All-MDI Fully Water Blown Flexible Foam Systems for Furniture Applications

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Summary

The Dow Chemical Company has recently made significant advances in the design of a new generation of cost effective high resilience all-MDI flexible foam systems. When the end use is furniture molding, the main advantage of this new generation of systems is the excellent aesthetics of the resulting parts, even with very complicated mold shapes and inserts, for big or small items. Dow was able to obtain these results thanks to in-depth modeling and improvement of the foam processing characteristics through a lab simulation process, consisting of a methodology and tools specifically developed for this purpose, coupled with the results and data gathered during industrial activities at customers' facilities.
This new technology uses Dow's high molecular weight and high efficiency polyols in combination with MDI prepolymers that have been designed to fit different physical-mechanical properties requirements and a reduced level of non-reactive additives that result in improved foam emission performance. This new generation of products offers a high degree of design flexibility combined with wide load-bearing and wide demolding time and density ranges.
The developmental work that was recently undertaken, also aiming at improving the foam durability properties, gave Dow the possibility to further broaden the product offering of this new generation of high resilience all-MDI systems. A new fully water blown system has now been introduced: this system enables the reduction of the applied density while maintaining outstanding aesthetics. Furthermore, other available system solutions offer very fast demolding profiles or self crushing system foams with superior durability properties.
This study covers in more detail the performance of this new generation of all-MDI systems produced by Dow particularly suitable for the furniture industry.

Objective/Purpose

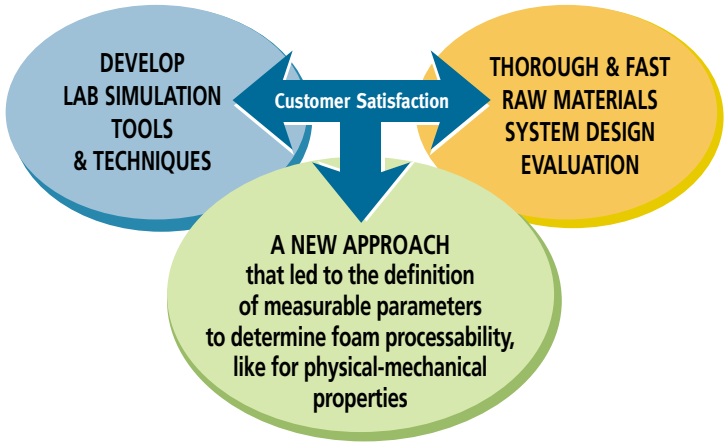
The aim of this study was to develop a new family of all-MDI fully water blown systems especially for furniture applications able to fulfill different processing requirements and specific customer needs as well as final foam properties.

"The Challenge": to broaden our current products offering to better meet specific production conditions and final foam properties requirements.

Foam Processing	Final Foam Properties
• Low density capability	• Durability (fatigue, compression set)
• Excellent aesthetics	• Resilience/Hysteresis (comfort)
• Industrial hygiene (minimal odor during processing)	• High & low foam load-bearing
• Demolding cycle	• Foam emissions (fogging)
• Mold temperature latitude	• Flammability
• Wide load-bearing range	
• Open foam (easy crushability)	

Research Approach

Our approach was to develop laboratory hardware and procedures able to predict and quantify typical foam processability limitations at the customer plant such as foam finishing, eventual voids sensitivity/distribution and foam crushability without the need of any actual molds or equipment. The hardware and procedures allow us to quickly and thoroughly investigate influences of raw materials and system design on both foam processability and physical-mechanical properties in one step.



