

# BULLETIN: MIXTURE SELECTOR FOR AUTOMATIC PACKAGING



## 1 Introduction

The use of different polyethylene mixtures is very common in the manufacture of flexible packages, both for food as well as for industrial applications. The amount of available raw materials to make these products is very large. Only in Venezuela it is possible to select among over 12 different polyethylene resins in order to obtain an appropriate balance between end properties of the product and processability. If you add to this the possibility of including special products, the transformer is facing the great dilemma of knowing if its mixture and process are adequate for the application under development.

The purpose of this technical bulletin is to introduce the reader to the package mixture selectors that POLINTER has developed in order to facilitate the task of selecting which combination is better for the application under development.

The mixtures selectors are developed in the form of a spreadsheet, where the user not only introduces the basic data (resin type and quality), and as a result he obtains a prediction, based on the experimental studies and statistical analysis carried out in the research and development laboratories of POLINTER, of the final properties of the film. This will serve for saving time during testing and experimentation in the plant (with the subsequent time and material saving) as well as for experiment the possibilities of improvement of the existing products.

There are two types of selectors currently available for POLINTER clients:

Automatic package mixture selectors (thickness of up to 80  $\mu\text{m}$ ).

Heat Shrink Tubing package mixture selectors.

The present bulletin covers the main features of the first selector (for automatic packaging).

## 2 How is a mixture designed?

At the moment of designing a mixture, several steps are usually taken, being in a formal or intuitive and almost unconscious form. If a formal sequence is

followed and documented, it is possible to obtain optimizations from the start, which will result in lower costs and/or better performance.

The following list proposes a series of stages that should be considered when designing a mixture:

Define the desired properties for the mixture in a quantitative manner. In the case of selectors, this will allow to quantify the quality of the selected mixture using numerical predictions of the selector. Select the resins to be chosen according to the desired properties, including their cost.

Tabulate the advantages and disadvantages of each resin. This will allow the identification of alternatives.

Use the selector to choose resin combinations that show potential of fulfilling the mixture requirements.

Make rough cost estimate. If the numbers are appealing, keep going; otherwise, select another resin set (step 4).

Analyze the selected mixture from the processing and final application point of view. Keep in mind that there are aspects, such as appearance, that cannot be foreseen with the selector:

Is it obvious that it will or will not work?

Will it be able to be processed with the available equipment?

Will it keep its properties along its useful life?

If the selected mixture is considered appropriate, use the selector to estimate the film properties. Compare to the desired resin properties (step 1) and adjust the component thickness or concentrations of the mixtures in order to optimize the properties.

## 3 Selector operation

In order to build mathematical models used in the selector, over 100 different mixtures were prepared, extruded and measured. The following limitations were applied to both selectors in the study:

PELBD (butene) content: between 60 and 90%.

PELBD (octene) content: between 0 and 30%.

PEBD type: Venelene<sup>®</sup> FA0240, FD0348 or FB3003.

Butene PELBD type: Venelene<sup>®</sup> 11F1, 11U4 or 11Q4.

Octene PELBD type: Venelene<sup>®</sup> 1101 and 1104.

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Wall thickness in microns ( $\mu\text{m}$ ). The thickness refers to only one face of the film (not to the collapsed film in the roll).

The mixtures must contain a minimum of 10% PEBD, with the purpose of maintaining good optical properties.

Figure 1 shows the material selector developed as a Microsoft Excel<sup>®</sup> spreadsheet, wherein statistical models are incorporated, developed to do mathematical calculations that provide the results presented on the same sheet, for easier handling and visualization.

