Exceed™ XP Exceed™ S Enable™ performance polyethylene
Exact™ plastomers

Case Study

Enabling flexible film circularity: from a recyclable* full PE barrier packaging solution to a high end heavy duty sack

- Recyclable* and incorporates recycled content
- Outstanding oxygen barrier
- Outstanding optics
- High package integrity

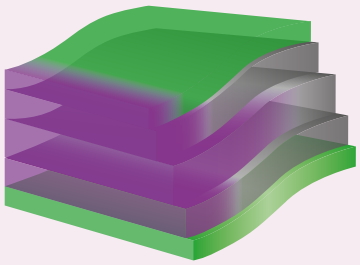
Challenge:

To create a >95% high oxygen barrier pouch - as an alternative to more difficult to recycle multimaterial high oxygen barrier laminates – which can be recycled back into a high-end film application. Thus enabling flexible film circularity.

MDO-PE film

Thickness: 25µm

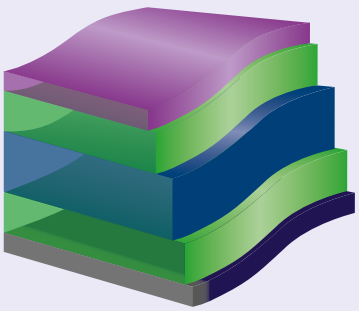
- Exceed XP 8656ML
- Enable 4002MC
- Enable 2705MC
- ExxonMobil HDPE



PE sealant film

Thickness: 120µm

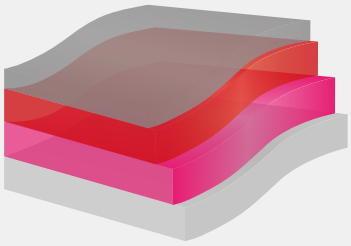
- Exceed XP 8784ML
- Enable 4009MC
- Exceed S 9243ML
- Exact 3237
- ExxonMobil LDPE



Lamination & barrier coatings layer

Basis weight: 5.4gsm

- Vacuum-coated AlOx
- Henkel top coating
- Printing ink
- Henkel PU adhesive



*Recyclable in communities with programs and facilities in place that collect and recycle plastic film

Solution:

Creating the pouch:

Using the latest in polymers and conversion technology and through a unique value chain collaboration, the team was able to create a 96% (by weight) PE pouch with high oxygen barrier and outstanding package integrity.

This blown film was produced with ExxonMobil best-in-class performance polyethylene resins like Exceed S, Exceed XP and Exact and produced on an Alpine 5-layer line with inline Machine Direction Orientation [MDO]. This state of the art MDO technology offers film quality with outstanding processability and optimized flatness.

