ThermoShape™
PET Hot Fill Solution
Executive Summary

Hot Fill Process  3
ThermoShape™ Adds Economy and Flexibility  4
Product and Contents  5
Strengths of PET Packaging  6
Efficient ThermoShape™ Process  7
Ease of Adapting Current Lines to ThermoShape™  8
Broad Design and Function Flexibility  9
Quality Closure Solution  10
Effective Filling Technology  11
Sustainable Packaging Solution  12
Plastipak's Complete Packaging Solution  13
Plastipak Packaging’s Systematic approach  14
The Final Word  15
Hot Fill Process

Hot Fill is an inexpensive and conventional filling technology that gives a robust, extended-life performance at ambient temperature to sensitive beverage and liquid food products, such as fruit and vegetable juices, nectars, soft drinks, enhanced water, and RTD teas. A well-recognized and simple method of filling high acid products (pH < 4.5), it has met superior quality standards of the beverage and food industry quite successfully for a very long time.

**Efficiency and effectiveness define Hot Fill processing.**

First, pasteurization renders the product microbiologically stable. The product is then filled hot to decontaminate the inner surface of the container and the closure. At this point, cooling the container rapidly and immediately maintains product taste and vitamin content integrity. As the result of this well-performing fill technology, Hot Fill products have a shelf life ranging from 6 to 12 months, similar to aseptic fill products.

In contrast to aseptic filling methods, however, hot filling involves a less rigorous level of technical training and product preparation. Hot Fill does not require any chemical decontamination of the preform, container or closure. Further, with Hot Fill technology, the stringent filling conditions that are required by aseptic processes to avoid any possible re-contamination of the product or the container during filling and capping are completely unnecessary.
PET bottles have been widely used for the Hot Fill of high acid products since the 1980s. Now, hot filling with ThermoShape™ provides a new, viable and economically attractive alternative packaging solution to processors currently using glass Hot Fill, PET aseptic fill, PET heavyweight Hot Fill, and PET cold fill with preservatives.

The hot product in the container and the hot headspace are losing volume during the cooling process creating an internal vacuum in the container. Until ThermoShape™ made the process more adaptable, PET bottles needed vacuum compensation devices that effectively limited a container’s design possibilities and required both heavier weights and specialized container manufacturing. Plastipak’s versatile ThermoShape™ packaging method opens up a promising array of new packaging and marketing possibilities.

For the first time ever, Plastipak’s revolutionary patented ThermoShape™ technology has made it possible to hot fill lightweight PET containers, providing customers with product integrity and cost effectiveness, as well as the luxury of extensive, brand-building design flexibility.
Bacteria Control

Yeast, molds and acid-tolerant bacteria dominate the micro-flora in high-acid, sensitive products. These microorganisms rarely represent a health risk, but will seriously spoil package content. Without proper control of the product as well as the complete decontamination of the container and closure, this situation can create a major commercial concern for beverage and food producers, and marketers.

Indeed, container and closure decontamination and aseptic filling represent real technical and production challenges that can be met only by serious capital investment and by maintaining stringent manufacturing processes and controls.

Hot filling, on the other hand, involves a very simple, direct and traceable solution to bacteria control that includes monitoring and recording product temperature at the filling head.

Oxidation

One of the most damaging effects resulting from oxygen ingress in acidic products like juices is the degradation of vitamin C. The presence of oxygen also contributes to a range of oxidative reactions leading to flavor scalping and possible discoloration of the product.

In contrast to aseptic filling, hot filled products are naturally de-aerated, making any oxygen ingress protection unnecessary, both before and during filling. With Hot Fill, the container headspace can also be easily flushed with nitrogen gas before closing as a simple and cost-effective method for eliminating nearly any oxygen contact with the product at the filling stage. Plus, vitamin C can be added as an antioxidant to improve shelf life and compensate for potential losses during hot filling.
Strengths of PET Packaging

Spoilage of bacteria-stable sensitive products is most commonly caused by chemical deterioration of the product due to oxygen ingress through the packaging material and closure after filling.

Standard PET material provides an efficient barrier to oxygen that enables a shelf life from 6 to 12 months at ambient temperatures for most high-acid products sized one liter and above. For longer shelf life or container sizes below one liter, active oxygen scavengers can be added to the PET material during the preform injection phase.

PET material also offers UV and infrared light barrier functions similar to glass containers. In the case of light-sensitive products, UV barrier material can be added to PET at the preform injection phase.
Plastipak produces its ThermoShape™ containers, with their final shape and free-standing base design, by using higher crystallization devices known as HR, or Heat-Resistant option kits, with commercially available PET blow-molding equipment.

