Aquapak Polymers Ltd

# Tech Transfer Document

Revision 5



Stuart Lloyd
January 2019

# Abstract

Plastics are core to today's world and are vital in our daily activities, but single-use plastics have created a pollution problem that is dangerous to marine life, filling land-fills and impacting human life throughout the world. Today, fewer than 15% of all plastics used in the world are recycled. The longevity of plastics is a negative attribute when they enter our natural world uncontrollably creating disastrous, long lasting effects.

Changing the way, we create, use and reuse plastics is key to their continued viability and growth. At Aquapak, we are at the forefront of the new plastics economy initiatives, using our proprietary technology to develop and manufacture sustainable plastics. Our advanced polymer, Hydropol™, is specifically formulated to generate high performance properties for a range of technical applications while having a range of end of life options depending on the application and inherently non-toxic. Hydropol™'s strength and flexibility makes it valuable for many types of applications in the food manufacturing and medical markets, as well as an ideal choice for high performance packaging.

# Table of Contents

## Introduction to the Process

The purpose of this document is to provide a technology transfer reference library for our approved film producers who wish to run the Aquapak pellets to make film, laminations or packaging from the Aquapak smart polymer.

The pellet has been developed to run without significant modifications on most PE machines. However, not all machines are the same in terms of geometry, quality, age & condition, therefore we believe these steps will provide the safest method to understanding how our polymer can be blown into film.

The Aquapak polymer resin is a unique pellet and as such does not always to standard PE operating protocols. It is therefore, critical that an Aquapak representative be on site for training during any initial pumping trials on the extruder.

There are important steps we describe within this document that must be read, understood and actioned prior to running any pellets for the first time. Aquapak accept no responsibility if extruders are damaged by not adhering to these instructions.

The steps have been developed over a period time and have been proven to offer a successful start-up procedure with minimal waste.

The following page gives a simple visual guide to the simplest pathway to follow through the technical transfer process to begin using Aquapak polymer resin. It is not a fixed procedure but historically has been found to be the smoothest way forward for cooperation between current partner companies.

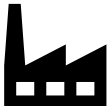
**Step 1**. Once an agreement has been made to work together between our companies, the technical transfer process can commence.


**Step 2.** The consumer will be sent a Pre-Assessment Check List. This must be completed to provide the Aquapak Technical Team with enough information to determine the suitability of the desired extrusion line to use. Any additional camera/video footage to compliment the completed check list is also highly desirable.

**Step 3.** A courtesy technical meeting will take place between Aquapak and the consumer to discuss the next steps in the process and as an introduction to all leaders in the project (either in person or via media alternative).


**Step 4.** An Aquapak representative will visit the customer site as an introduction and verification that the extrusion line is prepared suitably to run Aquapak polymer.


**Step 5.** A technical call will take place to agree that line conditions have been met and a date can be agreed for a pumping trial to take place.

**Step 6.** An Aquapak Transfer Technician will visit site to assist with training and perform a pumping trial on the line (usually with @100kgs of polymer)

**Step 7.** A technical meeting will take place to discuss the success of the pumping trial and next steps in the process towards arrangement of a larger scale trial.


**Step 8.** An Aquapak Transfer Technician will visit site to assist with training and complete a larger scale trial to blow film to the satisfaction of all parties.


**Step 9.** A final technical call to confirm both parties are in agreement with regards outcome and future partnership.

## Line Pre-Assessment

The Line Pre-Assessment Check List is a mandatory document to be completed by the customer prior to any further steps in the process. It is integral to the success of the Aquapak polymer resin that the Technical Team are fully informed of the extrusion line intended for use so they can conduct an informed assessment of the line suitability and recommend any modifications to the line to ensure the smooth running of the Aquapak polymer. Highlighted in red are some of the explanations for information requested.

## Line Pre-Assessment Check List

Date ……

Customer……

Line Number……

Extrusion Layers (ie mono) ……

Screw Design/Number ……

L/D Ratio (ie 30:1) ……

Number of Screw Flights (if known) ……

Screw Diameter……

Screw Compression Ratio……

Does Screw Have Mixing Chambers/Barrier ie Maddocks Mixer?

