

## 2. RECOMMENDED DOSAGE

With deep understanding that every chain extension problem is unique, our Technical Service experts will help you define the right dosage for your specific system. The guide below may be used as a reference for typical ranges of dosage of Joncryl chain extenders.

Plastic	Application	Recommended Dosage (% w/w)
Polyesters (PET)	Fiber (staple & filament)	0.1 to 0.4
	Injection/blow molding bottle	0.2 to 0.6
	Sheet, tape & profile extrusion	0.2 to 0.8
	Film & bottle blow molding	0.2 to 0.8
	Strapping	0.2 to 0.8
	Compatibilization PET/PA-nylon	0.5 to 1.0
	Foam	0.2 to 1.0
Polyesters (PETG, PBT, PLA, others)	Injection Molding	0.1 to 0.2
	Fibers	0.1 to 0.4
	Profile extrusion	0.2 to 0.6
	Sheet & film	0.3 to 1.0
	Branching	0.5 to 1.0
	Foam	0.2 to 1.0
Polyamides (nylon, PA 6 & 6,6, other)	Injection molding	0.1 to 0.2
	Profile extrusion	0.3 to 0.8
	Sheet, film & tape	0.4 to 1.0
	Branching	0.5 to 1.0
	Compatibilization polyester/PA-nylon	0.5 to 1.5
Polycarbonates (PC)	Injection molding	0.1 to 0.2
	Hydrolytic stabilization	0.3 to 1.0
	Sheet & film	0.4 to 1.2
	Branching	0.5 to 1.5
Other condensation thermoplastics (TPU, POM)	Melt strength	0.2 to 0.8
	Stabilization	0.2 to 1.0

### 3. METHODS OF DOSAGE

Operation	Procedure
1. Dry-blending	a) Flake or sugar size can be dry-blended with pre-dried and cold (<40°C) plastic pellets or flakes with the aid of low shear mixer such as tumble mixer or conical mixer.
	b) All solid forms of chain extender agent can be mixed with other materials in a high shear mixer such as a Henschell mixer below 50°C.
2. Addition of Chain extender agent on a single-screw extruder, twin-screw extruder or kneader.	a) Dry-blends prepared as in (1) can be volumetrically, gravimetrically or flood fed directly into the mixing zone of the extruder (see temperature recommendations in the Processing Conditions in Section 4.)
	b) Gravimetric feed metering systems can be used to feed any solid product form in a parallel stream with the plastic directly into the feeding zone of the extruder. Belt and disc feeders are particularly recommended for the flake form. Single Screw Feeders – Clearance of 3 to 5 mm (0.76 – 1.27 in) between the screw and the tube recommended. Twin-Screw Feeders – Non-intermeshing spiral screw with 6 mm (1.52 in) clearance between the screw and the tube recommended. Eliminate agglomeration at the throat or feed zone by maintaining tube temperature below 80 °C.
	c) Volumetric Feeders: Well calibrated feeders with variation of less than 0.5% are recommended. Clearance of 3 to 5 mm (0.76 – 1.27 in) between the screw and tube is also required to reduce fines. Eliminate agglomeration at the throat or feed zone by maintaining tube temperature below 80 °C.
	d) Side feed systems and other types of forced dosing extruders may be employed with all solid product forms, except for fine powder, to feed the products downstream. Residence time recommendations are given below in reference to downstream feeds.
	e) Direct gravimetric/volumetric addition of the chain extender in any form to the plastic melt may be carried out through any suitable downstream venting or degassing port.
	f) With the aid of a melting tank, chain extender agent becomes pumpable at temperatures about 120 - 140 °C. Jacketed melt tank with stirrer and temperature control up 145 °C with nitrogen purge recommended. Feed between 120 - 140 °C. Use continuous and positive displacement pump. Close Vent Delivery: Use pump that can deliver pressure up to 2000 psi. Injection valve with variable pressure control to deliver the additive at pressure higher than in the extruder. Pressure gauges are recommended.

### 3. METHODS OF DOSAGE - Continued

Operation	Procedure
3. Addition during injection molding and combined injection-blow molding operations.	a) Dry-blends prepared as in (1) can be volumetrically, gravimetrically or flood fed directly into the mixing zone of the injection molder (see temperature recommendations in the Operating Conditions in Section 4.)
	b) Flakes not recommended for direct addition to injection molding equipment.
	c) Volumetric Feeders: Well calibrated feeders with variation of less than 0.5% are recommended. Clearance of 3 to 5 mm (0.76 – 1.27 in) between the screw and tube is also required to reduce fines. Eliminate agglomeration at the throat or feed zone by maintaining temperature below 100°C for MB polymer carriers or 80 °C for wax carriers.
	d) With the aid of a melting tank, chain extender agent becomes pumpable at temperatures about 120 - 140 °C. Jacketed melt tank with stirrer and temperature control up 145 °C with nitrogen purge recommended. Feed between 120 - 140 °C. Use continuous and positive displacement pump. Close Vent Delivery: Use pump that can deliver pressure up to 2000 psi. Injection valve with variable pressure control to deliver the additive at pressure higher than in the extruder. Pressure gauges are recommended.
4. Addition during polymerization and in other chemical reactors	a) Additions of chain extender agent directly into polymerization reactors are feasible for some systems.
	Prior to any work including the use of chain extender agent in polymerization, we encourage you to discuss your system with our technical representatives.

