Teflon® FEP 160

fluoropolymer resin

Description

Teflon® FEP 160 fluoropolymer resin is a melt-processible fluoropolymer resin useful for constructions that require very high stress crack resistance in primaries or jackets.

As shown in **Table 1**, this resin provides the electrical and mechanical properties needed for low-voltage applications. *Teflon*® FEP 160 has the lowest melt flow of any *Teflon*® FEP fluoropolymer resin. This high melt viscosity corresponds to a high molecular weight that is useful for constructions with very thick walls, that require exceptional stress crack resistance, or that experience significant thermal cycling. The low melt flow, however, substantially reduces the rate at which *Teflon*® FEP 160 can be extruded.

Like all *Teflon*® fluoropolymer resins, *Teflon*® FEP 160 offers an excellent combination of properties: chemical inertness, exceptional dielectric properties, heat resistance, toughness, flexibility, low coefficient of friction, non-stick characteristics, negligible moisture absorption, low flammability, performance at temperature extremes, and weather resistance.

Applications

Teflon® FEP 160 is only used in specialized wire and cable applications that can benefit from its unusual properties such as its great resistance to stress cracking. *Teflon*® FEP 160 can be used as jacket material for data and telecommunications cables, for use in air return plenums, but CJ92 has a much faster processing speed which makes it more economical for most applications that do not require the stress crack resistance of *Teflon*® FEP 160.

Safe Handling

Use of an adequate ventilation system allows safe processing of *Teflon*® FEP in extruders at high temperatures. For further information, refer to the DuPont bulletin "*Teflon*® Fluorocarbon Resin: Safety in Handling and Use," E-35824-1, which can be obtained from your DuPont representative.

Packaging

Teflon® FEP 160 is supplied as pellets and is available in 55-lb (24.9-kg) multilayer kraft bags with an integral polyethylene liner.

U.S. Freight Classification

For rail shipments, *Teflon*® FEP 160 is classified as "Plastic, Synthetic, OTL, NOIBN;" for truck shipments as "Plastic Materials, Granules;" and for express shipments as "Plastics, Synthetic."

Processing Guidelines for Wire and Cable Use Extrusion Equipment

Teflon® FEP 160 is fabricated using the same melt processing techniques as other thermoplastics. A brief description of the extrusion equipment used with *Teflon*® FEP 160 is given here; for more detailed processing information, consult the DuPont "Extrusion Guide for Melt Processible Fluoropolymers," E-85783, which can be obtained from your DuPont representative.

Molten *Teflon*® resins are corrosive to many metals; therefore, special corrosion-resistant materials must be used for all parts of extrusion equipment that come into contact with the melt. Nickel-based alloys such as Hastelloy®, Inconel®, Monel®, and Xaloy® are the materials of choice. Hardened electroless nickel plate can be used, but even small holes, chips, or cracks in the plating can compromise its performance. Chrome-plated materials are not recommended. Additional information on materials of construction can be obtained from your DuPont representative. Corrosion is likely to occur if dead spots exist in the equipment, processing temperatures are too high or hold-up time is too long. In addition, resin degradation will accelerate corrosion.

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Table 1
Typical Properties of *Teflon*® FEP 160 Fluoropolymer Resin

Property	ASTM Method	Units	Value
Electrical			
Dielectric Constant	D-1531		
100 kHz (10^5 Hz)		–	2.05
1 MHz (10^6 Hz)		–	2.05
Dissipation Factor	D-1531		
100 kHz (10^5 Hz)		–	.0003
1 MHz (10^6 Hz)		–	.0006
Dielectric Strength	D-149		
10 mil film		V/mil	1800
1/8 in Sheet		V/mil	500
Mechanical			
Melt Flow Number	D-2116	g/10 min	1.2
Specific Gravity	D-762	–	2.14
Tensile Strength	D-1708	psi	5000
		MPa	34
Elongation	D-1708	%	320
Thermal			
Melting Point	DTA-E168	°C	263
		°F	505

A 1.5- to 2.5-inch (38- to 64-mm) extruder with a barrel length-to-diameter ratio of 20:1–30:1 is recommended for extruding *Teflon*® FEP 160. Extruder barrels should have three to five independently controlled heater zones with temperature controllers capable of accurate operation (±0.6°C/ ±1°F) in the temperature range of 316°C to 425°C (600°F to 800°F). Heaters should be made of cast bronze or aluminum. Controllers with proportional-integral-derivative (PID) action are recommended.

A 3:1 compression ratio screw consisting of a relatively long feed zone, a 1- to 3-turn transition and a metering section that comprises approximately 1/4 of the length of the screw is recommended. The addition of a mixing section at the end of the screw can improve processibility. Contact your DuPont representative for more information.