YES NO Type……

This will confirm the suitability of your current screw to extrude Aquapak polymer resin.

Motor Power (Kw)……

Motor Details (V, Amps, Hz) ……

Motor Pulley Diameter (MM) ……..

Gearbox Pulley Diameter (MM) …….

Due to the harder compound of Aquapak resin, the greater the ratio between motor and gearbox pulleys will ease the torque stress on the screw.

Throat cooling is critical if no groove feed section is fitted to barrel.

Is there Cooling for the Throat Area? YES NO

Can Screw Flights Be Visible During Production? YES NO

Grooved Feed Section in Barrel YES NO

Heated in Throat Area? YES NO

Number of Barrel Heater Controls…….

Number of Barrel Fans……..

Minimum number 3 required. 4+ preferential.

Number of Die Heater Controls…….

Minimum number 2 required. 3+ preferential.

Die Diameter (MM) ……

Die Gap (MM) ……..

Will determine the product size window available. 1mm-2mm gap required.

Insulated Gap Between Die Top and Air Ring? YES NO

Air Ring Type (ie LD/HD) ……

Nip/Path Roller Max Width (MM) …….

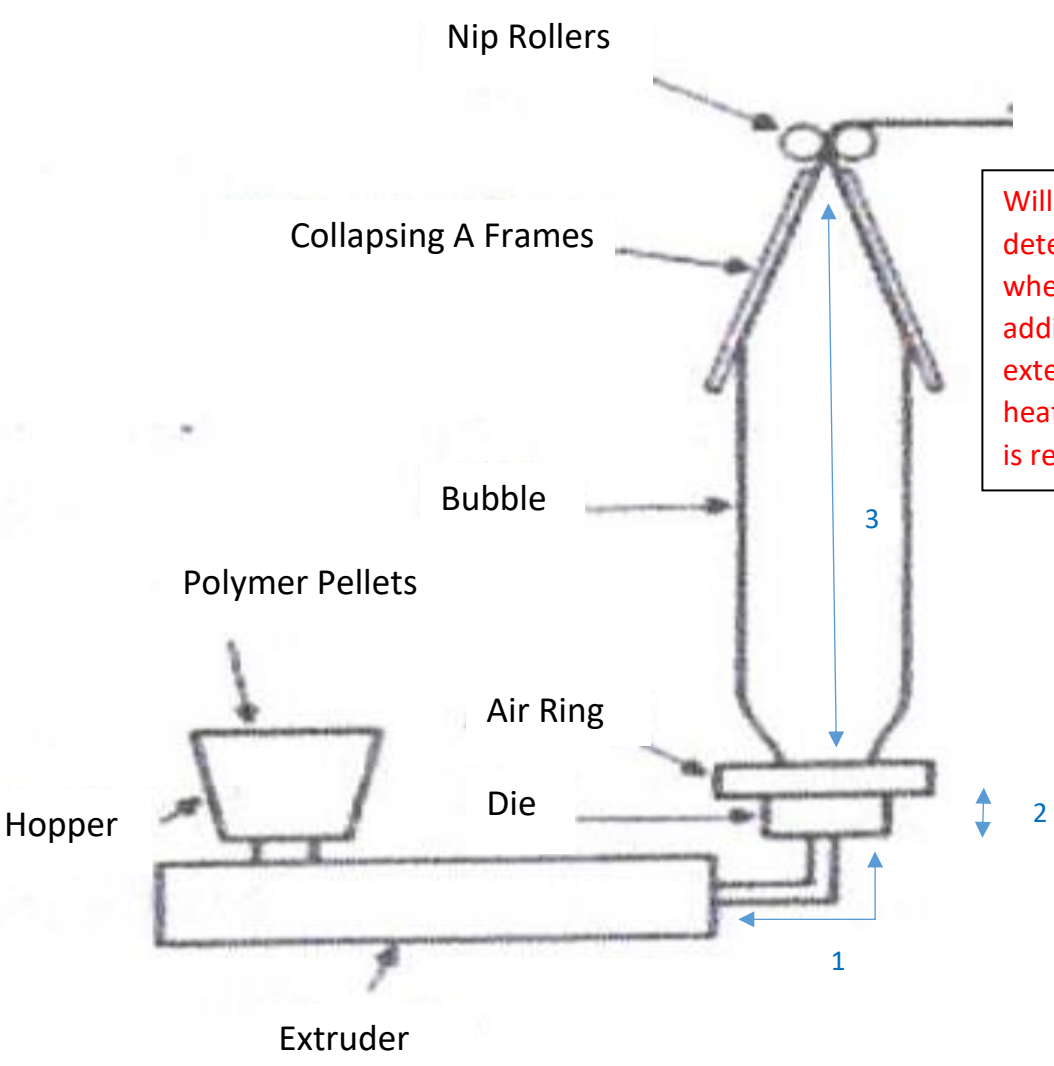
1.Length Between End of Screw and Die Base (MM) ……..