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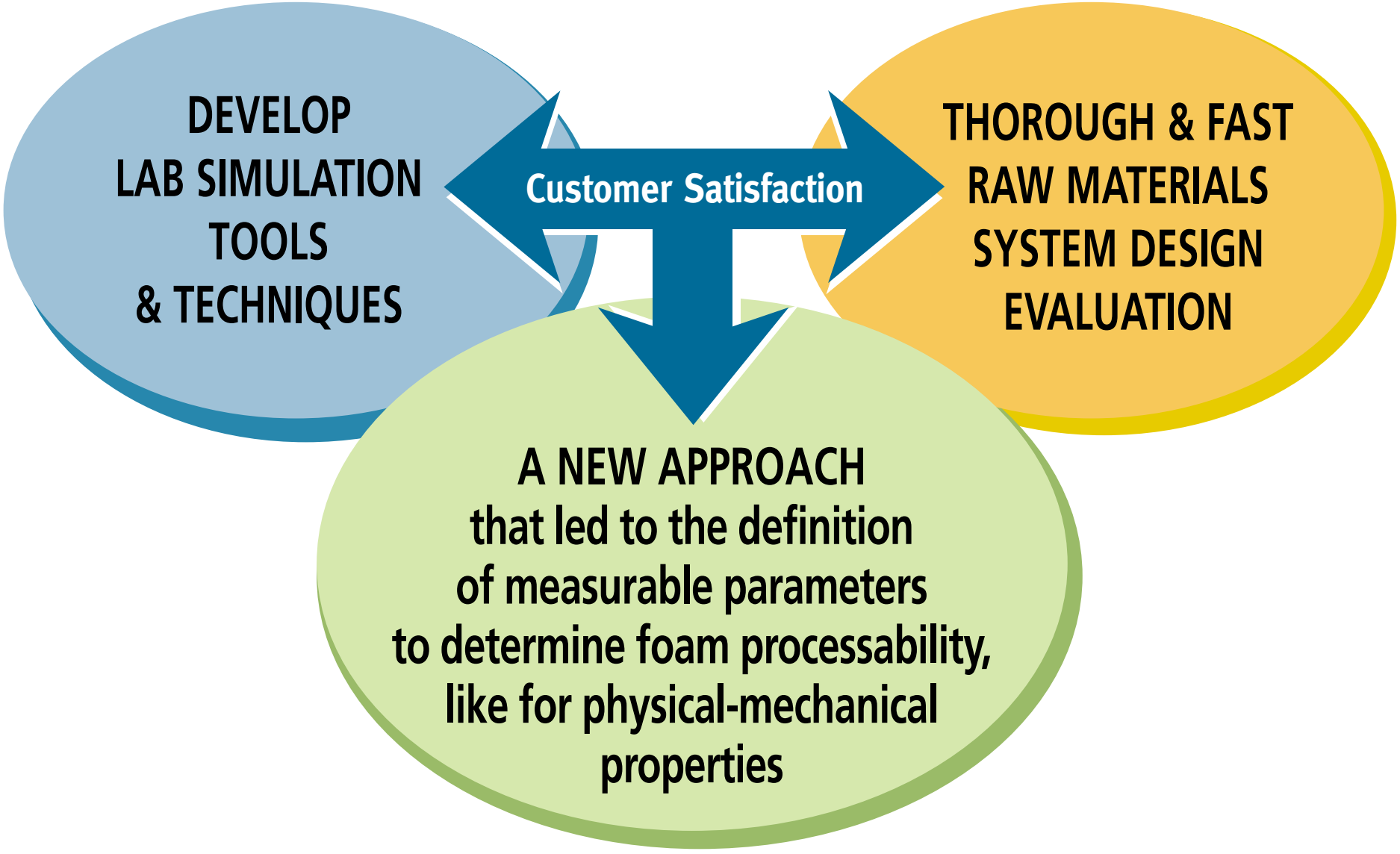
DEVELOP
LAB SIMULATION
TOOLS
& TECHNIQUES
Customer Satisfaction
THOROUGH & FAST
RAW MATERIALS
SYSTEM DESIGN
EVALUATION
A NEW APPROACH
that led to the definition
of measurable parameters
to determine foam processability,
like for physical-mechanical
properties

Key Points

Laboratory simulation hardware & techniques

Our objective was to quantify foam processability alongside foam physical-mechanical properties. The tools (mainly "molds") and methodologies to simulate the processability limitations at the customers' plants are the result of a systematic effort in comparing laboratory activities to actual customer processing situations carried out over the past 7 years.
Foam processing parameters such as, foam crushability, bubbles formation, defects, flowability, finishing, vent behavior, long pouring time and mold temperature sensitivity are currently continuously evaluated and quantified. To avoid subjectiveness of interpretation and to provide a high level of consistency a computerized system enables us to file and retrieve defect distribution images, in addition to data regarding foam physical-mechanical properties, such as flex fatigue, elongation at break and compression set.

Raw materials & system design

The need to meet very demanding foam properties as well as foam processability resulted in the use of:

- high molecular weight, high efficiency triol as main base polyol ingredient having high intrinsic reactivity;
- all-MDI prepolymer composition with an optimized isomer/oligomer ratio; the OH terminated component has been thoroughly examined and fine-tuned especially for its influence on cell opening performance;
- foam physical stabilization and the role of surface active substances have been extensively considered and fine-tuned;
- low amounts of non-iso reactive additives that produce very low fogging and emissions values.