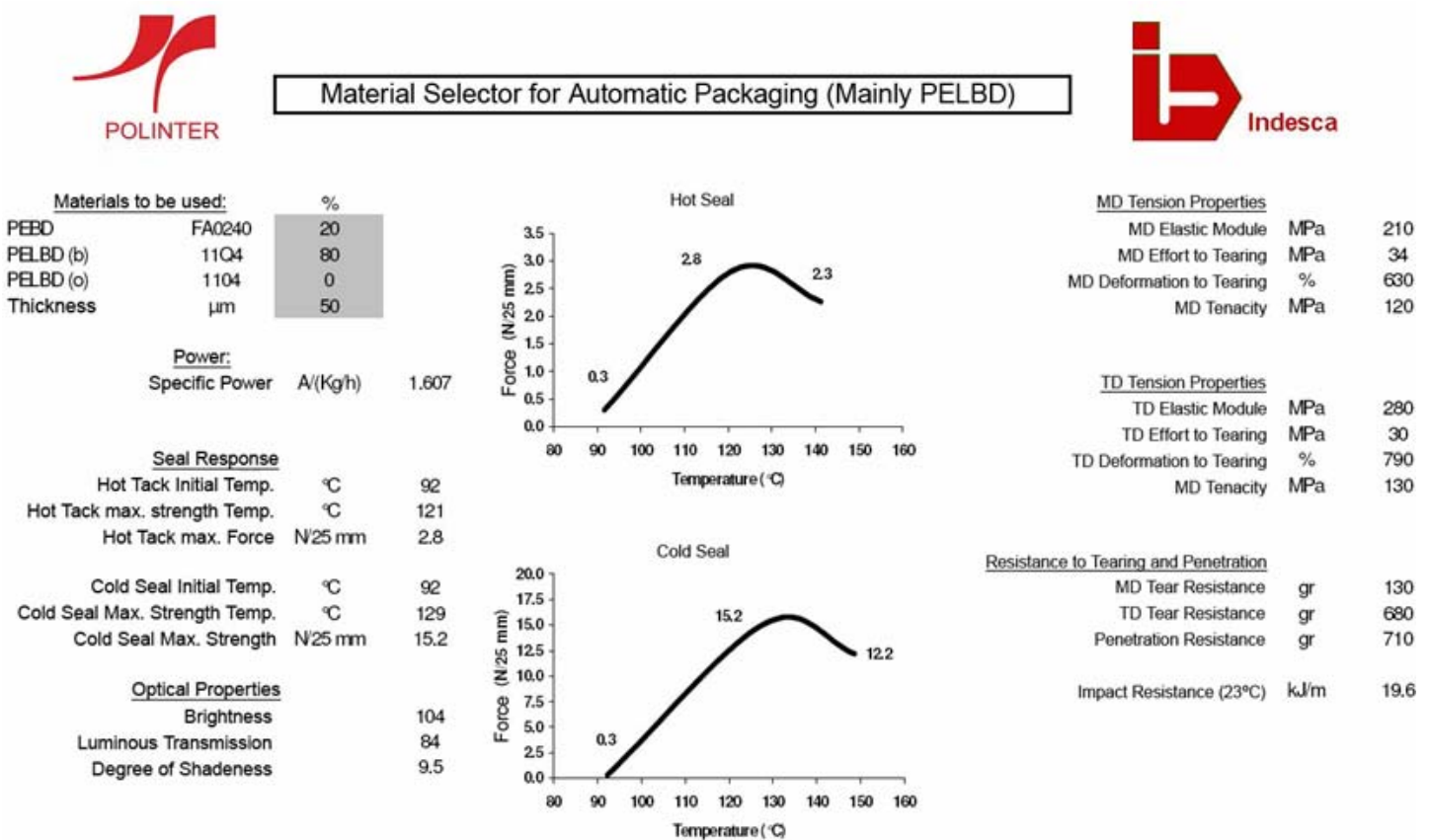


Figure 1. Automatic package mixture selector.

The use of the selector is very simple. In the superior left part (gray shaded area), the user introduces the percentages to the mixture. The programs emits a warning in the event that the selected mixture or the thickness chosen escape from the experimental design that served to generate the models, indicating to the user that, if he should proceed, the results will be a consequence of an extrapolation and will not be as reliable as if they were contained inside the design.

In the event that the selected ratios are not too far from the limits of the selector, their results may be used with certain confidence, at least to study the possible trends.

The results show the numerical way (lower left part and right part). The data in the cold and heat sealing are shown in a graphic manner and emphasizes the numerical values for comparative purposes.