2.Height Die Base to Die Top (MM) ……

3.Height Die Top to Nip Rollers (MM) ……..

Collapsing A Frame Material  Wooden Slats  Metal Rollers

To ensure flow spaces/non-driven movement of polymer is not too long.




Will help to determine whether additional external heating/cooling is required.

Signed…….

Print ……  Role ……





In addition to the checklist, it is advisable that any new customers send pictures of the line to aid the Technical Transfer team in their analysis of resources before suggesting recommendations.

For any advice please contact slloyd@aquapakpolymers.com.

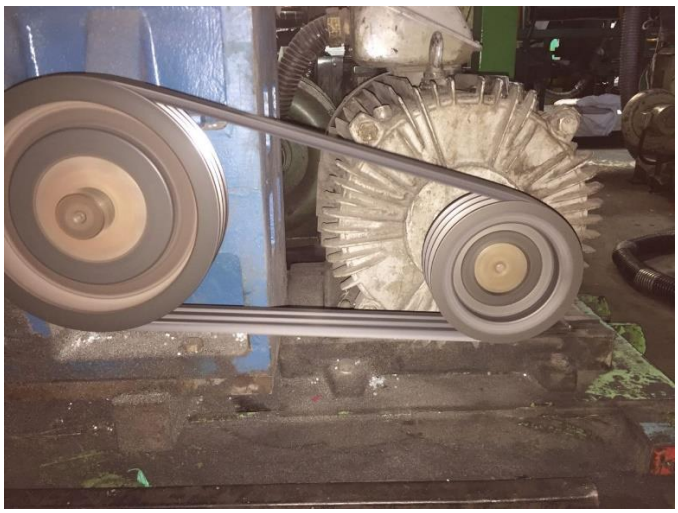
Once the checklist is received, the technical team will study and make recommendations if necessary. Once all recommendations have been actioned/agreed, the next step by means of a pumping trial can be arranged.

## Preparation of the Extruder

The internal parts of the extrusion line must be cleaned thoroughly and cleared of all contamination, e.g. surplus or burnt materials. The Aquapak polymer has higher viscosity when molten which can increase the torque of the motor driving the extruder screw. If the main motor has an AC drive, the available low speed torque may be an issue and during testing with the APL resin the risk of torqueing out is increased. To guard against this, it is a good idea to fit a smaller drive pulley to the motor. If the main motor has a DC drive, it is less likely to suffer from tripping out at low speed.

## Motor/Gearbox pulley ratio

Fit smaller motor pulley



If the diameter of the pulley is

5” change this to a 4” pulley
4” change this to a 3” pulley
3” change this to a 2” pulley

Failure to have a suitable amount of torque can cause the motor to trip out during the early stages of extrusion. This may require the process trial to be aborted.

Purge: If the trial must be aborted or at any change over point, then please have available 0.3MFI LDPE to use as a purge material. It is very important not to leave Aquapak resin in the extruder after use.

## Screw L/D

Aquapak have completed extensive testing using simple 3 stage plasticating screws with an L/D ratio of 30:1. The ideal screw has this ratio of 28-30:1 L/D
Shorter screws can be used but careful attention must be applied to ensure a good melt homogeneity has been achieved.
Longer screws are also possible but residence time is important as this needs to be minimised.

