

Thermoplastic vs. Thermoset Wire and Cable Materials

One of the most beneficial ways of distinguishing the characteristics of a wire or cable is to determine if the insulation or jacket material used is a thermoset or a thermoplastic. The two materials have significantly different properties that influence their performance in a variety of applications. Understanding the properties of these two materials can be invaluable when selecting an economic product or trying to help prevent a possible meltdown.

What is a thermoplastic material?

A simple analogy to a thermoplastic is a chocolate bar. When a chocolate bar is melted, it has the ability to take on a new shape as it cools. This ability to be molded again and again is characteristic of thermoplastics.

Thermoplastics are composed of chains of molecules such as polyethylene. Each thermoplastic molecule is composed of many smaller individual molecules, as seen here in Figure 1. When heat is applied to the material, the added energy will allow the bonds between the molecules to be separated, causing them to move around like a liquid.

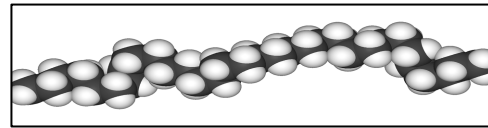


Figure 1: Structure of polyethylene

What is a thermoset material?

If a chocolate bar is analogous to a thermoplastic, thermoset materials can be described as being similar to a birthday cake. Once a cake is baked, it takes its final shape. Baking it longer does not increase or decrease the size of the cake. Ultimately if enough heat is applied, it will burn, but not melt like a chocolate bar. This particular characteristic is why thermosets are useful as durable materials that do not soften under high heat, such as car tires or flat roofing membranes.

Technically speaking, thermoset materials are those that are formed of basic polymer structures, such as polyethylene, and then cured or vulcanized. The curing process is what turns the plastic polymers into thermoset materials, which are also known as natural or synthetic rubber materials. The curing process can be done many ways, but the results are virtually the same. The long, individual polymer chains of the plastic become cross-linked by smaller molecules (shown as smaller red lines in Figure 2). The figure shows the different molecular structures of a thermoplastic and a thermoset.



Thermoplastic Molecular Chains



Thermoset Cross-linked Molecule

Figure 2: Thermoplastics vs. Thermoset

Note: Because of the cross-linking required to make a thermoset, they are often referred to as cross-linked materials. In fact, when you see an “XL” in front of the abbreviation for a plastic such as polyethylene (PE), it means that it has been cross-linked, not that it is “extra large.” Such thermoset materials are called cross-linked polyethylene or XLPE.

How do I choose a material for my application?

Knowing that the key difference between a thermoplastic and thermoset is in the way they respond to elevated temperatures can be an important aspect of which material to choose. For example, thermoset materials are often chosen for circuits that may experience an overload. This is because thermoset materials

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have a reduced likelihood of failure if momentarily operated at the higher temperatures that often accompany an overloaded conductor. Comparatively, thermoplastics are often easier to strip, which makes them easier to process on automated equipment for large volume applications.

There are other considerations when choosing between thermoplastic and thermoset materials. Even though it is not true in every case, Table 1 lists some general characteristics of the two material types and their implications to users.

Characteristic	Thermoplastic	Thermoset	How it affects the product
High temperature mechanical performance	Poor to good	Excellent	Increases survivability during emergencies or normal usage at high temperature
Coefficient of friction	Very low to moderate	Moderate to very high	Affects pulling tension, wire processing and tactile feel
Elongation	Poor to good	Good to excellent	Measure of stretch before breaking, encountered during installation, processing, and flexing
Tensile strength	Poor to excellent	Poor to excellent	Wide range in both material types, impacts durability and stripability
Colorability	Good to excellent	Poor to excellent	Affects identification, especially in low-light conditions
Heat deformation	Poor to good	Good to excellent	Becomes very soft as it nears its melting point
Cold temperature compatibility	Poor to excellent	Good to excellent	Affects storage, handling, installation and usage in cold environments, including air shipment

The variety of materials available to modern wire and cable manufacturers is immense. This results in a wide range of properties within each material type. The table is a generalized summary that does not apply to every material. It is important to understand how the properties impact the performance of the product in the intended application. Generally speaking, within a given material type, the old adage, “You get what you pay for,” still applies.