The smooth reactivity and rise profile of these systems assures high foam processability and doesn't affect curing and demolding performance which allows for "just in time" delivery.

Summary of the Results

SPECFLEX* Customized Systems Featuring: Foam Processing
Core density capability under actual production:
• This new family of systems typically achieves core densities of 2.68 to 3.43 pcf (i.e. 43-55 kg/m^3)
• A specially formulated system of our new family is capable of achieving core densities down to 2.50 pcf (i.e. 40 kg/m^3) without compromising foam processing or durability properties
Demolding range:
• Systems with demolding in the range of 6 minutes
• Systems with demolding in the range of 4 minutes
• Systems with very fast demolding down to 2 minutes and 45 seconds
Mold temperature:
• Generally the mold temperature is at 104 to 120° F (i.e. 40-49° C) depending on mold construction
• Particular systems are able to work as low as 95° F (i.e. 35° C)
Load-bearing (iso/pol) working window:
• Typically for a core density of 2.81 pcf (i.e. 45 kg/m^3) a 40% CLD of 0.22 to 0.87 psi (i.e. 1.5-6.0 Kpa) can be easily achieved
• A specially formulated system of our new family is capable to achieve, for the same above mentioned core density, a 40% CLD up to 1.23 psi (i.e. 8.5 Kpa)
Open foam (easy crushability):
• All the systems in this family allow very easy demolding & crushability
• Self crushing systems for somewhat higher molded densities, of 3.4 to 6 pcf, are also available with superior durability properties

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Targeted core density 2.81 pcf (i.e. 45 Kg/m³)
Pads produced in the laboratory by a square mold

SPECFLEX* NF 374 Polyol and SPECFLEX* NE 150 Isocyanate system
(excellent durability, medium/long demolding time)

PROPERTY		METHOD	UNIT	ISO/POL RATIOS 0.44	0.58	0.65	0.75
Interior Density	(1)	ASTM D 3574	pcf	2.84	2.80	2.83	
			Kg/m³	*45.5*	*44.9*	*45.4*	
Ultimate Elongation	(2)	ASTM D 3574	%	120	111	105	
Tear Strength	(3)	ASTM D 3574	pli	2.77	3.22	3.59	
			N/cm	*1.58*	*1.84*	*2.05*	
Comp. Set 50% with skin	(4)	ASTM D 3574	%	5.7	5.3	5.5	
Comp. Set 50% without skin	(5)	ASTM D 3574	%	6.2	5.7	5.9	
Dynamic Fatigue by Constant Force Pounding		ASTM D 3574 (test I_3)	Thickness loss (%)	3.1	2.7	2.0	
			Force Deflection loss (%)	20.0	19.2	15.5	
Resilience		ASTM D 3574	%	63	64	62	
I. F. D.	25%	ASTM D 3574 (test B_1) (6)	lb	14.6	32.6	46.1	
			N	*65*	*145*	*205*	
	65%		lb	39.6	79.8	106	
			N	*176*	*355*	*472*	
Comfort factor				2.70	2.45	2.30	
C. F. D.	40%	DIN 53577	psi	0.28	0.61	0.83	
			Kpa	*1.9*	*4.2*	*5.7*	
Sag factor				3.3	2.9	2.7	
Fogging		DIN 75201 Meth. B (gravimetric)	mg	« 1	« 1	« 1	
Flammability		CAL. TB 117		passed	passed	passed	

SPECFLEX* NF 502 Polyol and SPECFLEX* NE 150 Isocyanate system
(very fast demolding, very wide load-bearing range)

PROPERTY		METHOD	UNIT	ISO/POL RATIOS 0.44	0.58	0.65	0.75
Interior Density	(1)	ASTM D 3574	pcf	2.82	2.80	2.83	2.82
			Kg/m³	*45.1*	*44.8*	*45.3*	*45.1*
Ultimate Elongation	(2)	ASTM D 3574	%	125	116	111	107
Tear Strength	(3)	ASTM D 3574	pli	2.80	3.41	3.68	4.03
			N/cm	*1.60*	*1.95*	*2.10*	*2.30*
Comp. Set 50% with skin	(4)	ASTM D 3574	%	8.8	7.8	7.6	7.7
Comp. Set 50% without skin	(5)	ASTM D 3574	%	7.0	6.5	6.3	6.3
Dynamic Fatigue by Constant Force Pounding		ASTM D 3574 (test I_3)	Thickness loss (%)	2.8	2.3	1.9	2.7
			Force Deflection loss (%)	19.0	20.2	21.0	20.0
Resilience		ASTM D 3574	%	56	59	58	57
I. F. D.	25%	ASTM D 3574 (test B_1) (6)	lb	11.5	31.7	48.3	71.9
			N	*51*	*141*	*215*	*320*
	65%		lb	31.7	77.6	110	162
			N	*141*	*345*	*488*	*720*
Comfort factor				2.76	2.45	2.27	2.25
C. F. D.	40%	DIN 53577	psi	0.22	0.55	0.80	1.20
			Kpa	*1.5*	*3.8*	*5.5*	*8.3*
Sag factor				3.7	2.8	2.7	2.6
Fogging		DIN 75201 Meth. B (gravimetric)	mg	‹ 1	‹ 1	‹ 1	‹ 1
Flammability		CAL. TB 117		passed	passed	passed	passed

