Technical Information

LSZH Jacketed Cables and Hazardous Locations Reference

Approvals and Standards/Performance Data for Low-Smoke, Zero-Halogen Jacketed Cable

XLPE Insulation	
Physical: (per UL-44)	
Tensile (min)	1500 psi
Elongation (min)	150%
Deformation (max)	3.35
LOI	27

Haloarrest® Jacket	
Physical	
Tensile (min)	1500 psi
Elongation (min)	100%
Tear resistance	74 lbs/inch
LOI	38
Halogen Content	
IEC 754-1	0%
BS6425	0%
MIL-C-24643	<0.2%
NBS Smoke Chamber (.100″ wall)	
Flaming Mode	141 D_m corrected typical
Smoldering Mode	311 D_m corrected typical
Acid Gas	
IEC 754-2	4.3 pH, 28 µS/cm
VDE 0472 Part 813	4.3 pH, 27 µS/cm
Toxicity Index	
NES 713	1

Low-Smoke, Zero-Halogen Jacketed Cable Specifications

600V, 90°C TC-LS
NEC 340/UL 1277 & 1685

Instrumentation

- 18 to 12 AWG, BC or TC
- 90°C XLPE insulation
- UL 44 XHHW-2 — 90°C dry/wet
- Shielded or unshielded
- Haloarrest jacket

Control or Power

- 14 to 4/0 AWG, BC or TC
- 90°C XLPE insulation
- UL 44 XHHW-2 — 90°C dry/wet
- Shielded or unshielded
- Haloarrest jacket

Hazardous Locations Cable Reference

Article 500

Class I Division 1 Hazards

- Locations where flammable gases or vapors may exist under normal operating conditions, under frequent repair or maintenance operations, or where breakdown or faulty operation of process equipment might also cause simultaneous failure of electrical equipment.
- Use conduit or MI cable with approved termination fittings.

Class I Division 2 Hazards

- Locations where flammable gases, vapors or volatile liquids are handled either in a closed system, or confined within suitable enclosures, or where hazardous concentrations are normally prevented by positive mechanical ventilation. Areas adjacent to Division 1 areas belong in Division 2.
- Use PLTC, ITC, TC, MC, MV, MI with approved termination fittings.

Class II Division 1

- Locations where combustible dusts exist under normal conditions.
- Use conduit or MI with approved termination fittings.

Class II Division 2

- Locations where combustible dusts exist under abnormal conditions.
- Use conduit or PLTC, ITC, TC, MC with ventilated channel cable trays.
- Use conduit or MC, MI with approved termination fittings.

Class III Division 1

- Locations where easily ignitible fibers and flyings exist under normal conditions.
- Use conduit or MC, MI with approved termination fittings.

Class III Division 2

- Locations where easily ignitible fibers and flyings exist under abnormal conditions.
- Use conduit or MC, MI with approved termination fittings.

Article 504

Intrinsically Safe

- Equipment and wiring that are incapable of releasing sufficient electrical energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture in its most easily ignited concentration.
- Use CL3, CL2, PLTC, TC or CM cable, colored light blue, with approved sealing and separation.

Hazardous Location Cable Reference per Canadian Electrical Code CEC Section 18

All Armored cables printed “HL” per CSA C22.2 #174 are rated for all Hazardous Location Classes and Divisions (ie. Class 1, Div. 1).

All Tray Cables printed “TC” per per CSA C22.2 #230 are rated for all Hazardous Location Classes and Division 2 or lower. (ie. Class 1, Div. 2 or lower).

Technical Information

UL Approved Insulation/Jacketing Options

UL Listed for MC and TC			
Insulation/Jacket	Max. Temp Rating		Flame Tests
	Wet	Dry	
PVC-Nylon/PVC (THHN or THWN) 14 AWG & larger	75°C	90°C	UL 1685 FT4/ IEEE 1202/383 ICEA T-29-520
PVC-Nylon/PVC (TFN or TFFN) 16 & 18 AWG	NA	90°C	UL 1685 FT4/ IEEE 1202/383 ICEA T-29-520
XLPE/PVC or CPE (XHHW–2) 14 AWG & larger	90°C	90°C	UL 1685 FT4/ IEEE 1202/383 VW-1 rated singles ICEA T-29-520
XLPE/PVC or CPE (RFH–2) 16 & 18 AWG	75°C	75°C	UL 1685 FT4/ IEEE 1202/383 VW-1 rated singles ICEA T-29-520
FRPO/PVC 18 AWG & larger	—	75°C	UL 1685
TPE/TPE	75°C	90°C	UL 1685
FRPO/PVC	75°C	90°C	UL 1685
XLPE/Haloarrest (XHHW-2) 14 AWG & larger	90°C	90°C	UL 1685 FT4/IEEE 1202/383 ICEA T-29-520
XLPE/Haloarrest (RFH-2) 16 & 18 AWG	75°C	75°C	UL 1685 FT4/IEEE 1202/383 ICEA T-29-520
FEP/PVC	90°C	90°C	UL 1685