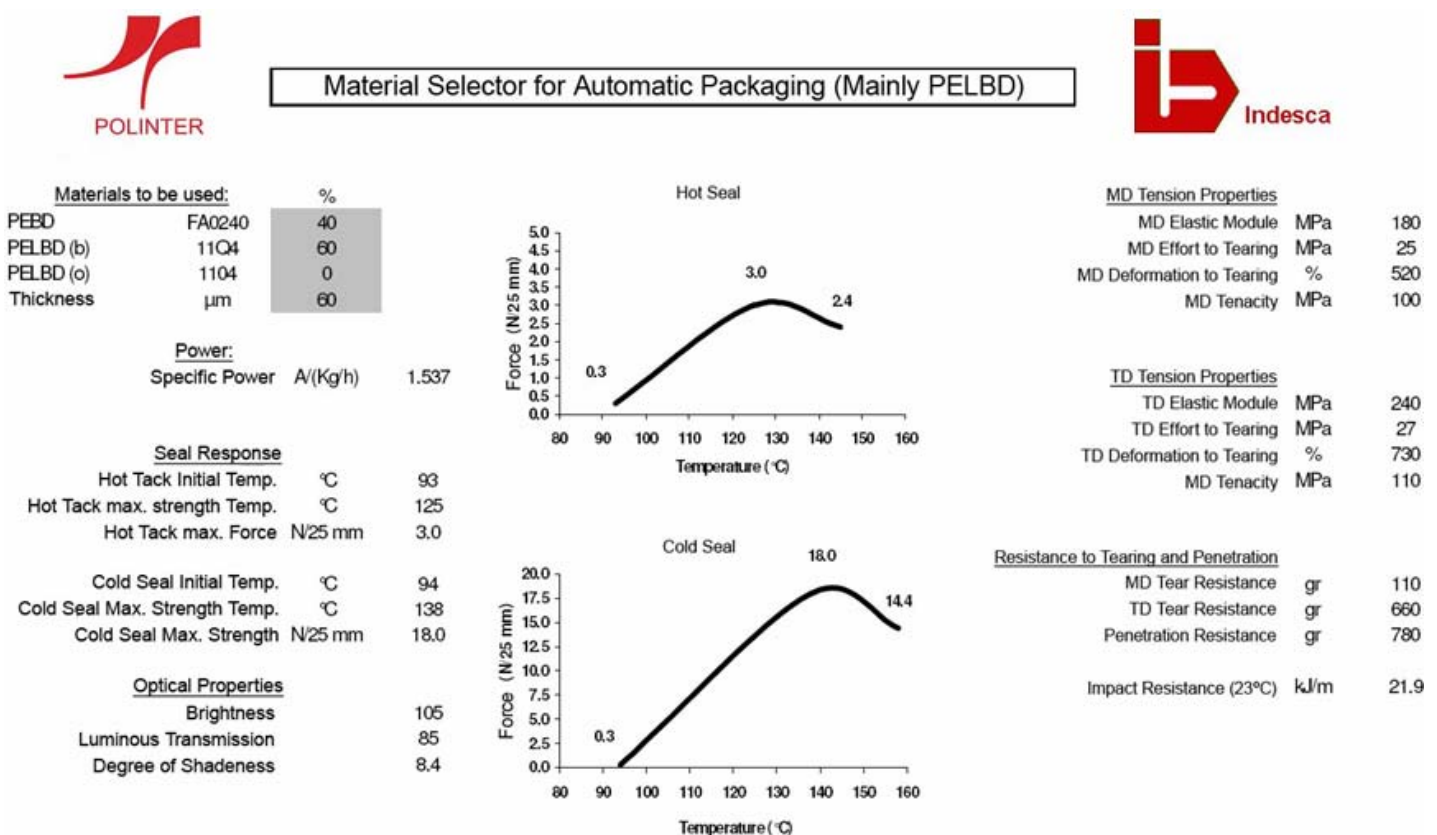
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## 4 Example

A transformer processes a Venelene® FA0240 mixture (40%) with Venelene® 11Q4 (60%), destined for a 1 kg. grain package, having a thickness of 60 µm. your client wishes to have a see-through film, with good brightness, so that it stands out from a large amount of competitors, due to the fact that the prices are not very different

(regulated market). He has also received comments from final users wherein they indicate that the package is reused, due to the fact that most buyers do not completely consume it when opened. This causes the tear resistance requirements to be enhanced in order to avoid the spilling of the product once the package is opened. The package properties, according to the selector, are the following (see Figure 2).



**Figure 2. Grain package properties (original situation: 60% Venelene® 11Q4, 40% Venelene® FA0240 60 µm).**

According to the information provided by the client, the most important aspects to check are: the optical properties (brightness, luminous transmission and turbidity) and the tear resistance properties in MD and TD. In this application, which is automatic package (FFS), is just as important to maintain at a low temperature of maximum sealing force (TFMS) and a sealing force (all this allows that the

packaging machine may operate at a greater speed and the cost of the product is minor). The first option examined is increasing the PELBD ratio in the mixture. This reduces the cost and increases the tear resistance, but it will surely affect the optical qualities. Nevertheless, with the increase of properties, a thickness reduction may be evaluated. Figure 3 shows the results in change of mixture ratios and thickness reduction from 60 to

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50  $\mu\text{m}$ . the optical properties are almost the same, with the exception of turbidity, which rises from 8.4 to 9.5. However, it is possible that this difference is not very noticeable due to the lower thickness of the film. Despite the thickness reduction, it is possible to slightly increase the tear resistance, which guarantees the integrity of the package.