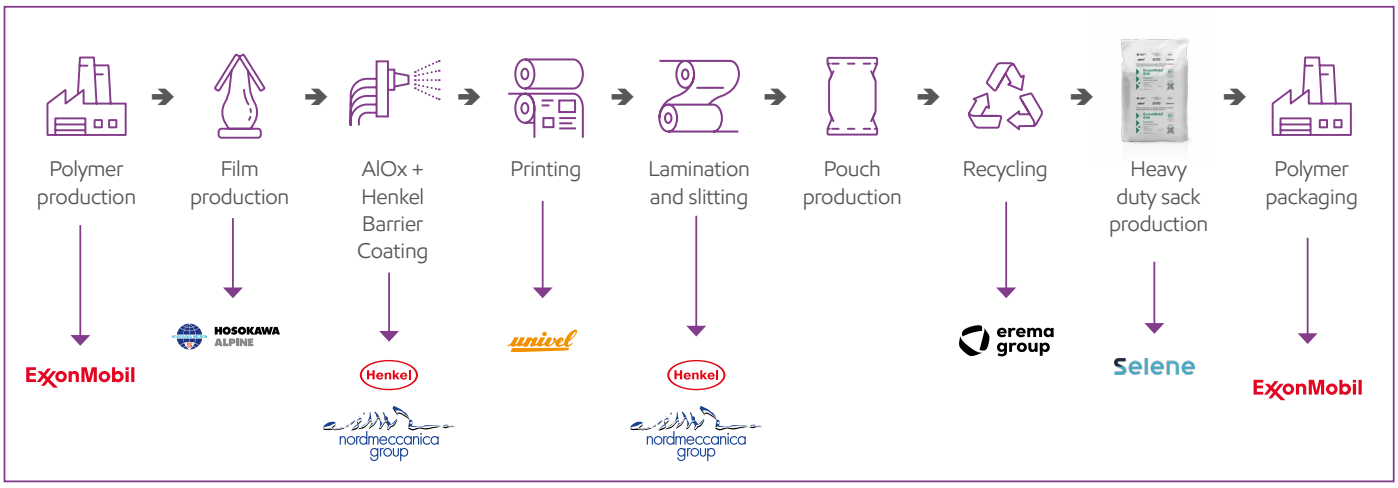
Two extremely thin functional layers were then applied on the MDO-PE to deliver outstanding barrier properties: the first layer consisted of 10 nanometers of uniform and homogeneous aluminium oxide [AlOx], while the second layer consists of 1 micron of Henkel's newly developed Barrier Coating. Both functional layers were applied using Nordmeccanica's Vacuum & Coating technologies [Nordmet 12F Plus / Super Combi 5000].

These technologies offer industry leading performance in terms of reliability, uniform laydown, thickness control and energy consumption.

Subsequently, the film was printed with a standard Flexo process by Univel - building on 75 years of groundbreaking solutions for flexible packaging.

In the following step, the MDOPE was laminated with the sealant web on a Nordmeccanica SC 5000 Coating-Laminating machine by using Henkel's customized SL Recyclable adhesives.

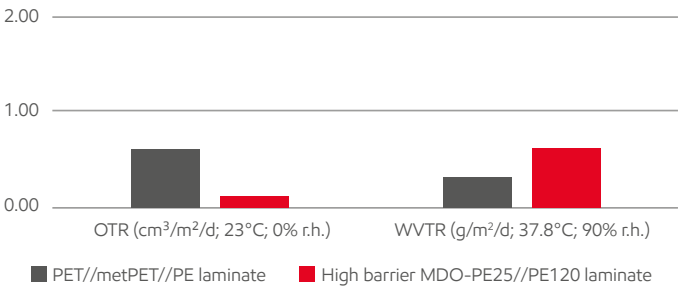
In addition – the end of life pouches were reprocessed by EREMA, the world market and technology leader in plastics recycling systems. EREMA used their extruder system INTAREMA® TVEplus® to produce plastic granules. Out of these recyclates, Selene - with its extensive experience in blown extrusion and recycled granules-produced high-quality Form Fill and Seal [FFS] tubular for Heavy Duty Sacks [HDS] . These HDS were subsequently filled with EVA resin at the Meerhout PE production site.



Barrier properties:

This pouch incorporates the innovative concept of AlOx and wet top coatings – to produce a very high PE content (96%) pouch while still providing low Oxygen Transmission Rate (OTR) of ~0.14 $cm^3/m^2/d$; and Water Vapour Transmission Rate (WVTR) of ~0.6 $g/m^2/d$ comparable to multi-material structures, as can be seen in Graph 1.