UL Listed for PLTC	
Insulation/Jacket	Max. Temp Rating
XLPE/PVC	90°C
XLPE/CPE	90°C
PVC/PVC	105°C
PVC/CPE	105°C
PE/PVC	75°C
FPE/PVC	75°C
TPE/TPE	105°C
XLPE/Haloarrest®	90°C
FEP/FEP	200°C

Abbreviations Key

CPE	**Chlorinated Polyethylene**
FEP	**Fluorinated Ethylene-propylene**
FPE	**Foam Polyethylene**
FRPO	**Flame-Retardant Polyolefin**
PE	**Polyethylene**
PVC	**Polyvinyl Chloride** Nylon insulated singles are type THHN or THWN for conductors 14 AWG or larger. Conductor sizes 16 and 18 AWG are Type TFN or TFFN singles.
TPE	**Thermoplastic Elastomer**
XLPE	**Cross-Linked Polyethylene** Cross-Linked Polyethylene (XLPE) insulated singles are type XHHW-2 for conductors 14 AWG or larger. Conductor sizes 16 and 18 AWG are RFH-2.

Vertical Tray Flame Test Comparison

Test	UL-1685 (UL-1581)	FT4/IEEE 1202/ IEEE 383-2003	IEEE 383-1974	IEC 323-3	ICEA T-29-520
Flame Test Chamber	Vertical Tray	Vertical Tray	Vertical Tray	Vertical Tray	Vertical Tray
Burner Type	Ribbon gas burner	Ribbon gas burner	Ribbon gas burner	Ribbon gas burner	Ribbon gas burner
Theoretical Heat Input	70,000 BTU/hr	70,000 BTU/hr	70,000 BTU/hr	70,000 BTU/hr	210,000 BTU/hr
Burner Positioning	horizontal 3″ from samples 18″ from tray base	20° up from horizontal 2.95″ from cable surface 11.8" above floor	horizontal 3″ from samples 18″ above tray bottom	horizontal 2.95″ from cable surface 23.6″ above floor	horizontal 8-1/4″ from cable surface 12-1/4″ above tray base
Tray Dimensions	8′ length 12″ width 3″ side flanges	9.84′ length 11.81″ width 2.85″ side flanges	8′ length 12″ width 3″ side flanges	11.5′ length 19.7″ width none	8′ length 12″ width 3″ side flanges
Sample Spacing	1/2 cable diameter	1/2 cable diameter	1/2 cable diameter	lesser of 1/2 cable diameter and .78″	1/2 cable diameter
Duration of Flame Application	20 minutes	20 minutes	20 minutes	20 minutes	20 minutes
Mode of Failure	Cable blistering or charring has reached the top of the sample after the cable has self-extinguished.	Cable char has exceeded a length of 4.92′.	Cable blistering or charring has reached the top of the sample after the cable has self-extinguished.	Cable charring has reached a height of 98.4″ above the bottom of the burner.	Cable blistering or charring has reached the top of the sample after the cable has self-extinguished.

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. Belden cables are available in UL Listed and CSA Approved insulation compounds.

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.

- **Flamarrest® —** A Belden jacketing innovation, Flamarrest is a low-smoke, flame retardant compound that is five times more flexible than fluorocopolymer. Cables jacketed with Flamarrest are cost efficient and easy to install.

Also included in our wide selection of jacketing compounds are:

- **Polyvinyl-chloride**
- **Polyethylene**
- **Polyurethane**
- **Teflon**
- **Tefzel®**
- **Halar®**
- **Neoprene**
- **EPDM**
- **Hypalon®**
- **Silicone rubber**
- **Natural rubber**

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

Teflon, Tefzel and Hypalon are DuPont trademarks.
Halar is an Ausimont Corporation trademark.

