Most polymer resins are inherently electrically insulating. These resins can be compounded with certain types of conductive fillers or additives, which impart electrical conductivity to the plastic resin.

CONDUCTOMER® incorporates the inclusion of various levels of conductive carbon black into the resin polymer providing a conductive path for electrons to flow. These electrons follow a path wherever carbon particles dispersed in the plastic resin contact each other or are separated by a distance of less than 100 angstroms (1 angstrom = 0.0001 micron). Therefore, it is necessary that the concentration of carbon particles, dispersed in an insulating plastic polymer, be high enough to provide the necessary electron path to convey electricity. The greatest influence on the degree of electrical conductivity is the concentration of conductive carbon black added to the polymer.

Adding conductive carbon black to insulative thermoplastic polymers provides a permanently conductive mechanism within the polymer. This is in contrast to the anti-static additive approach to induce electrostatic dissipation. Many of these anti-static additives are dependent upon the additive blooming to the surface of the fabricated plastic part and the relative humidity of in the atmosphere in order to make the plastic statically dissipative on the surface. Anti-static additives are usually static conductive only on the surface (surface conductivity) and not through the thickness of the part (volume conductivity). Anti-static additives lack permanence in that if they are removed via rubbing or cleaning, then the part again becomes insulative on the cleaned surface.

Conductive carbon blacks are typically based upon furnace black production technologies. This type of carbon black provides an optimum level of electrical conductivity when dispersed in polymers because of four important factors:

1. STRUCTURE
2. IRREGULAR SHAPE
3. POROSITY
4. LOW VOLATILE CONTENT

The structural property of carbon black relates to the size of the carbon particle or aggregate. A carbon aggregate is the smallest dispersible unit of carbon black consisting of a cluster of fused carbon particles. The fusion of the particles occurs during the manufacturing process. Fusion has a great affect on the overall conductivity of the polymer into which it is dispersed. The smaller the carbon black aggregate the more aggregates per unit volume of compounded thermoplastic resin resulting in higher conductivity.
The irregular shape of the carbon black aggregate provides an optimum electron path (higher conductivity) when mixed into a thermoplastic resin. If the carbon black aggregate structure is irregular, and also very porous, this also results in reduced inter-aggregate distances enabling higher electrical conductivity.

Furnace blacks also have very low volatility making them more conductive. Volatility in reference to carbon aggregates primarily relates to the presence of oxygen/carbon complexes on the surface of the carbon particle. The presence of oxygen/carbon complexes tends to reduce the conveyance of electrons and presents an insulative type of condition which inhibits conductivity. Furnace blacks are very low in carbon/oxygen complexes, therefore these type of carbon blacks optimize electrical conductivity.

Compounding carbon black into insulative thermoplastic resins requires that an optimum degree of mechanical shear be generated to disperse the carbon black in the resin. Over dispersion of the carbon aggregates in the resin results from excessive shear and mixing. This has the effect of encapsulating the carbon with the insulating resin and inhibiting electrical conductivity of the mixture. Minimal shear and mixing can result in poorly dispersed carbon black aggregates which can also yield poor conductivity due to large inter-aggregate distances between carbon aggregates. Poor dispersion of the carbon also adversely affects the physical properties of the thermoplastic resin/carbon mixture while providing a very rough and lumpy surface on molded or extruded parts.

Typically, compounding thermoplastic resin with conductive carbon black develops electrical conductivity rapidly during the start of mixing. As mixing continues a plateau of highest conductivity is reached. Electrical conductivity diminishes gradually as mixing continues. For the same reasons, the additional mixing during post-compounding thermoplastic processing, such as injection molding or extrusion, can have the same effect as over mixing during compounding which diminishes conductivity.

The type of thermoplastic resin polymer used in CONDUCTOMER® also affects the level of conductivity at a given percentage of conductive carbon black aggregates in the resin mixture. For example, at a constant level of carbon black, EVA and PVC resins provide a higher degree of conductivity than the same concentration of conductive black in polyethylene or polypropylene. This is due to factors of inherent polymer resistivity, crystallinity, density and molecular structure.

End-use thermoplastic processing of CONDUCTOMER® can greatly influence the ultimate electrical conductivity of the finished part. Injection molding techniques yield parts with highest surface resistivity compared to extruded or compression molding techniques. The injection pressure and shear that develop when CONDUCTOMER® is forced to flow through small nozzles and gates tends to further disperse and encapsulate the carbon black aggregates. This has the effect of further reducing electrical conductivity. There is also a tendency, in injection rheology, to coat the surface of the mold cavity with a resin-rich part surface as the resin leads the flow of material to fill the cavity. This resin-rich surface has slightly reduced carbon content and, therefore, higher surface resistivity.

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Extrusion processes typically provide parts with higher conductivity compared to injection molding. This is due to slower melt transfer and fewer restrictions of the melt through the extruder and die configuration. For similar reasons, compression molding techniques also yield high conductivity.

Other factors that can influence the conductivity of CONDUCTOMER® parts include temperature extremes and mechanical stresses. An increase in part temperature generally results in a slight decrease in conductivity, while a decrease in part temperature may yield a slight increase in part conductivity. This expansion or contraction of the material increases or decreases the inter-aggregate distances of the carbon black particles. This variation in the inter-aggregate distances detracts from or enhances CONDUCTOMER® capacity to convey electrical current. When allowed to return to room temperature, CONDUCTOMER® parts will also return to normal conductivity levels. Mechanical stresses such as severe flexing of parts, will reduce conductivity in the stressed area. Over a period of time, the stressed area will recover most of its original conductivity when in a relaxed, unstressed condition.

All CONDUCTOMER® Compounds are hygroscopic due to the tendency of the high structure conductive carbon black aggregates to adsorb moisture. Synthetic Rubber Technologies takes great precautions to insure that finished CONDUCTOMER® Compounds are packaged in a manner to insure low moisture content necessary for thermal processing. Caution should also be taken when using this product that the pellets not be exposed for long periods of time in to a humid atmosphere environment prior to processing. This is especially true for CONDUCTOMER® regrind because the increased surface area of the regrind particles allows even more potential for moisture pick-up. Conventional polymer drying techniques will remove any adsorbed moisture from CONDUCTOMER® and restore it to its optimum, low moisture processing condition.

As with any process sensitive product, continued monitoring of the electrical conductivity of fabricated parts is required to insure that the necessary level of conductivity is being maintained.

CONDUCTOMER® Compound grades currently available include:

- **HDC-34 CONDUCTIVE CONCENTRATE**
  FOR INJECTION MOLDING, BLOW MOLDING & EXTRUSION (HDPE BASED)
- **HDC-22 CONDUCTIVE COMPOUND**
  FOR INJECTION, BLOW MOLDING & EXTRUSION (HDPE BASED)
- **HDC-22HLMI CONDUCTIVE COMPOUND**
  FOR EXTRUSION & BLOW MOLDING (HLMI PE BASED)
- **ABS-22 CONDUCTIVE COMPOUND**
  FOR EXTRUSION (ABS BASED)
- **HDC-25 CONDUCTIVE COMPOUND**
  FOR INJECTION MOLDING (HDPE BASED)
- **HDC-17HLMI-FR CONDUCTIVE COMPOUND**
  FOR INJECTION & EXTRUSION (HLMI PE BASED V-0 FLAME RATED UL-94)
- **HDC-19HLMI-FR CONDUCTIVE COMPOUND**
  FOR INJECTION & EXTRUSION (HLMI PE BASED V-0 FLAME RATED UL-94)
- **TPUC-20 CONDUCTIVE COMPOUND**
  FOR INJECTION & EXTRUSION (TPU BASED)

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