After hot filling, the containers are transferred into a closed-loop water cooling tunnel, where they deform under the vacuum created by the product and the head space temperature drop. Containers are then fed into the ThermoShape™ machine – provided by Plastipak Packaging for simple reshaping back to their original form.
With currently available ThermoShape™ machine size, ThermoShape™ bottle reshaping can be performed at standard packaging line speeds of up to 450 bottles per minute. In the case of existing Hot Fill glass or Hot Fill PET packaging lines, several pieces of equipment can be modified or adapted to the ThermoShape™ packaging line.

1. Plastipak ThermoShape™ Preform
2. Plastipak ThermoShape™ bottle supply or ThermoShape™ in line bottle blowing from Plastipak ThermoShape™ preform
3. Hot Filling
   Capping
4. Water Cooling
5. Bottle Shrinking
6. Labeling or Sleeving
7. Case Packaging and Palletization

current step can be re-used or modified
Plastipak’s container design team customizes creative and highly functional containers, applying Plastipak’s patented ThermoShape™ base design to meet our customers’ marketing and economic objectives. In fact, ThermoShape™ container design freedom now equals that of cold-fill sensitive product containers.

ThermoShape™ bottle sizes range from 200 ml to 2 liter. Below are examples of validated ThermoShape™ bottle weights.

<table>
<thead>
<tr>
<th>Bottle Size</th>
<th>Neck Finish</th>
<th>Bottle weight*</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 ml round shape</td>
<td>38 mm 2 leads</td>
<td>21 grams</td>
</tr>
<tr>
<td>1 liter round shape</td>
<td>38 mm 2 leads</td>
<td>32 grams</td>
</tr>
<tr>
<td>1.5 liter round shape</td>
<td>38 mm 2 leads</td>
<td>41 grams</td>
</tr>
</tbody>
</table>

*Weights are approximate and depend on final container design and qualification.
Commercially available one-piece “double lip” HDPE closures, similar to the ones used for aseptic filling, have been qualified with ThermoShape™ bottles for Hot Fill temperatures up to 92°C without the need for a crystallized neck finish. When necessary, “double lip” closures with active oxygen scavenger liners can also be used.
Effective Filling Technology

The fill temperature must be a minimum of 82°C and can reach up to 92°C.

The hot filling of lightweight PET containers can be performed on standard neck handling level Hot Fillers or volumetric Hot Fillers with no vacuum and sound product recirculation. Most level Hot Fillers used for glass hot filling can be modified to accommodate ThermoShape™ PET containers.

The containers are then closed and tilted for up to 15 seconds to ensure product contact with the inside closure surface. Within five minutes or less, the containers are then transported to a water-cooling tunnel. Rapid product cooling prevents sugar buildup and subsequent product color and vitamin content degradation from extended heat exposure.
ThermoShape™ provides a sustainable, balanced packaging solution for our customers.

After all, PET, already widely used for packaging Hot Fill and aseptic fill high acid sensitive products, is one of the most commonly recycled packaging materials in the world. As a part of its success in recycling PET, Plastipak Packaging is a leading global manufacturer of the bottle-to-bottle PET recycled material that is integrated into our preforms during the injection step.

Plastipak relies on sustainable operations as well. Our Hot Fill process does not require the use of any chemical decontaminant for preform, container and cap decontamination. It also does not require the use of sterile water for container and closure rinsing after decontamination – very unlike the “wet” aseptic solution. The aseptic solution usually means that, in most countries, chemically loaded sterile water needs to be treated prior to disposal, adding additional costs over and above that of water rinse usage and sterilization. Plastipak prefers to affect natural resources as little as possible.
Plastipak’s Complete Packaging Solution

From the inception of a project, Plastipak’s complete packaging solution approach integrates all of our customer’s objectives and constraints, from container design to distribution.

Our fully equipped Packaging Development centers support complete container and closure development and prototyping, including a full range of performance testing.
Plastipak Packaging's Systematic Approach

Plastipak consulting services span the entire scope of a complete project and include the following to ensure a one-stop shop approach:

- Creative and functional container design
- PET material selection
- PET material barrier selection and qualification
- Closure selection and qualification
- Preform design and prototyping
- ThermoShape™ container prototyping and validation
- Filling test assistance at customer location for shelf life evaluation
- ThermoShape™ preform and/or ThermoShape™ bottle
- Packaging line design and modification consulting services
- Blow-molding & packaging equipment specification and selection
- ThermoShape™ machine integration, installation and start-up
- ThermoShape™ Packaging line start-up and operation assistance.
ThermoShape™ Hot Fill technology is ideal for beverage and liquid food processors who require a long product life, moderate capital investment and operating costs, as well as minimum operational risk management.