## 4. PROCESSING CONDITIONS

Operation	Procedure
Pre-drying	Pre-dry the base plastic at manufacturer's recommended conditions.
	In some instances small amounts of Joncryl chain extenders can compensate for poor/incomplete drying, thus bringing robustness and savings to your operations. For example in polyesters, degradation brought about by 100 ppm of moisture can be compensated by 0.2 % of chain extender agent.
	Hygroscopicity: there is no evidence of bulk absorption of moisture over extended periods of time for chain extender agent. - At normal conditions of temperature and relative humidity (i.e. 77°F and 50% RH) its surface reaches equilibrium saturation through adsorption at less than 0.25% moisture. - At extreme conditions (i.e. fine powder at 95°F and 100 % RH) its surface reaches equilibrium saturation at less than 0.50 % of moisture. - This means that chain extender agent can generally be processed without any drying, even after long exposure to drastic conditions bringing no more than 5 ppm moisture per every 0.1% used.
	In systems where moisture sensitivity is extreme, chain extender agent can be dried in a desiccant dryer at 30°C for 1 hour, prior to use.
Extruder/injection molder temperature profile	When feeding solid chain extender agent into the 1st zone of the extruder or injection molder, we recommend to operate this zone at 20°C to 40°C lower temperature than normal. This will prevent early melting and agglomeration of the additive.
	All other zones should employ normal processing conditions as recommended by the plastic's manufacturer.
Additive thermal stability	Neat chain extender agent is thermally stable up to 300°C (<0.5% evolution in TGA @ 10°C/min in N <sub>2</sub> ). Above this temperature additive decomposition may occur. PET compounded with 1% of chain extender showed identical thermal behavior as PET (TGA, 10°C/min. in N <sub>2</sub> ). Therefore, melt temperature should not exceed 320°C.
Residence time	Chain extender agent reacts quickly. Its reaction will be over 99% complete if at least 120 sec residence time is provided at 200°C in a well mixed system. Alternatively, 30 sec residence time at 280°C will provide 99% completion.
	These limits accommodate most extrusion and injection molding processes for the recommended thermoplastics and applications.
	For use in polymerization reactors where residence time is over 5 minutes, see Recommendations in Section 3.

### Maximum Use Temperature:

**Chain extender agent** should not be processed at temperatures higher than 320°C (see Thermal Stability in Section 4.

## 5. EXTRUDER PRESSURE EFFECTS

The use of **chain extender agent** in reactive extrusion or reactive injection molding operations produces significant increases in molecular weight of the plastic being modified. This increase in molecular weight raises the melt viscosity, which in turn raises the pressure observed in the equipment.

The table below exemplifies the large increases in die pressure that are observed in PET as **chain extender agent** is added to a large extruder. Similar increases are expected in other plastics.

It is important that operators be aware of these expected pressure changes. Alarms, automatic shut-offs, screen purging set-points, and other operation variables should be adjusted to accommodate these normal and expected pressure increases.

Extruder Variable	PET Control	0.50% BX ADR 4370	1.00% BX ADR 4370	1.50% Joncryl BX ADR 4370
Pressure @ die	1	1.45-1.65	1.90-2.30	2.20-2.60
Pressure @ screen	1	1.45-1.65	1.90-2.30	2.20-2.60
Motor power draw	1	1.08-1.10	1.13-1.18	1.17-1.21

As shown, pressure increases both at the die and in front of the screen system may be 50% to 160% higher than typical operating pressure for higher usage levels.

Instantaneous pressure variations and spikes are due to large instantaneous changes in melt viscosity. At constant temperature, changes in melt viscosity are often due to variable feed rate and/or poor mixing

To illustrate the effect of variable feed rate, the pressure and power draw changes with fluctuations in feed rate are calculated on the table below. For example, a variation of 20% in the feed rate causes a 9% increase or decrease in pressure, which is a variability range of 18%.

Extruder Variable	Steady feed within 5% of target value	Unsteady feed within 10% of target value	Unsteady feed within 20% of target value
Pressure @ die	+/- 2.0%	+/- 4.3%	+/- 9.0%
Pressure @ screen	+/- 2.5%	+/- 4.5%	+/- 9.2%
Power draw	+/- 0.4%	+/- 0.8%	+/- 1.75%

Fluctuations in the feed rate of **Chain extender agent** larger than 10% of the target value may cause large instantaneous extruder pressure spikes.

To attain steady and consistent pressure, homogenous dry blends or robust co-feed systems are essential.

The selection of the screen pack can influence the pressure. Finer screen mesh will produce even higher pressures when used with **Chain extender agent**.

## 6. TROUBLESHOOTING

### In Case of Unexpectedly High Pressure:

1. Decrease the feed rate of **Chain extender agent**.
2. Decrease the RPM. This decreases pressure on single screw extruders and flood-fed twin-screw extruders, and will decrease heating on starve-fed twin-screw extruders
3. Slowly increase the temperature, starting from the die and then from the last to the zone.

In a typical extruder with an  $L/D > 24$  normally most of the extension reaction takes place in the first half of the extruder length. Increasing the temperature in the zones of the final half of the extruder will generally result in lower viscosity and pressure.

4. With pressure under control, increase the **Chain extender agent**. feed slowly.
5. For steady operation follow recommendations given in the section 5 above. Keep in mind that chain extension will always result in higher pressure at constant extruder settings