Graph 1 - Pouch Oxygen and Moisture barrier*

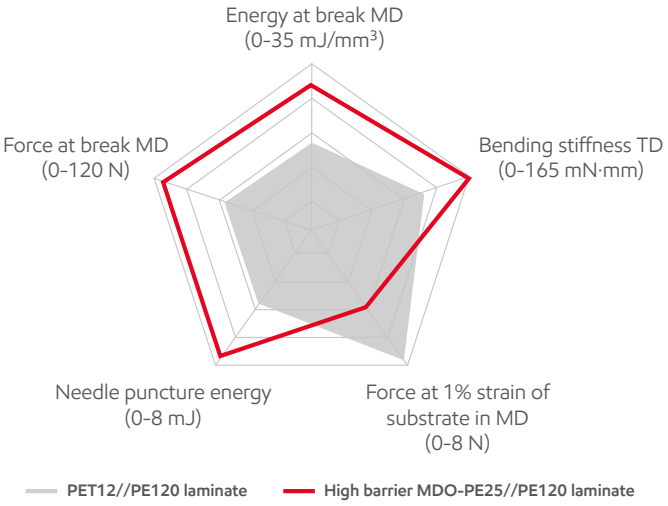


*All barrier values are to be considered as indicative as they may strongly depend on various parameters and test conditions

Mechanical Properties:

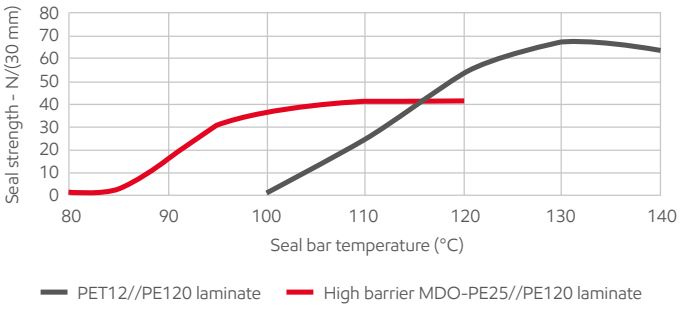
This pouch features the latest PE resin Exceed S to deliver outstanding package integrity – resulting in a 70% improvement in needle puncture energy and force at break versus comparable multi-material alternatives, while keeping comparable bending stiffness to maintain stand-up ability. These results are quantified in Graph 2.

Graph 2 - Pouch Mechanical properties



In addition, the pouch features the Exact plastomers 3-series sealant materials to lower the Seal Initiation Temperature with ~15°C as can be seen in Graph 3.

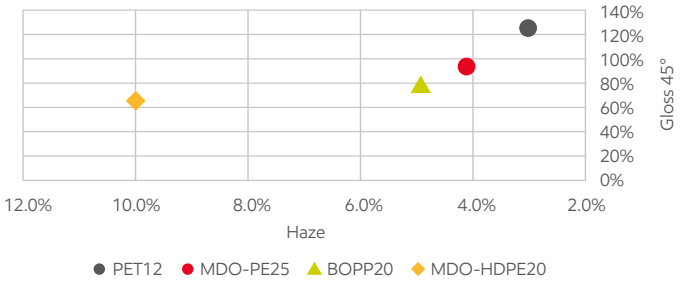
Graph 3 - Pouch Seal Strength



Optical properties:

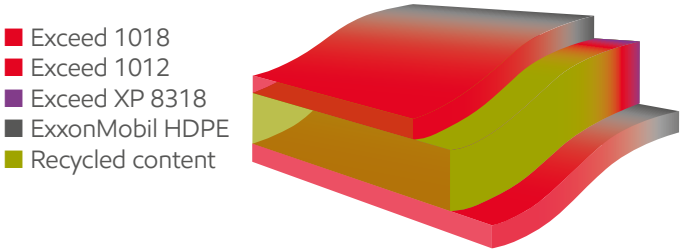
The MDO substrate also does not compromise on shelf-appeal with outstanding gloss (~100%) & low haze (~4%), rivaling the best-in-class PET substrate, as can be seen in Graph 4.

