# Insulations and Jackets
Overview

### Insulations

Belden expends a great amount of time and effort to formulate its own insulations. As a result, Belden insulations provide superior performance under a variety of hostile environmental conditions.

Among the insulations we utilize are:

- **Polyethylene**
- **Polyvinyl Chloride (PVC)**
- **Polypropylene**

Also available are:

- **Datalene®**
  For computer and data transmission. Datalene is crush resistant, lightweight, and offers good performance characteristics over a wide range of temperatures.
- **Teflon® Insulated Plenum & High-temperature Cables**
  For data communications, instrumentation/control, and other commercial and industrial applications. Plenum cables eliminate the need for conduit and reduce installation time.

### Jackets

Belden electronic cables are manufactured in a wide selection of jacketing materials.

- **Polyvinyl Chloride**
- **Polyethylene**
- **Polyurethane**
- **Teflon®**
- **Tefzel®**
- **Neoprene**
- **EPDM**
- **Silicone rubber**
- **Natural rubber**

Special compounds and variations of standard compounds are used as well.

Teflon® and Tefzel® are DuPont trademarks.

# Insulations and Jackets

## Typical Characteristics of Popular Insulation and Jacketing Compounds

### EPDM

EPDM (ethylene-propylene-diene elastomer) is a chemically cross-linked elastomer with excellent flexibility at low and high temperatures (-55°C to 150°). It has good insulation resistance and dielectric strength, as well as excellent abrasion resistance and mechanical properties. EPDM also has better cut-through resistance than silicone rubber, which it replaces in some applications.

EPDM is compatible with most varnishes, but after the dip and bake cycle varnish tends to adhere to the insulation (because EPDM, unlike some rubber insulations, does not exude oils or waxes). As lead wires are pulled apart for termination, the varnish cracks, sometimes breaking the insulation.

To resolve this problem, a stearic solution is applied to the lead wire during the put-up process. This ensures that rigid varnish does not cause EPDM insulation to rupture when the wire is terminated.

Field evaluations by numerous users reveal that the coated EPDM has excellent varnish resistance at least equal to synthetic elastomers, cross-link polyethylene, or silicone glass braid in dip and bake systems.

### Neoprene

The temperature range of this material can vary from -55°C to 90°C. The actual range would depend on the formulation used. Neoprene is both oil-resistant and sunlight-resistant, making it ideal for many outdoor applications. The most stable colors are Black, Dark Brown, and Gray. The electrical properties are not as good as other insulation materials. Because of this, thicker insulation should be used. Typical designs where this material is used are lead wire insulation and cable jackets.

### Polyethylene (Solid and Foamed)

A very good insulation in terms of electrical properties. Low dielectric constant, a stable dielectric constant over all frequencies, very high insulation resistance. In terms of flexibility, polyethylene can be rated stiff to very hard, depending on molecular weight and density – low density being the most flexible, with high-density, high-molecular weight formulation being very hard. Moisture resistance is rated excellent. Black and specially formulated colored versions have excellent weather resistance. The dielectric constant is 2.3 for solid insulation and typically 1.64 for foam designs. Flame retardant formulations are available with dielectric constants ranging from about 1.7 for foam flame retardant to 2.58 for solid flame retardant polyethylene.

### Polypropylene (Solid and Foam)

Similar in electrical properties to polyethylene. This material is primarily used as an insulation material. Typically, it is harder than polyethylene. This makes it suitable for thin wall insulations. UL maximum temperature rating may be 60°C, 80°C or 105°C. The dielectric constant is 2.25 for solid and typically 1.55 for foam designs.

### Polyurethane

This material is used primarily as a cable jacket material. It has excellent oxidation, oil, and ozone resistance. Some formations also have good flame resistance. It is a hard material with excellent abrasion resistance. It has outstanding “memory” properties, making it an ideal jacket material for retractile cords.

### PVC

Sometimes referred to as vinyl or polyvinylchloride. Extremely high or low temperature properties cannot be found in one formulation. Certain formulations may have -55°C to 105°C rating. Other common vinyls may have -20°C to 60°C. There are many formulations for the variety of different applications. The many varieties of PVC also differ in pliability and electrical properties. The price range can vary accordingly. Typical dielectric constant values can vary from 3.5 to 6.5.

