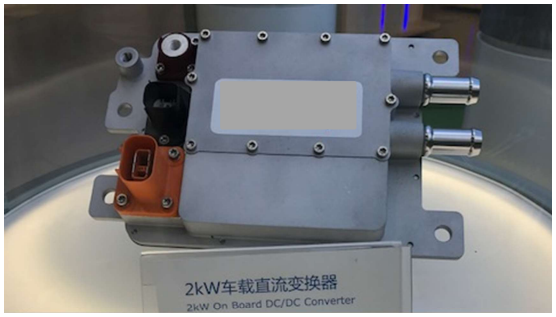
Toyota
Onboard Charger



Chevrolet Volt
DC/DC Converter



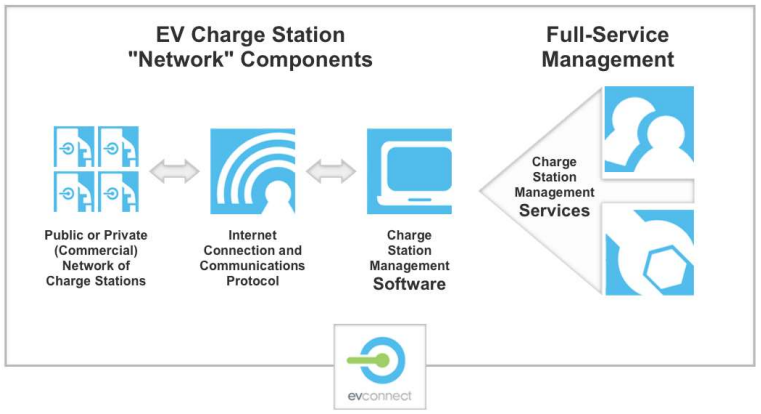
Formex Solution Examples



Charging Station

Application Examples

Tesla Supercharger

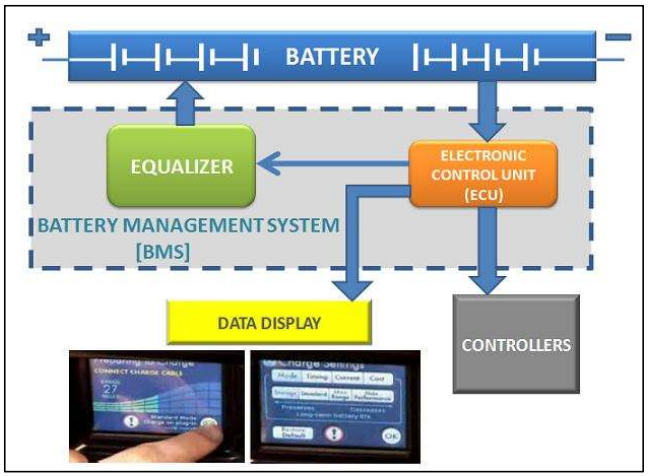


Formex Solution Examples

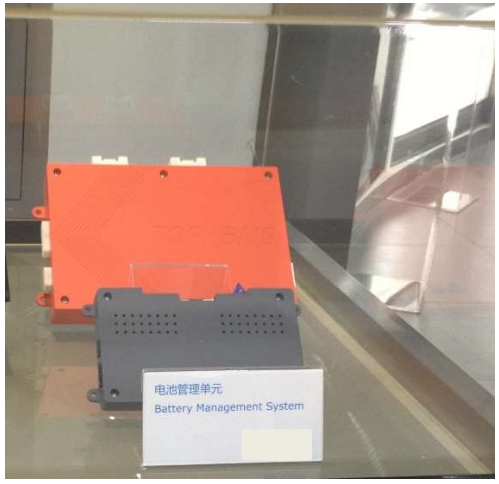
Battery Management System

Application Examples

ODM BMS

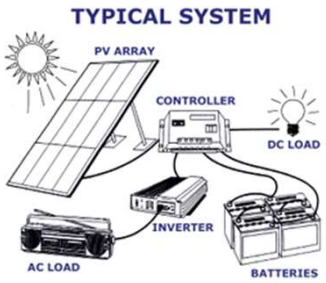


Formex Solution Examples



Adjacency – Green Energy

Application Examples



Formex Solution Examples

EV Power

ITW Insulation Materials Portfolio

ITW Formex
Flame Retardant Materials

EV Power

Formex Solutions for Demanding Requirements

http://itwformex.com

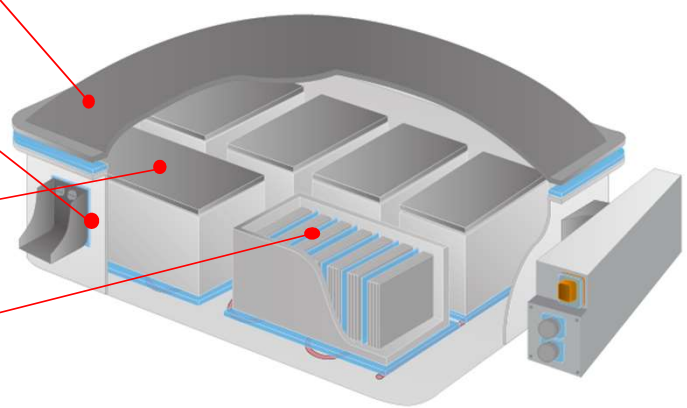
ITW Formex	Ultra-thin Film	Thin Film	Mid-gauge Film	Thick-gauge Film
Main Application	Cell separator	On-board charger insulation	Busbar insulation	Battery pack cover
	Cell cover	Charging station insulation	BMS insulation	Battery pack case insulation
	Module case insulation		Module case insulation	
			On-board charger insulation	
			Charging station insulation	
Material	PP	PC	PP	PP
Thickness in mil	5	8, 10	10, 17	30
Dielectric breakdown in kV	11	16-17	16-20	29
Dielectric strength in kV/mil	2.2	1.7-2.0	1.2-1.6	0.98
Volume resistivity in Ohm-cm	3.97 E+15	1.2 E+16	3.97 E+15 - 1 E+16	3.97 E+15
RTI (Relative Thermal Index) in C	115	80, 130	90, 115, 125	90, 115