(1) specimens dimension: 4 x 4 x 2 in (abt 10 x 10 x 5 cm);
(2) original bench marks separation: 0.98 in (25 cm);
(3) crosshead speed: 11.81 in/min (30 cm/min);
(4) specimens dimension: 4 x 4 x 2 in (abt 10 x 10 x 5 cm);
(5) specimens dimension: 2 x 2 x 1 in (abt 5 x 5 x 2.5 cm);
(6) specimens dimension: 15 x 15 x 0.8 in (abt 38 x 38 x 2 cm) with 1 skin.

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Comfort factor			2.70	2.45	2.30	
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			N	*141*	*345*	*488*	*720*
Comfort factor				2.76	2.45	2.27	2.25
C. F. D. 40%		DIN 53577	psi	0.22	0.55	0.80	1.20
			Kpa	*1.5*	*3.8*	*5.5*	*8.3*
Sag factor				3.7	2.8	2.7	2.6
Fogging		DIN 75201 Meth. B (gravimetric)	mg	< 1	< 1	< 1	< 1
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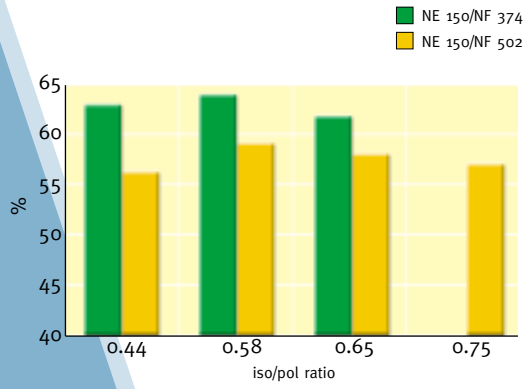
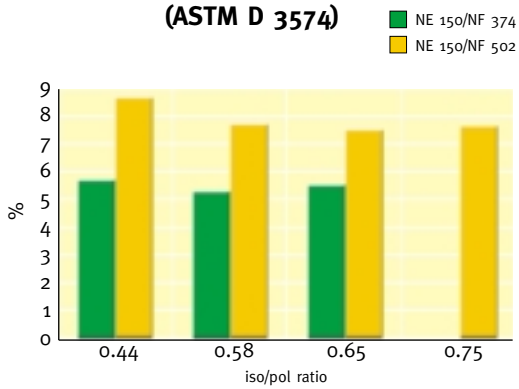
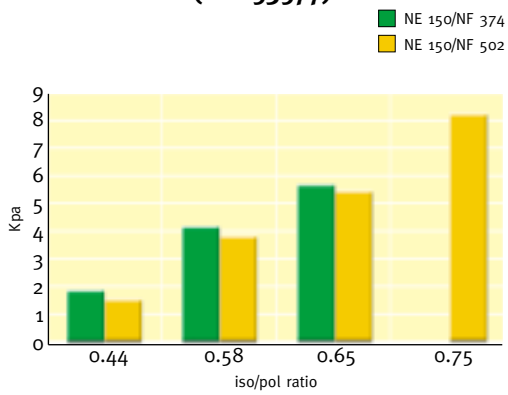
Resilience (ASTM D 3574)



50% Compression Set with Skin Specimen 4 x 4 x 2 in (ASTM D 3574)

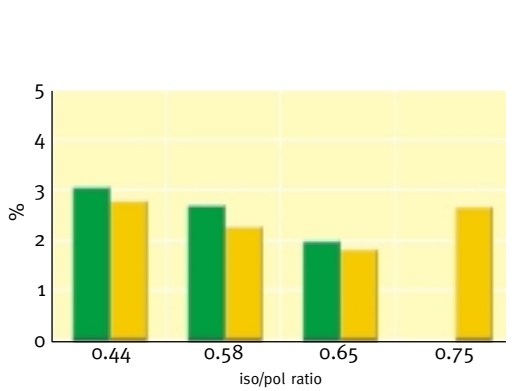


40% CLD (DIN 53577)