Additionally to what is expected, a greater rigidity is gained (as a module), both in MD as in TD, and it reduces in 1°C the TIS and TFMS. This is accomplished through the small sacrifice (less than 10%) of the maximum sealing force. In conclusion, this option seems appealing.



## Material Selector for Automatic Packaging (Mainly PELBD)



Materials to be used:		%
PEBD	FA0240	20
PELBD (b)	11Q4	80
PELBD (o)	1104	0
Thickness	$\mu\text{m}$	50

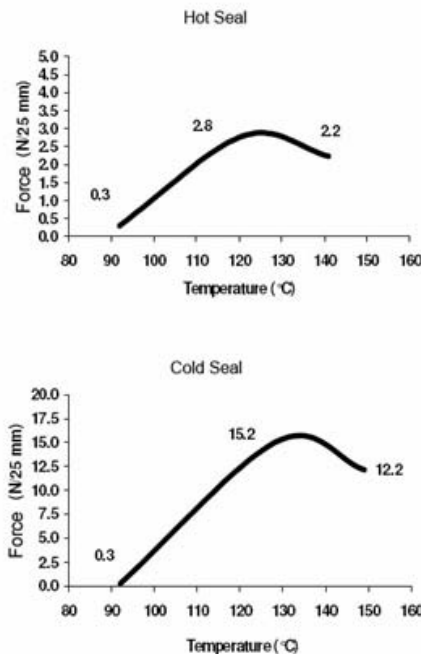
Power:		
Specific Power	A/(Kg/h)	1.607

Seal Response		
Hot Tack Initial Temp.	$^{\circ}\text{C}$	92
Hot Tack max. strength Temp.	$^{\circ}\text{C}$	121
Hot Tack max. Force	N/25 mm	2.8
Cold Seal Initial Temp.	$^{\circ}\text{C}$	92
Cold Seal Max. Strength Temp.	$^{\circ}\text{C}$	129
Cold Seal Max. Strength	N/25 mm	15.2

Optical Properties		
Brightness		104
Luminous Transmission		84
Degree of Shadeness		9.5



MD Tension Properties			
MD Elastic Module	MPa		210
MD Effort to Tearing	MPa		34
MD Deformation to Tearing	%		630
MD Tenacity	MPa		120

TD Tension Properties			
TD Elastic Module	MPa		280
TD Effort to Tearing	MPa		30
TD Deformation to Tearing	%		790
MD Tenacity	MPa		130

Resistance to Tearing and Penetration			
MD Tear Resistance	gr		130
TD Tear Resistance	gr		680
Penetration Resistance	gr		710
Impact Resistance (23 $^{\circ}\text{C}$ )	kJ/m		19.6

Figure 3. Mixture with 80% Venelene<sup>®</sup> 11Q4 and 20%. (Venelene<sup>®</sup> FA0240 at 50  $\mu\text{m}$ ).

However, the pressures to reduce the packaging costs are maintained and the transformer wishes to have an "Ace in his sleeve". The option of using a small amount of octane PELBD and reduce the thickness may be the alternative. In spite of the octane PELBD being a greater cost product, the thickness reduction that can be obtained for its high tear resistance and good sealing, compensates and improves this difference. Furthermore, the sealing must be noticeably improved and the tear resistance maintained. Therefore, it is suggested to

prepare a mixture of 80% Venelene<sup>®</sup> 11Q4 PELBD, 10% Venelene<sup>®</sup> 11U4 and 10% Venelene<sup>®</sup> FA0240 PEBD at 40  $\mu\text{m}$ , thus reducing the original thickness by 20%, thereby compensating the cost of the octane PELBD product. Nevertheless, doubts arise: Won't it be too risky reducing the thickness so much? Will a ternary mixture affect the optical properties? Will the package rigidity be maintained? Can the extruder process a PELBD ratio of such size? All these questions are very valid and would make more than one transformer doubt before

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using the resin, machine time and operation time in an action that could fail.  
The use of a selector sheds some light that allows having greater skill and answering some questions.

In Figure 4 the results for the chosen mixture and thickness, offered by the selector, are shown.