### Rubber

The description of rubber normally includes natural rubber and SBR compounds. Both of these materials can be used for insulations and jackets. There are many formulations of these basic materials. Each formulation is for a specific application. Some formulations are suitable for -55°C minimum, while others are suitable for 75°C maximum.

### Silicone

This is a very soft insulation which has a temperature range from -80°C to 200°C. It has excellent electrical properties plus ozone resistance, low moisture absorption, weather resistance, and radiation resistance. It typically has low mechanical strength and poor scuff resistance.

### Teflon®

This material has excellent electrical properties, temperature range and chemical resistance. It is not suitable where subjected to nuclear radiation and does not have good high voltage characteristics. FEP Teflon® is extrudable in a manner similar to PVC and polyethylene. This means that long wire and cable lengths are available. TFE Teflon® is extrudable in a hydraulic ram type process. Lengths are limited due to amount of material in the ram, thickness of the insulation, and preform size. TFE must be extruded over a silver- or nickel-coated wire. The nickel- and silver-coated designs are rated 260°C and 200°C maximum, respectively. The cost of Teflon® is approximately 8 to 10 times more per weight unit than that of PVC.

Teflon® is a DuPont trademark.

## Insulations and Jackets

Table 5: Comparative Properties of **Plastic** Insulating and Jacketing Compounds

| Properties | PVC | LDPE | Cellular Polyethylene | HDPE | Polypropylene | Cellular Polypropylene | PUR | Nylon | CPE | LSNH | FEP Teflon® |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Oxidation Resistance** | E | E | E | E | E | E | E | E | E | E | O |
| **Heat Resistance** | G-E | G | G | E | E | E | G | E | E | G-E | O |
| **Oil Resistance** | F | G-E | G | G-E | F | F | E | E | E | G | E |
| **Low-temperature Flexibility** | P-G | E | E | E | P | P | G | G | E | F-G | O |
| **Weather, Sun Resistance** | G-E | E | E | E | E | E | G | E | E | G | O |
| **Ozone Resistance** | E | E | E | E | E | E | E | E | E | E | E |
| **Abrasion Resistance** | F-G | G | F | E | F-G | F-G | O | E | E-O | F-G | E |
| **Electrical Properties** | F-G | E | E | E | E | E | P | P | E | G | E |
| **Flame Resistance** | E | P | P | P | P | P | P | P | E | E | E |
| **Nuclear Radiation Resistance** | F | G-E | G | G-E | F | F | G | F-G | O | F | P |
| **Water Resistance** | F-G | E | E | E | E | E | P-G | P-F | O | G | E |
| **Acid Resistance** | G-E | G-E | G-E | E | E | E | F | P-F | E | P-F | E |
| **Alkali Resistance** | G-E | G-E | G-E | E | E | E | F | E | E | G | E |
| **Aliphatic Hydrocarbons Resistance** (Gasoline, Kerosene, etc.) | P | G-E | G | G-E | P-F | P | P-G | G | E | F | E |
| **Aromatic Hydrocarbons Resistance** (Benzol, Toluol, etc.) | P-F | P | P | P | P-F | P | P-G | G | G-E | P-F | E |
| **Halogenated Hydrocarbons Resistance** (Degreaser Solvents) | P-F | G | G | G | P | P | P-G | G | E | P | E |
| **Alcohol Resistance** | P-F | E | E | E | E | E | P-G | P | E | G | E |
| **Underground Burial** | P-G | G | N/A | E | N/A | N/A | G | P | E-O | F | E |

CPE = Chlorinated Polyethylene • HDPE = High-density Polyethylene • LDPE = Low-density Polyethylene • PUR = Polyurethane • LSNH = Low-smoke Non-halogen • FEP = Fluorinated Ethylene-Propylene • P = Poor • F = Fair • G = Good • E = Excellent • O = Outstanding

These ratings are based on average performance of general purpose compounds.
Any given property can usually be improved by the use of selective compounding.

