

Conductive & EMI Thermoplastic Technologies

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Outline

- Conductive Classification & Testing
- Overview of Conductive Modifiers
- EMI Shielding
- Wrap Up and Questions

Conductive Classification & Testing

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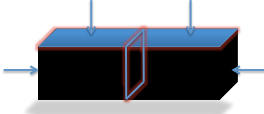
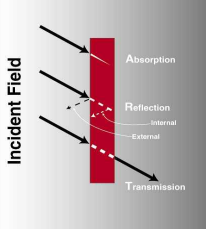
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Conductive Classification

- Classification
 - Anti-static
 - Static dissipative (ESD)
 - Conductive/EMI Shielding
- The application will fit into one of these...
- How do you Qualify/test performance?

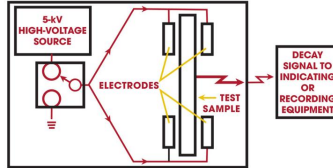

Qualification Testing
YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Anti-static**
 - Decay rate (seconds to decay)
- **Static dissipative (ESD)**
 - Surface resistivity (ohm/square)
 - Surface resistance (ohm)
- **Conductive/EMI**
 - Volume resistivity (ohm-cm)
 - Shielding effectiveness (dB)

Anti-Static Testing
YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- **Static decay rate**
 - Measures seconds to decay
 - 5000 to 50 V
 - 12% relative humidity
- **Standards/specifications**
 - MIL PRF 81705 D
 - NFPA 56A
 - Numerous others


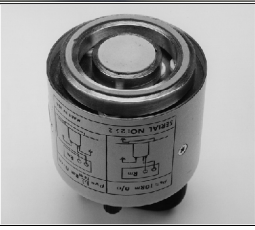



Static Dissipative Testing
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- **Surface resistivity (ohm/square)**
- **Surface resistance (ohm)**
- **Standards/specifications**
 - ASTM D257
 - ESD STM11.11
 - IEC 60079-0
 - Numerous others

Surface Resistivity Test
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- **Voyager SRM-110**
 - Small samples
 - Irregular parts
 - In-field test
 - Units = ohm/square
- **Guarded Ring**
 - Flat specimen
 - Precise measurement
 - Units = ohm/square

Surface Resistance Test
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- Surface resistance
 - Point-to-point
 - Measuring small & critical areas on part
 - Units = ohm

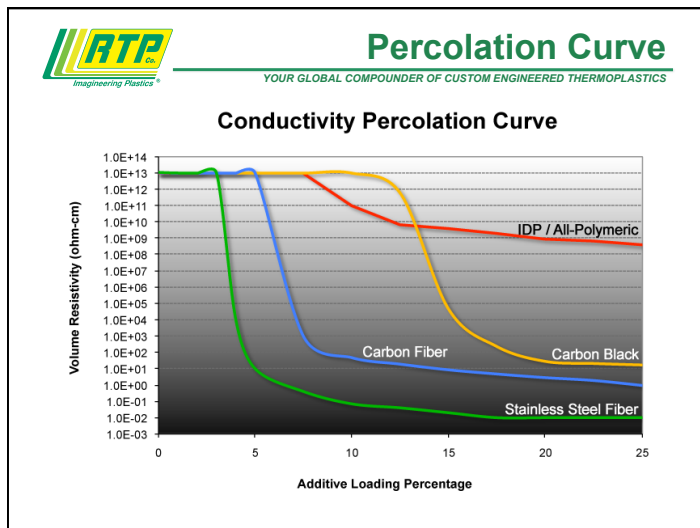
Conductive Modifiers

THERMOPLASTIC ELASTOMERS • STRUCTURAL • WEAR
CONDUCTIVE • COLOR • FLAME RETARDANT

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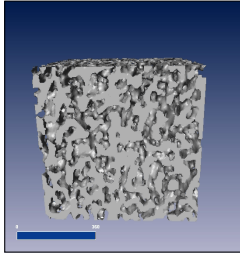


Migratory Anti-Static Agents
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- Migrating surfactant based – not bonded to resin
- Temperature & humidity dependent
 - Best at room temperature & high humidity
- Colorable
- Liquids & semi-solids with low boiling points
- Compatible only with low-temp resins
 - Olefins, Styrenics, PVC
- Economical/commodity materials

RTP **Inherently Dissipative Polymers (IDP)**
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- **All-polymeric, based on IDP**
 - Typically consist of PE oxide
 - Other block dictates compatibility
 - Forms a co-continuous morphology with the base resin
- **Over 20 different resin systems**
 - Limited process temps (< 520 °F)
- **Surface resistivity**
 - Standard: 10^{10} to 10^{12} ohm/sq
 - PLUS: 10^8 to 10^9 ohm/sq
- **Static decay rate**
 - Standard < 2.0 s
 - PLUS < 0.5 s