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 high and low temperatures (150° to -55°C). 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.

Flamarrest®

Flamarrest is a plenum grade chloride-based jacketing material with low smoke and low flame spread properties. Cables jacketed with Flamarrest meet the ANSI/NFPA Standard 262-1985 (UL910), Plenum Cable Flame Test.

Halar®

Thermoplastic fluoropolymer material with excellent chemical resistance, electrical properties, thermal characteristics, and impact resistance. The temperature rating is -70°C to 150°C.

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 polyvinyl-chloride. 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 pound than PVC compounds.

Tefzel®

Fluorocopolymer thermoplastic material having excellent electrical properties, heat resistance, chemical resistance, toughness, radiation resistance, and flame resistance. The temperature rating is -65°C to 150°C.

Teflon and Tefzel are DuPont trademarks.
Halar is a Solvay Solexis trademark.

Insulations and Jackets

Table 4: Comparative Properties of Plastic Insulating and Jacketing Compounds

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

CPE = Chlorinated Polyethylene • HDPE = High-density Polyethylene • LDPE = Low-density Polyethylene • PUR = Polyurethane

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

Legend	
P	Poor
F	Fair
G	Good
E	Excellent
O	Outstanding

Insulations and Jackets

Table 5: Comparative Properties of Fluoropolymer Insulating and Jacketing Compounds

Properties	FEP Teflon®	Tefzel® (ETFE)	PTFE Teflon	Solef® / Kynar® (PVDF) / PVF	Halar® (E-CTFE)
Oxidation Resistance	O	E	O	O	O
Heat Resistance	O	E	O	O	O
Oil Resistance	O	E	E–O	E	O
Low-Temperature Flexibility	O	E	O	F	O
Weather, Sun Resistance	O	E	O	E–O	O
Ozone Resistance	E	E	O	E	E
Abrasion Resistance	E	E	O	E	E
Electrical Properties	E	E	E	G–E	E
Flame Resistance	O	G	E	E	E–O
Nuclear Radiation Resistance	P–G	E	P	E	E
Water Resistance	E	E	E	E	E
Acid Resistance	E	E	E	G–E	E
Alkali Resistance	E	E	E	E	E
Aliphatic Hydrocarbons Resistance (Gasoline, Kerosene, etc.)	E	E	E	E	E
Aromatic Hydrocarbons Resistance (Benzol, Toluol, etc.)	E	E	E	G–E	E
Halogenated Hydrocarbons Resistance (Degreaser Solvents)	E	E	E	G	E
Alcohol Resistance	E	E	E	E	E
Underground Burial	E	E	E	E	E

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

Legend	
P	Poor
F	Fair
G	Good
E	Excellent
O	Outstanding

Teflon and Tefzel are DuPont trademarks.
Halar is a Solvay Solexis trademark.
Solef is a Solvay trademark.
Kynar is a Atofina Chemical Corporation trademark.

Insulations and Jackets

Table 6: 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

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

Legend	
P	Poor
F	Fair
G	Good
E	Excellent
O	Outstanding

Hypalon is a DuPont trademark.

Insulations and Jackets

Table 7: 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
Halar®	-70°C	150°C	—	—
Tefzel®	-65°C	150°C	—	—
PTFE Teflon	-70°C	260°C	—	—
CPE	-35°C	90°C	-45°C	105°C
Solef® / Kynar®	-20°C	150°/125°C	-40°C	150°/150°C
Flamarrest®	-20°C	75°C	—	—

Hypalon, Teflon and Tefzel are DuPont trademarks.
Halar is a Solvay Solexis trademark.
Solef is a Solvay trademark.
Kynar is a Atofina Chemical Corporation trademark.

Shielding and Armoring
Overview

Innovative Leadership

The evolution of technology maintains steady demand for sophisticated cable shielding. Belden meets that demand with innovative shielding and shield effectiveness testing methods to supply you with high quality, dependable cable.