Graph 4 - MDO Substrate Optical properties



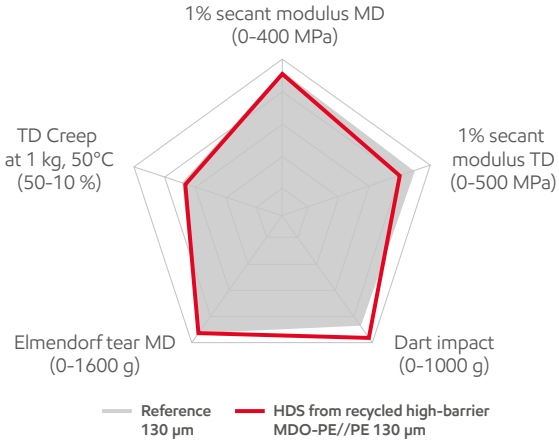
Creating the Heavy Duty Sack:

Heavy Duty Sack Film 130 micron



The high barrier pouch was subsequently recycled and a new heavy duty sack film was produced with 50% of the pouch recyclate in the film structure. The end-result is an HDS bag which is, thanks to the use of ExxonMobil PE, meeting and in some cases even exceeding the performance of industry reference bags. Graph 5 is showing that key properties like creep, dart & tear of the HDS bag with 50% recyclate are of comparable performance to the HDS bag currently in use at the ExxonMobil Meerhout PE production facility. In addition, Table 1 is showing the outstanding bag drop performance. The HDS incorporating 50% recycled content is meeting the ExxonMobil plant specification* and even exceeding expectations on the more demanding ExxonMobil staircase method.

Graph 5 - HDS Mechanical properties



* ExxonMobil plant specification: FFS bags must pass following bag drop test: 18 bags are randomly taken and dropped from 2 m height. 6 Bags are dropped on the face, 6 bags dropped on the side and 6 bags dropped on the top.

Table 1 - Bag Drop Measurements

Drop Height	Drop Position	bag 1	bag 2	bag 3	bag 4
1m	F (flat)	Pass	Pass	Pass	Pass
	S (seal)	Pass	Pass	Pass	Pass
	G (gusset)	Pass	Pass	Pass	Pass
2m	F	Pass	Pass	Pass	Pass
	S	Pass	Pass	Pass	Pass
	G	Pass	Pass	Pass	Pass
3m	F	Pass	Pass	Pass	Pass
	S	Pass	Pass	Pass	Pass
	G	Pass	Pass	Pass	Pass
4m	F	Pass	Pass	Pass	Pass
	S	Pass	Pass	Pass	Pass
	G	Pass	Pass	Pass	Pass
5m	F	Pass	Pass	Pass	Pass
	S	Pass	Pass	Pass	Pass
	G	Pass	Pass	Pass	Fail
6m	F	Pass	Pass	Pass	
	S	Pass	Fail	Pass	
	G	Fail		Pass	

ExxonMobil Staircase test method: each bag is dropped from the same height (1m) in 3 different drop positions (on flat side / on seal side / on gusset). If the bag survives the drops, the same bag is then dropped from an increased height (2m) in 3 different drop positions. If the bag survives, the height is again increased (3m, etc.) until the bag fails. 6m height is the maximum height available on the drop equipment at ExxonMobil.

In summary, this unique value chain collaboration has shown it is possible to create a >95% PE stand up pouch (without compromising on functionality or shelf-appeal), which can be recycled into a high-end HDS bag exceeding the most stringent requirements.

Test item	Test method
Oxygen transmission rate (OTR)	ExxonMobil test method
Water-vapor transmission rate (WVTR)	ExxonMobil test method
Tensile properties on film at room temperature	ExxonMobil test method
Dart drop impact resistance by free falling dart : method A and B	based on ASTM D-1709-16aε1
Puncture - needle test	ExxonMobil test method
Heat seal strength at RT	ExxonMobil test method
Bag drop test	ExxonMobil test method
Bending stiffness	ExxonMobil test method
Haze	based on ASTM D-1003-13
Gloss 45°	ExxonMobil test method
Elmendorf tear	based on ASTM D1922
Creep resistance at elevated temperature	ExxonMobil test method