Flammability UL 94	VTM-0	VTM-0	VTM-0, V-0	V-0
Water absorption in %	0.06	0.25	0.06	0.06

ITW Formex Battery Cover
Mechanical protection
Electrical insulation
EMI shielding

ITW Formex Brackets
Electrical insulation
Contact corrosion

ITW Formex Busbar
Electrical insulation

ITW Formex Spacers
Electrical insulation between cells



Formex – Superior Performance Rating

Component - Plastics E121855

Guide Information

FORMEX, DIV OF ILLINOIS TOOL WORKS INC, FORMERLY

Fastex, Div Of Illinois Tool Works Inc, 1701 W Armitage Ct, Addison IL 60101-4221

FORMEX GK-(a)(d)(f2)

Polypropylene (PP), furnished as sheets

Color	Min. Thk (mm)	Flame Class	HWI	HAI	RTI Elec	RTI Imp	RTI Str
ALL	0.05	VTM-0	4	0	115	-	115
	0.10	VTM-0	4	0	115	-	115
	0.20	VTM-0	4	0	115	-	115
	0.37	V-0	4	0	115	-	115
	0.71	V-0	4	0	115	-	115
	3.0	V-0	1	0	115	-	115

Comparative Tracking Index (CTI): 0

Dielectric Strength (kV/mm): 42

High-Voltage Arc Tracking Rate (HVTR): 0

Dimensional Stability (%): 0

Inclined Plane Tracking (IPT) kV: 1.5

Volume Resistivity (10^x ohm-cm): 15

High Volt, Low Current Arc Resis (D495): 6

(a) - One to three digit suffix indicating nominal thickness in mils.

(d) - May have additional suffix letter(s) indicating color.

(f2) - Subjected to one or more of the following tests: Ultraviolet Light, Water Exposure or Immersion in accordance with UL 746C, where the acceptability for outdoor use is to be determined by UL.