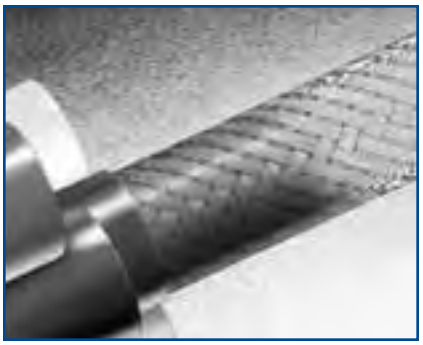
With the creation of trademarked shield designs and patented test methods, Belden has earned a reputation for innovation and leadership that is unequaled in the wire and cable industry. In addition, Belden offers the broadest line of shielded multi-conductor, coaxial and flat cable in the industry.

Several unique Belden innovations are utilized across a wide range of shielding applications:

- **Beldfoil® —** The first aluminum/polyester foil developed for use as a cable shield. Provides 100% shield coverage for optimum protection.
- **Duofoil® —** Consists of an aluminum-poly-aluminum laminate wrapped around the cable's dielectric core. Provides 100% physical coverage, and improves shield reliability and flex life.

Belden also utilizes a number of innovative techniques to apply shielding to multi-conductor and paired cables:

- **"French Braid" Shields —** Belden's patented "French Braid" shield is a double spiral (double serve shield) with the two spirals tied together by one weave.



Belden's patented "French Braid" shield.

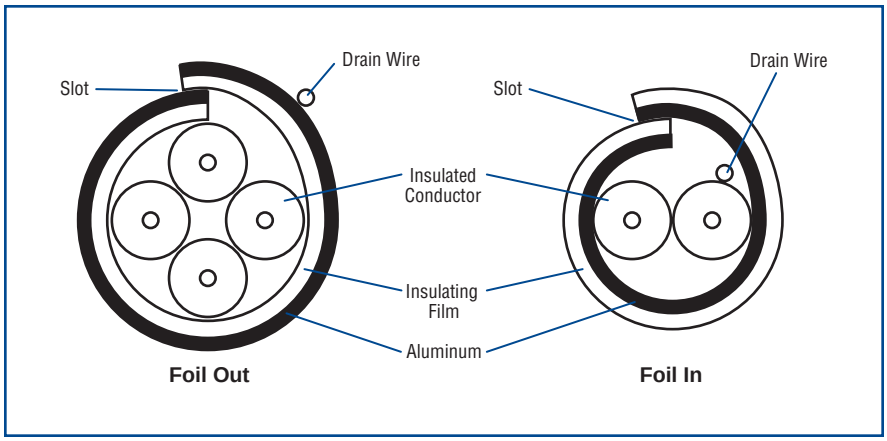


Figure 1: Foil shield configurations without shorting folds.

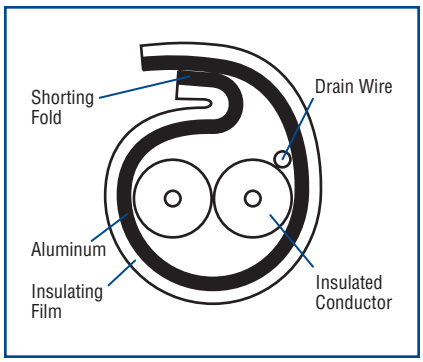


Figure 2: Foil shield configuration with shorting fold.

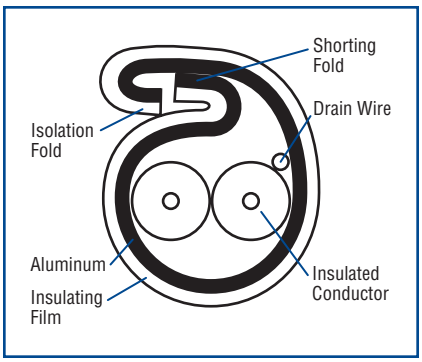


Figure 3: Foil shield with Z-Fold reduces crosstalk in multi-pair applications.

- **Shorting Fold —** Belden uses a shorting fold technique to maintain metal-to-metal contact for improved high frequency performance. Without the shorting fold, a slot is created through which signals can leak and cause interference. (See Figures 1 and 2 above.)

- **Z-Fold® —** Belden improves on the traditional shorting fold by employing a Z-Fold designed for use in multi-pair applications to reduce crosstalk. The Z-Fold (see Figure 3) combines an isolation and a shorting fold. The shorting fold provides metal-to-metal contact while the isolation fold keeps shields from shorting to one another in multi-pair, individually shielded cables.

The use of either a shorting fold or a Z-Fold increases the foil shield's range of effectiveness to higher frequencies.