## Material Selector for Automatic Packaging (Mainly PELBD)



Materials to be used:		%
PEBD	FA0240	10
PELBD (b)	11Q4	80
PELBD (o)	1104	10
Thickness	µm	40

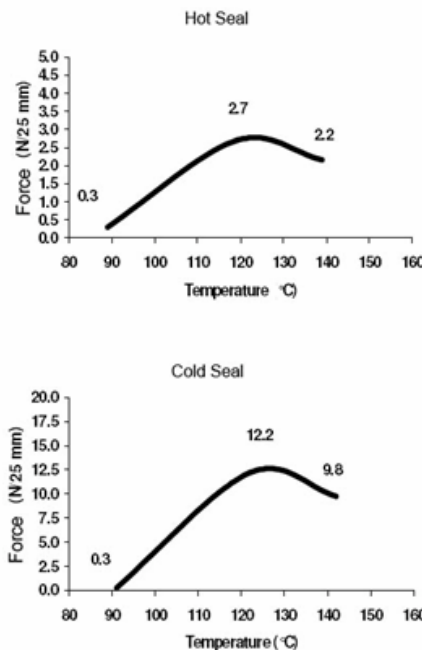
Power:		
Specific Power	A/(Kg/h)	1.647

Seal Response		
Hot Tack Initial Temp.	°C	89
Hot Tack max. strength Temp.	°C	119
Hot Tack max. Force	N/25 mm	2.7
Cold Seal Initial Temp.	°C	91
Cold Seal Max. Strength Temp.	°C	122
Cold Seal Max. Strength	N/25 mm	12.2

Optical Properties		
Brightness		103
Luminous Transmission		84
Degree of Shadeness		9.4



MD Tension Properties		
MD Elastic Module	MPa	230
MD Effort to Tearing	MPa	42
MD Deformation to Tearing	%	670
MD Tenacity	MPa	140

TD Tension Properties		
TD Elastic Module	MPa	250
TD Effort to Tearing	MPa	32
TD Deformation to Tearing	%	780
MD Tenacity	MPa	140

Resistance to Tearing and Penetration		
MD Tear Resistance	gr	140
TD Tear Resistance	gr	710
Penetration Resistance	gr	680
Impact Resistance (23°C)	kJ/m	18.8

**Figure 4. Results for an 80% Venelene® 11Q4 10% Venelene® 1104 and 10% Venelene® FA0240 PEBD at 40 µm.**

When analyzing the main properties for this mixture and thickness, it can be seen that the tear resistance is maintained above the original values, whereas the optical properties are practically the same (with the plus that the lower thickness should give an impression of greater transparency), thus maintaining the key properties in a film, being 30% thinner. On the other hand, the TIS is reduced in 4°C and the maximum sealing temperature in 6°C,

which should be translated in an increase of package sealing speed. The films are more rigid (greater module), which is an additional benefit. The only consideration that the transformer should be aware of is that this film consumes 7% more processing energy per Kg/h, for which he will probably need to increase the extruder temperature. Chart 1 shows a summary of the expected changes with both assessed options.

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TABLE 1 – Summary of Results given by the Selector.

	Units	Original	Case 1	(Dif. %) <sup>1</sup>	Case 2	(Dif. %) <sup>1</sup>
PEBD %		40	20		10	
Butene-PELBD %		60	80		80	
Octene-PELBD %		-	-		10	
Thickness	µm	60	50	-17%	40	-33%
Power	A	1.54	1.61	5%	1.64	6%
Seal Initial Temp.	°C	93	92	-1%	89	-4%
Max. Force Temp.	°C	125	121	-3%	119	-5%
Max. Force	N / 25mm	3.0	2.8	-7%	2.7	-10%
Brightness	-	105	104	-1%	103	-2%
Luminous Transmission	-	85	84	-1%	84	-1%
Degree of Shadiness	-	8.4	9.5	13%	9.4	12%
MD Tear Resistance	Gr.	110	130	18%	140	27%
TD Tear Resistance	Gr.	160	680	325%	710	344%
MD Elastic Module <sup>2</sup>	MPa	180	210	17%	230	28%
TD Elastic Module <sup>2</sup>	MPa	240	280	17%	250	4%

Indicates an advantage due to changes.

Indicates a disadvantageous feature to be appraised.

From the chart it can be seen that the benefits of change (less thickness, lower TIS and TFMS, greater rigidity and greater tear resistance) compensate the declines (greater energetic consumption and turbidity) that presents the use of the new alternatives found by the selector. This declines may be compensated by an increase of the processing temperature (makes the material less viscous and hence demands less energetic consumption; on the other hand, it also improves the brightness and turbidity), which will be limited by the stability of the bubble.

## 5 In summary

Through the example, the potentiality of the selector can be seen: in a few minutes a person can analyze the effects of changes in the mixture (in resin as well as in the composition itself) and film thickness about all o the final product key properties, not only those that you seek to improve, but the "side effects" that almost always arise when these changes are introduced. All of these situations allow the minimization of the amount of material, human and machinery effort required for optimizing the mixtures for automatic and industrial packaging applications.

## 6 References

For more information, the following references may be consulted:

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