Celanese

The chemistry inside innovation™

GENERAL EXTRUSION GUIDE CELANESE EVA POLYMERS

INTRODUCTION

Low-density polyethylene is produced through the polymerization of ethylene through a high-pressure process. Ateva® EVA copolymers are produced by copolymerizing ethylene (E) with vinyl acetate (VA) to form significantly different materials. As the VA content increases, the flexibility, resilience and transparency increase and the softening point decreases. The variety of possible applications is demonstrated in Table 1.

Certain Ateva EVA copolymers are similar in flexibility to plasticized PVC grades at ambient temperatures, but have greater flexibility and toughness at low temperatures. Ateva EVA copolymers contain no plasticizers, and can be used in place of plasticized PVC where plasticizer migration is a problem.

Although Ateva EVA copolymers are often more expensive than PVC on a weight basis, they may be less expensive on a volume basis due to their lower density.

In addition, Ateva EVA copolymers, particularly those with high VA contents, are able to tolerate high filler loadings without a significant decrease in flexibility and other mechanical properties.

This guide is intended for general extrusion recommendations and will not cover other important applications for LDPE or Ateva EVA copolymers (e.g. extrusion coating extrusion laminations, foam extrusion, injection or blow molding, carpet backing, hot-melt adhesives).


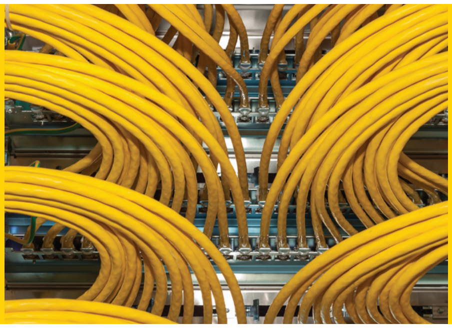
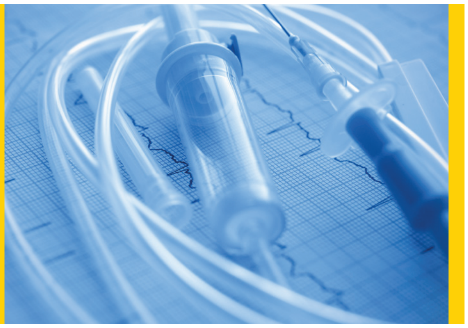

Table 1. Typical applications for LDPE and Ateva® EVA copolymers

Category	Typical Applications	Advantages
Sheet, cast film	Cap Liner, Nutrition bags	Good sealing properties, organoleptic, no plasticizers
Blown Film	Flexible packaging, batch inclusion bags	Sealing properties, flexibility, transparency, organoleptic and lack of plasticizers
Hose and tubing	Beer tubing, spirit bottling lines, medical tubing	Negligible odor, flexibility, transparency. No additives to cause taint problems
Helically wound or blow molded hose	Vacuum cleaner or swimming pool hose, anesthesia tube	Resilience, transparency, flexibility, floats on water, durability, drapability and lightweight
Thin wall tubing	Sachets for shampoos etc.	Excellent clarify, good environmental stress cracking resistance (ESCR), good welding
Protective strip	Car door buffers, furniture strip	Good resistance, no additives to attack car paints. Flexibility and rubbery nature.
Foam	Pipe, mattresses, shoe components	Low cost, strength, flexibility
Cable insulation and sheathing	High-performance wiring	Can be produced with high loadings of suitable fillers and cross-linked by irradiation or chemically, low smoke and toxic gas emission.
Compounds and master batches	Flame retardants, sound deadening, color master batches	Can be produced with high loadings of suitable fillers while retaining physical properties.
Hot melt adhesives and sealants	Hot melt glue sticks, glue for packaging and book binding.	Adhesion, cohesive strength, compatibility with wax and tackifiers
Extrusion coating and laminations	Tie layers to bond polyester covers to substrates	Clarity, adhesion, low gel content
Injection or blow molding	Medical components, mouth guards	Ease of processing, flexibility, low toxicity, good organoleptic

Various grades of Celanese LDPE and Ateva® EVA copolymers recommended for extrusion are listed in Tables 2 and 3 below. These low melt flow index grades enable good control of the extruded profile (MI<10 g/10min, 190°C, 2.16kg).