NOTE - HVTR, CTI and D495 are not dependent on thickness

Report Date: 1991-08-19

Last Revised: 2017-08-11

Flame class:

UL94 V – Vertical Burn Testing: V-0, V-1, V-2

UL94 VTM – Vertical Thin Material burn testing: VTM-0, VTM-1,VTM-2

V-0 ≈ VTM-0

	Self-extinguishing (t1 or t2) /(t2+t3)	Burning-supporting
0 :	fastest(10s/30s)	and no
1:	fast (30s/60s)	and no
2:	slow (30s/60s)	or yes
- :	continuous burning or no testing	

HAI: High Amperage Index (number of arc)
The number of arc rupture exposures necessary to ignite a material
(Testing cond. 240V, 32.5A)

HAI, Number of Arc (NA)	Assign PLC On UL Card
120 ≤ NA	0
60 ≤ NA < 120	1
30 ≤ NA < 60	2
15 ≤ NA < 30	3
0 ≤ NA < 15	4

CTI: Comparative Tracking Index (Volt)
Volts for leakage with contamination impact on insulation performance such as acid, water, dust, glue, electrolyte. Thickness independent.

CTI, Tracking Index TI (Volts)	Assign PLC On UL Card
600 ≤ TI	0
400 ≤ TI < 600	1
250 ≤ TI < 400	2
175 ≤ TI < 250	3
100 ≤ TI < 175	4
0 ≤ TI < 100	5

RTI: Relative Temperature Index (℃)
Most important index of material degradation. Refer to working temperature at which, after continuous 60,000h (7 years) of operation, electrical/mechanical properties drop to 50% of its initial value.

Formex – EV UL Insulation Compliance

UL2580 insulation requirements - HEV/EV Battery

-Polymeric enclosure should have an RTI >= 100 ℃

-Temperature measured on insulation part shall not exceed their specifications (RTI)

-Insulation sheet is needed for not enough spacing distance through the air and over surface

-No fire or explosion in tests of overcharge, short-circuit, over discharge (refer to material flame class, HAI)

-Minimum isolation resistance 100Ω/V

UL1741 insulation requirements - Inverters, Converters

-Minimum spacing is required for safety requirement

-Insulation sheet is needed for not enough spacing distance through the air and over surface

-Barrier used in lieu of required spacing should be >= 0.71mm

UL 2202 insulation requirements – EV Charging System

-A barrier of insulating material, used to provide separation between the wiring of different circuits shall comply with the requirements for flammability classification , no less than 0.028 inch (0.71 mm) thick

- An insulating material shall be moisture-resistant

- Consideration is to be given to the insulating material's resistance to hot wire ignition, resistance to high-current-arc ignition, resistance to high-voltage-arc ignition, dielectric strength, insulation resistance, and heat-resistant qualities

Formex – Designing for EV

Consider	Evaluate	Formex
Design concern with fire	Flame class	UL94 – V0 (self extinguishing < 30 sec)
Design concern with insulation material still meeting original electrical/mechanical design after 50% performance degradation	RTI	Up to 130c 7 years
Design concern with contamination impact on insulation performance	CTI	> 600 volts
Design concern with short circuit due to arcing risk	HAI	> 120 arcs
Design concern with moisture	Water absorption	0.06%
Design concern with chemical erosion	Material type	Polypropylene
Design concern with weight/space	Material thickness	As thin as 0.005”

EV Power

Formex EV Value Proposition

EV Priorities	Formex benefit	Value to customer
Fire safety	High safety rating (VTM-0/V-0)	Peace of mind
Electrical safety	High dielectric strength (13,125V @5mil GK)	Reliability
Product durability	Low material degradation	Longevity
Energy efficiency	Lightweight	Usability
3D design	Thermoforming/Score/Fold	Cost saving

EV Power

Formex Global Support

The Formex® brand name stands for:

- Proud member of ITW, a Fortune 200 company
- 30 years of flame retardant insulation technology know-how
- Trusted partner by Tier 1 EV manufacturers
- Industry leading product innovation
- Flame retardant insulation application design expertise
- Fabrication prototyping quick-turn
- Reliable high volume mass production
- Global supply chain footprint

Please engage your Formex RSM for your next flame retardant insulation need.

Thank you!