## Ideal Screw Configuration

Screws that have a gradual increase in diameter from the throat to the metering zone, of an HDPE format, work best. Barrier screws have been used successfully but can increase the required torque. A short melting section reduces the available time to melt and in extreme circumstances can over torque the screw.

A typical HDPE three stage screw with no barrier or mixers, 2:1 compression ratio is ideal.

The 2:1 compression ratio screw has proved suitable for flood feeding but it is advisable to trickle feed initially, either by partially closing the throat entry iris/flap or by using an Aquapak trickle feeder system (see section 4). This can be brought to site by an Aquapak Transfer Technician.

The barrel should have a minimum of three temperature control zones and a cooled throat section to prevent bridging. It is vital that all zones are operating correctly (heating and cooling). A grooved feed section is not recommended for initial trials.

(38mm & 65mm screws)

A minimum of 3 heater zones for the barrel and 2 for the die is acceptable. The greater the control the better. The throat should have a water cooling system plumbed in and working.

If the barrel contains a groove feed section at the throat it may be possible to eventually flood feed the line but the groove feed section must be heated to a minimum of 200C or the screw will jam.

## Feeder system

A feeder system supplied by Aquapak will aid in the reduction of torque when using a standard 3:1 compression HDPE screw or starting initially with a standard 2:1 model and it will help monitor the throughput rate at the same time. The feeder should be fitted in such a way that you can view the screw in the throat to check that it is not fully covered by the pellets.

The feeder system requires a single phase 240 VAC supply. A 110 VAC supply feeder can be supplied on request.

## Die

(Typical Spiral Mandrel HDPE die body with LDPE air ring running Aquapak polymer)

## Die Gap

Recommended between 1.0mm to 2mm, depending on the gauge of film required.  Aquapak can advise ideal process conditions for a given gauge.

BUR: the die/product dimensions should be selected to achieve a blow up ratio of between 2:1 and 4:1, although BURs of over 6:1 have been achieved in some cases.

## Haul off

The haul off needs to be in good condition as the toughness of the Aquapak polymer requires a strong and consistent grip on the web.

# You are now ready to start.

## Extruding the Aquapak Polymer

Based on 38mm / 45mm / 55mm / 65mm screws

When running Aquapak polymer resin for the first time it is essential that a suitable Aquapak employee (ideally transfer Technician) be present as different extrusion lines may require adjustments to settings. Once settings are established, running conditions are repeatable.

### Barrel Temperatures for start-up non-grooved feed section in barrel

| Zone 1 Throat | Zone 2 | Zone 3 | Zone 4 | Die Bottom | Die Middle | Die Top |
|---|---|---|---|---|---|---|
| 140$^0$C | 220$^0$C | 220$^0$C | 220$^0$C | 220$^0$C | 220$^0$C | 225$^0$C |

Zone 1: This is kept low to avoid bridging in the throat. Water cooling should be fitted and operational.

### Barrel Temperatures for start-up grooved feed section in barrel

| Zone 1 Throat | Zone 2 | Zone 3 | Zone 4 | Die Bottom | Die Middle | Die Top |
|---|---|---|---|---|---|---|
| 200$^0$C | 220$^0$C | 220$^0$C | 220$^0$C | 220$^0$C | 220$^0$C | 225$^0$C |

Zone 1: Minimum temperature found to get polymer through feed section.

These temperatures may need to be tuned by ±10$^0$C for optimal conditions.

## Screw Speed

50 rpm (or half maximum screw speed).
Initially line should be flushed (flood fed) with a 0.3 MFI LDPE to ensure no contamination is present and line is in good working order. Once clear the LDPE can allowed to empty and feeding of Aquapak pellets can commence. At this point it is recommended to vary screw speeds at 30 second intervals to alternate purge rates and aid the flushing of the line (Ensure motor current does not override. Once molten Aquapak polymer is visibly extruding from the die, the material must be run through clear and free from bubbles.

Initially the combination of Aquapak polymer and LDPE will extrude together and a skin of LDPE will be noticeable. This is because of the conflicting nature of the polymers and should wear off as the remnants of the LDPE are extruded. As the remaining LDPE clears the bubble can be established and the feed rate & screw speed increased making sure the motor current is below maximum level.