Table 2. Ateva EVA grades recommended for general extrusion

Grade	Vinyl Acetate (wt %)	Melt Index (g/10min, 190° C, 2.16kg)
Ateva 1030	7	1.5
Ateva 1070	9	2.8
Ateva 1075A	9	8.0
Ateva 1081	9	1.1
Ateva 1211A	12	0.35
Ateva 1221	12	0.8
Ateva 1231	12	3.0
Ateva 1241	12	10
Ateva 1609	16	8.4
Ateva 1807A	18	0.7
Ateva 1811	18	1.6
Ateva 1821A	18	3.0
Ateva 2604A	26	4.0
Ateva 2810A	28	6.0

Table 3. Celanese LDPE grades recommended for general extrusion

Grade	Nominal Density (kg/m³)	Melt Index (g/10min, 190° C, 2.16kg)
505	924	0.3
525	922	0.8
472	917	6.6
220	921	2.0

In general, LDPE grades are selected based on melt index (indication of melt viscosity for processing) and density (higher density correlates to a higher crystallinity, which dictates many properties including flexibility).

For EVA copolymers, the acetate groups decrease crystallinity (and therefore increase flexibility) but increase density due to the greater molecular weight of acetate over ethylene. Therefore acetate content, and not density, is more important in determining physical properties.

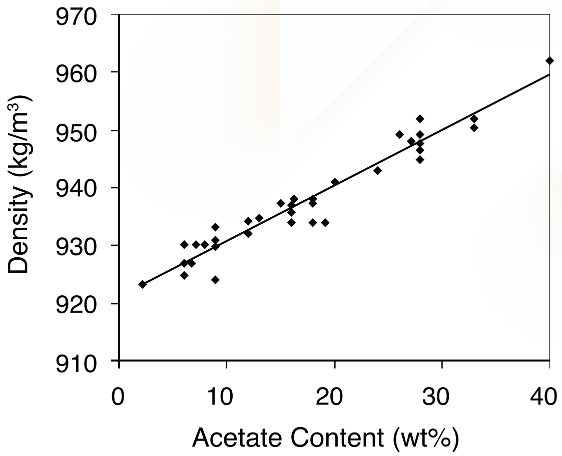

Figure 1. Correlation between acetate content and density for Ateva EVA copolymers.

EQUIPMENT

SCREW DESIGN

In general, it is desirable to use the same design of screw as is recommended for low-density polyethylene (standard polyolefin screw), i.e. one with three zones: feed, metering and compression. Compression ratios are typically between 2:1 and 4:1, (preferably 2.5:1 to 3.5:1). A length to diameter ratio of 20:1 or greater is recommended to ensure a homogeneous melt and to ensure good dispersion of any master batches added.

Screw cooling can be useful in preventing bridging or undesirable degrees of starve feeding. Internal cooling of the screw should cover the first 4-5 turns of the feed section, without entering the metering section.

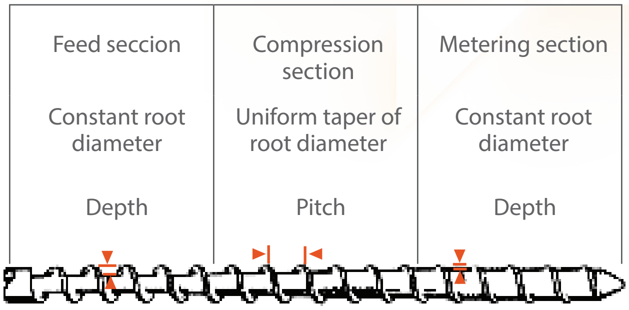

Figure 1. Polyolefin screw

BREAKER PLATE

For good homogenization, it is recommended that a breaker plate combined with a filter pack consisting of one or more 250 or 400 µm (60 or 40 mesh) gauges should be used. While back pressure is typically developed using a properly designed screw, additional back pressure can be generated by using a tighter mesh screen pack (e.g. for improved mixing or melt homogenization).

DIES

Dies should be of well-polished hardened steel. It is advisable to use steel with high chromium content in processes with high extrusion temperatures. For optimum performance, the flow channels within the die, crosshead and adaptor should be streamlined to avoid build-up of material and thermal degradation of the copolymer.

EXTRUSION RECOMMENDATIONS

RECOMMENDED TEMPERATURE PROFILES

The recommendations included here are for general referencing and may need adjusting for a particular process. However, a rough guide to the processing temperature can be estimated from the melt index and vinyl acetate content. Lower melt indices (high viscosity) require elevated temperatures to prevent excessive extruder amperage. The melting point of EVA copolymers decreases with increasing VA content and can often be run cooler. Typical DSC melting temperatures for polymers in the range of 0 to 28% VA are on the order of 115°C to 70°C, respectively. Running cooler for higher VA contents also helps prevent sticking, as higher VA content copolymers have higher melt tackiness.