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## Insulations and Jackets

Table 6: Comparative Properties of **Fluoropolymer** Insulating and Jacketing Compounds

| Properties | FEP Teflon® | Tefzel® (ETFE) | PTFE Teflon® |
|---|---|---|---|
| **Oxidation Resistance** | O | E | O |
| **Heat Resistance** | O | E | O |
| **Oil Resistance** | O | E | E-O |
| **Low-temperature Flexibility** | O | E | O |
| **Weather, Sun Resistance** | O | E | O |
| **Ozone Resistance** | E | E | O |
| **Abrasion Resistance** | E | E | O |
| **Electrical Properties** | E | E | E |
| **Flame Resistance** | O | G | E |
| **Nuclear Radiation Resistance** | P-G | E | P |
| **Water Resistance** | E | E | E |
| **Acid Resistance** | E | E | E |
| **Alkali Resistance** | E | E | E |
| **Aliphatic Hydrocarbons Resistance** (Gasoline, Kerosene, etc.) | E | E | E |
| **Aromatic Hydrocarbons Resistance** (Benzol, Toluol, etc.) | E | E | E |
| **Halogenated Hydrocarbons Resistance** (Degreaser Solvents) | E | E | E |
| **Alcohol Resistance** | E | E | E |
| **Underground Burial** | E | E | E |

FEP = Fluorinated Ethylene-Propylene • ETFE = Ethylene Tetrafluoroethylene • PTFE = Polytetrafluoroethylene
P = Poor • F = Fair • G = Good • E = Excellent • O = Outstanding

These ratings are based on average performance of general purpose compounds.
Any given property can usually be improved by the use of selective compounding.

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## Insulations and Jackets

Table 7: Comparative Properties of **Rubber** Insulations

| Properties | Rubber | Neoprene | Hypalon® (Chlorosulfonated Polyethylene) | EPDM (Ethylene-Propylene-Diene Elastomer) | Silicone |
|---|---|---|---|---|---|
| **Oxidation Resistance** | F | G | E | E | E |
| **Heat Resistance** | F | G | E | E | O |
| **Oil-resistance** | P | G | G | P | F-G |
| **Low-temperature Flexibility** | G | F-G | F | G-E | O |
| **Weather, Sun Resistance** | F | G | E | E | O |
| **Ozone Resistance** | P | G | E | E | O |
| **Abrasion Resistance** | E | G-E | G | G | P |
| **Electrical Properties** | G | P | G | E | G |
| **Flame Resistance** | P | G | G | P | F-G |
| **Nuclear Radiation Resistance** | F | F-G | E | G | E |
| **Water Resistance** | G | E | E | G-E | G-E |
| **Acid Resistance** | F-G | G | E | G-E | F-G |
| **Alkali Resistance** | F-G | G | E | G-E | F-G |
| **Aliphatic Hydrocarbons Resistance** (Gasoline, Kerosene, etc.) | P | G | F | P | P-F |
| **Aromatic Hydrocarbons Resistance** (Benzol, Toluol, etc.) | P | P-F | F | F | P |
| **Halogenated Hydrocarbons Resistance** (Degreaser Solvents) | P | P | P-F | P | P-G |
| **Alcohol Resistance** | G | F | G | P | G |

P = Poor • F = Fair • G = Good • E = Excellent • O = Outstanding

These ratings are based on average performance of general purpose compounds.
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Hypalon® is a DuPont trademark.

## Insulations and Jackets

Table 8: Nominal Temperature Range for Various Insulating and Jacketing Compounds

| Compound | Normal Low | Normal High | Special Low | Special High |
|---|---|---|---|---|
| **Chlorosulfonated Polyethylene (Hypalon®)** | -20°C | 90°C | -40°C | 105°C |
| **EPDM (Ethylene-Propylene-Diene Monomer)** | -55°C | 105°C | – | 150°C |
| **Neoprene** | -20°C | 60°C | -55°C | 90°C |
| **Polyethylene (Solid and Foamed)** | -60°C | 80°C | – | – |
| **Polypropylene (Solid and Foamed)** | -40°C | 105°C | – | – |
| **Rubber** | -30°C | 60°C | -55°C | 75°C |
| **FEP Teflon®** | -70°C | 200°C | – | – |
| **PVC** | -20°C | 80°C | -55°C | 105°C |
| **Silicone** | -80°C | 150°C | – | 200°C |
| **Tefzel®** | -65°C | 150°C | – | – |
| **PTFE Teflon®** | -70°C | 260°C | – | – |
| **CPE** | -35°C | 90°C | -45°C | 105°C |

Hypalon®, Teflon® and Tefzel® are DuPont trademarks.