PermaStat®


RTP **PermaStat® Technology Benefits**
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- Permanent ESD protection
- Cleanliness (non-sloughing, non-migratory)
- Humidity independent
- Fully colorable
- Transparent grades available
- FDA grades available
- Base resin properties retained


RTP **Typical Applications**
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Reticle boxes
ABS/PMMA



Inhalers
ABS/PP/PMMA



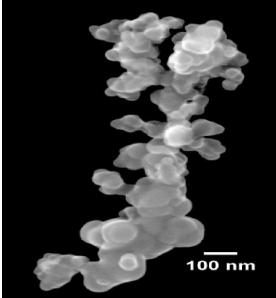
ATEX IBC
PE



Gas cap
POM


RTP **Conductive Carbon Black**
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- **Defined by**
 - Structure
 - Size of particles
 - Porosity
 - Surface chemistry
- **Numerous choices**



Conductive Carbon Black
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- Permanent
- Black color
- Sloughing / Marking / Crayoning
- Economical
- Dissipative or conductive
 - SR 10^3 to 10^9 ohm/sq
 - VR 10^0 to 10^6 ohm-cm




Carbon / Graphite Fiber
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- Non-sloughing
- Colorable
- Anisotropic shrinkage
- Reinforcing
- Dissipative or conductive
 - SR 10^2 to 10^6 ohm/sq
 - VR 10^{-1} to 10^4 ohm-cm

Chopped Fiber – ¼" long "bundles"

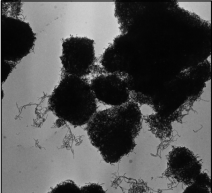
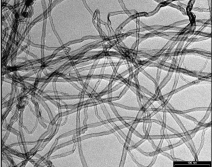


Milled Fiber – pulverized




Carbon Nanotubes (CNT)
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- > 90% graphite
- Hollow
- 10 nanometer diameter
- High L/D ratio
- First produced in 1987

CNT Size Difference
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Carbon fiber
7 µm

A carbon fiber surrounded by CNTs, emphasizing just how different CNTs are from carbon fiber technology

RTP Co. **4 Primary Benefits of CNTs**
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- Electrical conductivity
- **Eliminate residual voltage, “Hot spots”**
- LPC cleanliness
- Low outgassing & ionic contamination
- Effective at low loadings
- Lower specific gravity than CF compounds
- **Good surface appearance**
- Mold thinner wall thicknesses
- Isotropic properties
- Ability to use regrind

RTP Co. **Electrical Conductivity**
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SEM (2000x) of typical CNT compound

- Smooth surface finish
- Uniform shading is a direct result of uniform electrical conductivity

SEM (2000x) of typical CF compound

- Rough surface finish
- White shading indicates a point of high conductivity - “Hot spot”
- Possible conductive particle generation site

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EMI Shielding

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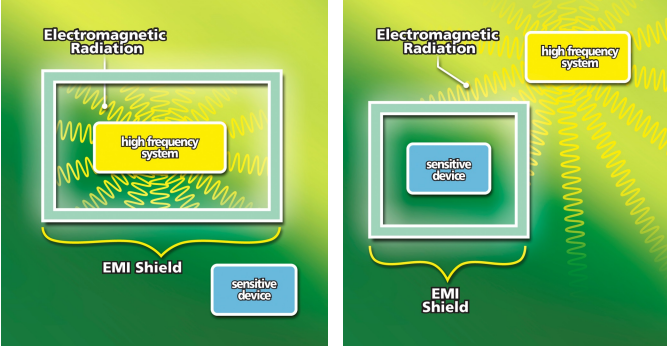
RTP Co. **What is EMI?**
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- **E**lectro**M**agnetic **I**nterference = EMI
- Emitted from a source or Received by a device
- Frequency range of 1 kHz to 10 GHz
- Faraday Cage Principle:
 - Barrier that reflects or conducts signals to ground
- Shielding provides “Immunity”

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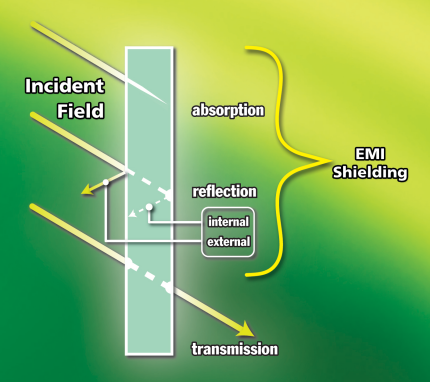
EMI in Action
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EMI shields protect sensitive devices



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EMI in Action
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Controlling EMI
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EMI Shielding is a function of 4 variables:

- Thickness of the material (Design)
- Frequency of the interference (Design)
- Distance between source & shield (Design)
- **Conductivity of the material (RTP)**

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EMI Shielding Fillers
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Electrically Conductive modifiers:

- Carbon Powder
- Carbon fiber
- Graphite
- **Stainless steel fiber**
- **Nickel-coated carbon fiber**
- Other metallic additives

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Key Additive Comparison
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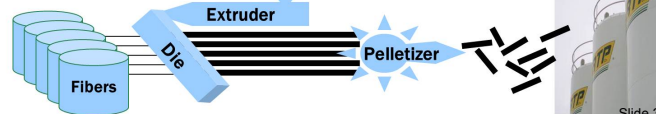
<p>Stainless Steel Fiber</p> <ul style="list-style-type: none"> - Minimal affect properties - Neat resin shrinkage - Good shielding - Cost effective - Colorable 	<p>Nickel Coated Carbon Fiber</p> <ul style="list-style-type: none"> - Similar to CF Compounds - High Shielding Performance - Higher Cost - Less Colorable - Light Weight
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The Long Fiber Process
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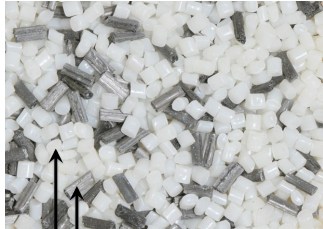

Pellet Comparison
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Short Fiber **VLF**

- The process results in very long, oriented fibers
- Creates better shielding than randomized short fibers

The Long Fiber Compound
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Optimized via “Cube Blends”

“A” Pellet – LF Product provides EMI shielding
 “B” Pellet – All other properties (Color, FR, Impact, etc.)

Cube Blends Maintain Fiber Length in Molded Part

RTP **Coaxial Trans. Line Test**
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- ASTM D4935
- Direct measurement
- Frequency from 300 to 1500 MHz
- Results in dB of SE

**Spectrum Analyzer/
Tracking Generator**

Test specimen

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RTP **Review of Shielding Options**
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EMI Compound	Conductive Coated Plastic	Metal

- VR is key parameter
- SR is misleading
- SE dependent on filler loading and wall thickness
- Easily Grounded
- SR key parameter
- Other surfaces insulative
- SE depends on coating Conductivity & Thickness
- Care in grounding required
- Uniform Conductivity
- SR easily measured
- Easily grounded

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RTP **Challenges in Auto Sensors**
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- Weight reduction
- Consistent shielding and quality
- Low frequency shielding
- Thermal management
- Global manufacturing and tech. support

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RTP **Sensor Application Successes**
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RTP Conductive EMI Resin:
 Stainless Steel Filled PBT (SE through Reflection & Absorption)

Results:

- Uniform SE, even in corners
- Better grounding
 - All surfaces are conductive
- Eliminated process steps
- Eliminated a supplier (Paint)
- Improved yields
- Reduced total cost

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Combining EMI + TC

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- SSF is a poor thermal conductor
- Thermal fillers can provide some EMI shielding
- Custom formulations can balance design requirements

RTP Formulation	Shielding Effectiveness (300 MHz – 1.5 GHz)	Thermal Conductivity (Through-plane)	Thermal Conductivity (In-plane)
RTP EMI 2562	60 – 85 dB	0.3 W/mK	N/A
299X124222C	30 – 55 dB	3.4 W/mK	25 W/mK
299X124222D	32 – 38 dB	3.1 W/mK	19 W/mK
299X124222E	40 – 60 dB	5.3 W/mK	32 W/mK
299X124223B	45 – 55 dB	1.4 W/mK	4.1 W/mK

Modifier Pros & Cons

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Technology	Pros	Cons
Migratory Antistats	• Economical	• Non-permanent • Process temperature limited • Humidity dependent
Inherently Dissipative Polymer PermaStat®	• Permanent • Transparent availability • Colorable • No loss of mechanical properties	• Limited to dissipative range • Process temperature limited
Carbon Black	• Economical • Dissipative or conductive • Resists Tribocharging	• Sloughing • Black only • Lower impact strength
Carbon Fiber	• Dissipative or conductive • Reinforcing • Non-sloughing	• Anisotropy • Poor tribocharging
Carbon Nanotubes	• Dissipative or conductive • Superior tribocharging performance • Minimal effect on mechanical and viscosity • Low LPC	• Cost • Black only
Metallic Additives	• EMI/RFI shielding • Highly conductive	• Limited colorability • Higher specific gravity

Wrap-Up

YOUR GLOBAL COMPOUNDER OF CUSTOM ENGINEERED THERMOPLASTICS

- Need to understand what conductive property you are testing and what regime you are targeting
- All conductive additives need a percolated network
- Wide variety of additives to solve most conductive problems
- Each have pros and cons

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Questions?

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