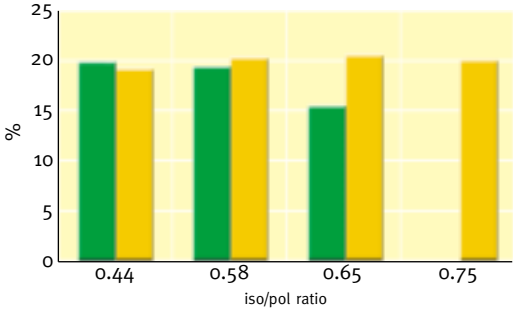


Dynamic Fatigue by Constant Force Pounding (ASTM D 3574)

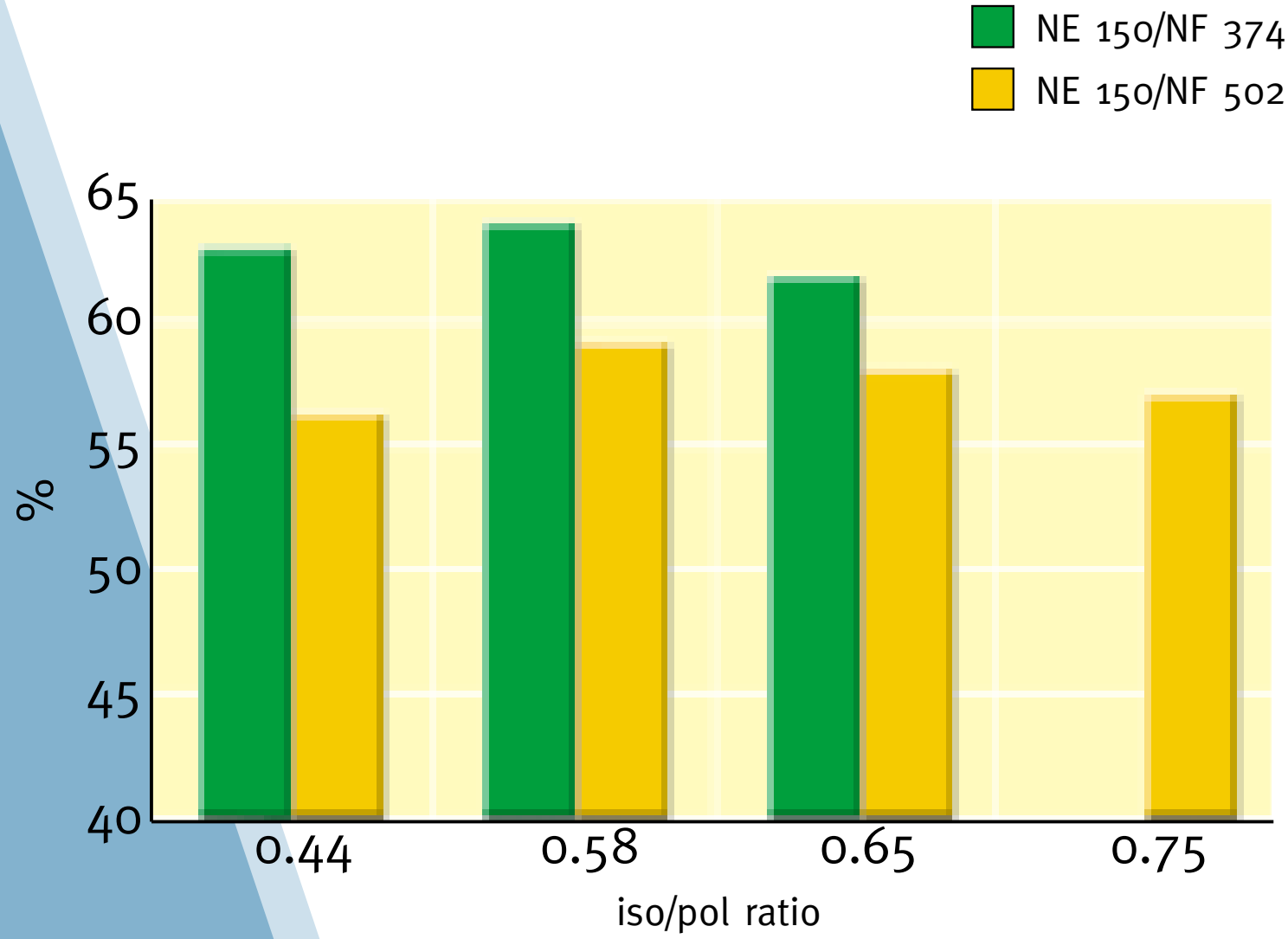
Thickness loss



Force Deflection loss



Resilience (ASTM D 3574)