Table 4 contains a rough estimate of the desirable melt temperature for general extrusion. The recommended profiles presented in Table 5 are 'guidelines' only. Because each extrusion process is unique, it is strongly recommended that you monitor both extruder amperage and head pressure at all times to ensure they do not exceed machine operating limits. Extrusion profiles may need to be adjusted accordingly if either approaches machine operating limits. All extrusion processes will be slightly different with some notable exceptions. For example, extrusion coating and laminating of LDPE can run in excess of 300°C while extruded foam can be run very close to the polymer's melting point.

In general, EVA copolymers should not be extruded hotter than 220°C since degradation may occur. Degradation products include the elimination of acetic acid, which can account for a "vinegar" odor and corrosion of some materials.

The suggested profiles should be adjusted based on a variety of factors:

- Larger extruders and/or longer residence times require hotter profiles
- Tighter screen packs require hotter profiles
- Screw designs with ore shear heating (shallow depth, long screw) can result in elevated melt temperatures

Table 4. Nominal melt temperature as a function of vinyl acetate content and melt index

Melt Index (g/10min)	Vinyl Acetate Content (wt%)				
	0-5	5-10	10-15	15-20	20-30
<1	210	205	205	200	190
1-5	180	175	175	170	160
5-10	160	155	150	145	140

Nominal melt Temperature (°C)

Table 5. Extruder profile temperatures (°C)for desired melt temperature

Desired Melt Temperature	Feed Pocket	Rear Zone	Middle Zones: Zone 3	Middle Zones: Zone 4	Front Zone	Extension	Die
205	Cold*	90	150	205	205	205	205
175	Cold*	90	150	175	175	175	175
150	Cold*	90	150	150	150	150	150

* Water-cooled feed throats are recommended due to the low melting points of EVA copolymers

SHUTDOWN CONSIDERATIONS

Care should be taken to prevent oxidation of the resin during shutdown. This is especially true for EVA copolymers, which are more susceptible than LDPE. Oxidation can lead to an increase in viscosity (through crosslinking), and even gel formation. This oxidized material can be difficult to purge, resulting in longer start-up times.

For minor stoppages during production runs, it is recommended to keep the screw turning over at a low RPM to move the melt slowly through the system.

Longer-term shutdowns (overnight, maintenance or the end of a production run) require further precautions. In general, first cool the melt prior to stopping the feed (25-50°C below processing temperature, but above the melting point). This can be performed at low RM. By leaving the screw full there is less space for air (oxygen accelerates degradative oxidation).

If you are running EVA, it is recommended that you first purge the extruder with low-density polyethylene of a similar melt index. If this is not possible, follow similar procedures as for LDPE, but monitor the quality of resin during start-up. It may also be recommended to use a grade of polymer containing antioxidant, as this will help to slow down the degradation process.

It is generally not recommended to run an extruder dry. This is because it is virtually impossible to completely empty the barrel, and it will result in more oxygen being present to cause degradation.

START-UP CONSIDERATIONS

If using EVA (or even LDPE), it is beneficial to first heat up to an intermediate temperature between the melting point and the processing temperature. This will allow the resin to melt and swell (expelling any air in the screws), without excessive exposure to higher temperatures. Once this is complete, the set points can be elevated to processing temperatures.

Ensure that a long enough heat-soak has occurred to fully melt the polymer; otherwise excessive torque may possibly result in shearing of the screw.

BRIDGING

Bridging results from partial or complete interruption of flow in the screw channel. This can result in:

- Reduction or variation in amperage and head pressure
- Reduction or variation in die output
- Entrapped air causing bubbles in the melt

In the extreme case, complete loss in die output can occur, with no head pressure and minimum amperage. Due to the low melting points of EVA copolymers, it is essential to prevent premature melting and sticking in the fee section. The following recommendations are required to help prevent bridging:

- Water cooling of the feed throat
- Low temperature for the rear barrel heating zone
- Proper screw design with internal screw cooling for the fee section

If bridging occurs, rapidly increase the screw speed to attempt to dislodge the bridge. If this does not help, it may be necessary to insert a polyethylene rod (large pieces get bitten off), or purge with polyethylene pellets. In the extreme case, the screw will need to be pulled and cleaned.

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EVA-015-GeneralExtrusionGuide-TG-EN-1115