A melt thermocouple and melt pressure probe should be installed in the adapter section of the extruder. To obtain an accurate measurement, the thermocouple should extend to the center line of the flow channel.

Degradation of the resin during processing greatly reduces the performance of *Teflon*® FEP 160 in stringent applications. Degradation is caused by excessively high melt temperatures, long residence time in the extruder, and/or excessive shear from the screw. In general, increases in the melt flow number (MFN) greater than 10% during extrusion should be avoided. This 10% rise in MFN will occur after only five minutes at 393°C (740°F), 10 minutes at 382°C (720°F), or 40 minutes at 360°C (680°F). This indicates the importance of maintaining resin flow through the extruder while at operating temperature and shows why temperatures should be decreased if the extruder is down for even a short period of time.

Other processing conditions that can reduce the resin's performance include melt fracture, very low or uneven melt temperatures, and the presence of hydrocarbon or silicone oils which act as stress crack promoters.

Wire-Coating Techniques

Teflon® FEP 160 is typically applied as a wire insulation using tubing techniques. Draw-down ratios (DDR) generally ranging from 50:1 to 200:1 are common. A draw-ratio balance (DRB) ranging from 0.9 to 1.1 is recommended. A complete discussion of DDR and DRB can be found in the DuPont "Extrusion Guide for Melt Processible Fluoropolymers," E-85783, which can be obtained from your DuPont representative.

A controlled vacuum is required at the rear of the crosshead to adjust the melt cone to the desired length. A melt cone that is too long results in excessive caliper variations while a melt cone that is too short results in excessive spark failures and cone breaks. Laboratory experience has shown that a cone length of 2.5 in to 3.0 in (64 mm to 76 mm) yields satisfactory results with a DDR of 122:1 and a DRB of 1.05. Control can be achieved at a shorter cone length if a higher DRB is used.

An electronic wire preheater located as close to the crosshead as possible is recommended for preheating the wire to 149°C to 204°C (300°F to 400°F) while operating at a typical line speed of 100 ft/min (30 m/min).

Stationary pulleys should be located on both sides of the crosshead to reduce wire flutter. The wire should pass through the crosshead, without touching the crosshead or the extrusion tip. Sponges should not be used to reduce flutter downstream of the crosshead because they can produce insulation faults.

The coated wire should pass through a 1- to 5-ft (0.3- to 1.5-m) air gap to allow uniform cooling and prevent the formation of shrinkage voids in the insulation.

Processing conditions depend on the equipment size and line speed. **Tables 2** and **3** list the actual processing conditions for a 15-mil wall of *Teflon*® FEP 160 on AWG #14 Solid Copper Wire. Adjustments may be necessary for other equipment.

Color Concentrates

Teflon® FEP based color concentrates are commercially available from several manufacturers. Only inorganic pigments should be used due to the high temperatures used to process *Teflon*® FEP. Concentrate loading information is available from the manufacturer, and it will normally depend on the compositions of concentrate, wire size, insulation thickness, and intensity of color desired. Your DuPont representative can provide additional information on suppliers.

Band Marking

Band marking inks for *Teflon*® FEP are commercially available from several manufacturers. In-line band marking of *Teflon*® FEP can be accomplished by positioning the band marking unit as close to the crosshead as possible and by using inks with high-boiling solvents. Your DuPont representative can provide additional information on suppliers.

Table 2
Typical Temperature Profile for Extruding *Teflon*® FEP 160 on AWG #14 Solid Copper Wire[1]

Zone	°C	°F
Rear Zone[2]	366	690
Rear Center[2]	382	720
Center	388	730
Front Center	396	745
Front	399	750
Clamp	399	750
Adapter	399	750
Crosshead	410	760
Die Holder	416	770
Melt	394	741

[1] Based on a 60-mm extruder with a 30:1 L/D; adjustments may be necessary for other equipment.

[2] For a smaller machine, it will be necessary to raise the temperature to ensure that the resin is completely melted before entry into the extruder's transition zone. A surging output at the die could be caused by incomplete melting.

Table 3
Typical Operating Conditions for Extruding *Teflon*® FEP 160 on AWG #14 Solid Copper Wire[1]

Extruder Speed	rpm	5
Line Speed	ft/min	100
	m/min	30
Wire Preheat	°C	–
	°F	–
Pressure	MPa	4.8
	psig	690
Die	in	1.000
	mm	25.4
Tip	in	0.650
	mm	16.5
DDR	–	122:1
DRB	–	1.05

[1] Based on a 60-mm extruder with a 30:1 L/D; adjustments may be necessary for other equipment.

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