Once the bubble is stable, any observed gels or fisheyes can be removed by optimising the screw speed.

'Unmelts' are usually caused by insufficient mixing and are removed by small increase of screw speed.

'Fisheyes' are caused by over working the polymer and can be removed by a small decrease of screw speed. However, Fisheyes with a white tint are a sign of under working so will decrease with increased screw speed.

'Gels' are caused by increased residence time/overheating in the die causing the polymer to stick in the die. This can be eliminated by cooling die or increasing throughput levels/screw speed.

## Air ring

Very low speed using ambient humid air (heated air is an option).
This is to avoid instability of the bubble. It is possible to run with no cooling air flow at all within the air ring but for best stability, a very low air flow is ideal. It is difficult to adjust a mechanical (iris) system precisely enough, electronic (inverter) control of the fan motor is more suitable.

## Haul off

This will vary but for start-up say, 10m/min, increasing incrementally as the bubble visibly stabilises.

## Feeder speed

(**if required**) This is adjustable in frequency and should be calibrated to identify the kg/hr for a given frequency (prior to running a trial).

Partial filling of the screw flights required. Suggested 50% filling of flights.

It is important during the first hour, at least, that flights remain visible in the throat to avoid over torque on the motor and overheating/degradation of the polymer.

## Purge Material

0.3 MFI LDPE (used to remove residual polymer on shutdown - do NOT leave the Aquapak polymer in the barrel after use!).

## Purge Material

0.3 MFI LDPE (used to remove residual polymer on shutdown - do NOT leave the Aquapak polymer in the barrel after use!).

## Polymer Storage

The polymer will arrive on site sealed inside a large poly bag within an octabin placed on a heat-treated pallet. When not in use, the polymer should return to this state of being contained inside a sealed poly bag.

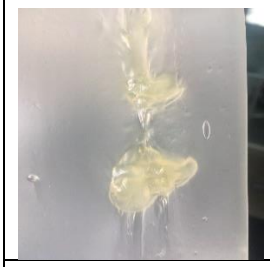
The polymer should be stored indoors with an ambient air temperature between 5c and 30c.

## Curing

The key attribute of Hydropol is the ability to gain strengthening properties from the humidity in the air surrounding it. In a low humidity environment the first generation of Hydropol may appear brittle when first extruded and will require a short period of “curing”, or exposure to the atmosphere, in order to gain additional strength and pliability.

## Common Issues

| Issue | Cause | Solution |
|---|---|---|
| Un-melted lumps in film  | Melt temperature too low | Increase melt temp either by increasing throughput/screw speed or barrel temperatures |
| Voids/“Fish eyes” in the film  | Over working of the polymer | Reduce screw speed, note that reducing die temperature in some cases can increase or decrease this issue (due to increased melt pressure in barrel) |
| Bubble instability | 1. Extruder surging due to:<br>a) insufficient/inconsistent feeder speed/ too high screw speed<br>b) barrel temps too high<br><br>2. Air ring setting too high | 1. a) balance these two parameters but don’t over fill the screw at the throat<br>b) lower barrel temps (optimum melt temp 205c)<br><br>2. reduce air ring flow rate (or turn off to verify if this is the cause |
| Film splitty | Film not cured | The film will tear easily after blowing until it equilibriates with atmospheric moisture when it will become very tough.<br>A humidity chamber may be required for film to travel through in less humid climates. |
| Very high melt pressure | Screen fitted or die temp too low | Line should be run with a maximum 40 mesh screen or no screen (just a breaker plate), die temp should be approx 225c (UK) to ease flow of polymer |

| | | |
|---|---|---|
| "Gels" in the film  | Too hot/Flow too slow through die | Decrease base die temperatures/Increase throughput rate to clear out die grooves (can take a little time to run clear after hang up) |
| Black/Dark Brown specks in film  | Aged polymer hanging up in line | Run alternate screw speeds at 30 second intervals until flushed clear. |
| Film too brittle and snapping/creasing through Haul Off Area | Film cooled too quickly | If bubble clear, add quartz heaters to/between collapsing boards to soften film prior to travel through nip rollers |