50% Compression Set with Skin
Specimen 4 x 4 x 2 in
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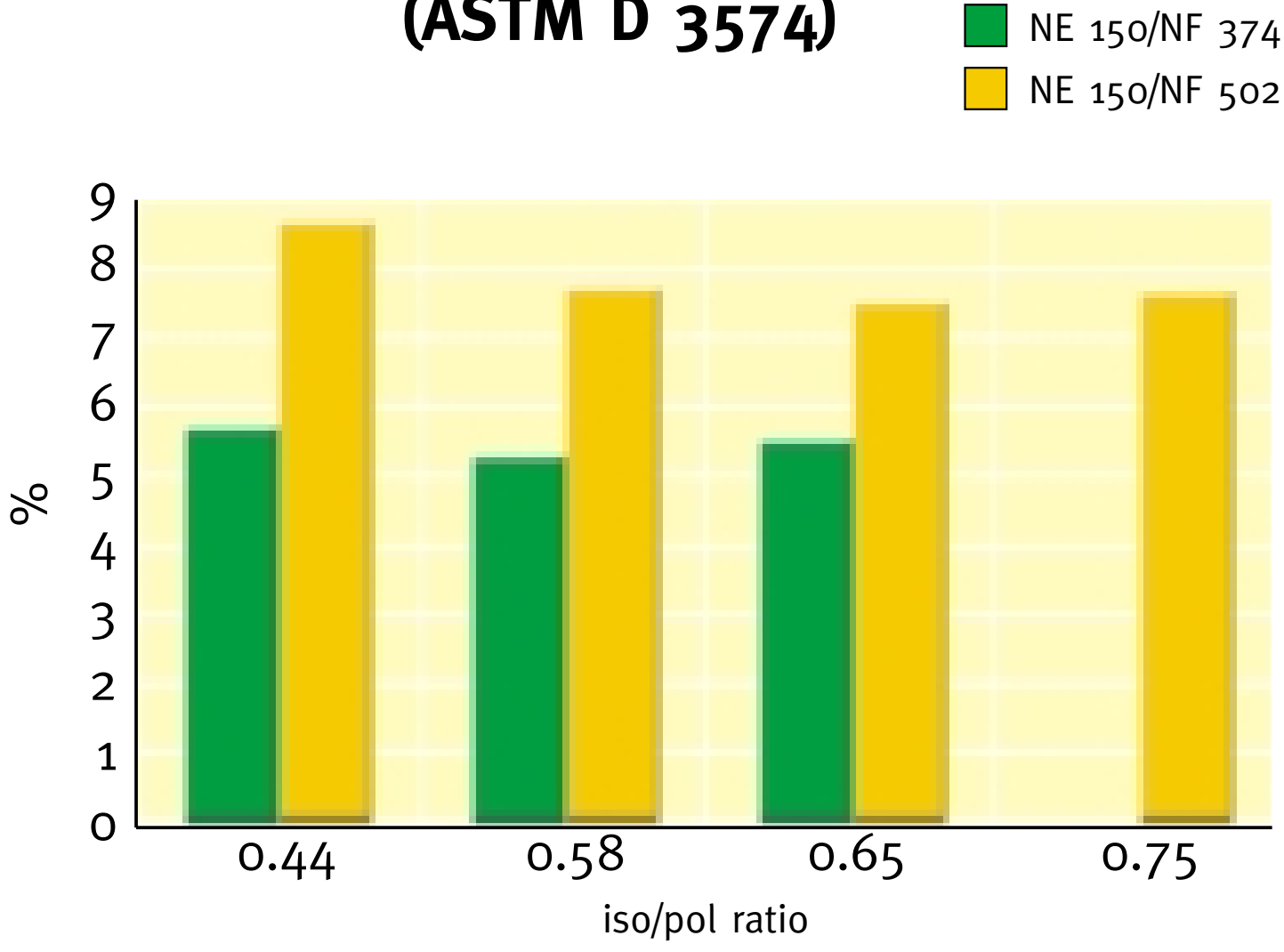

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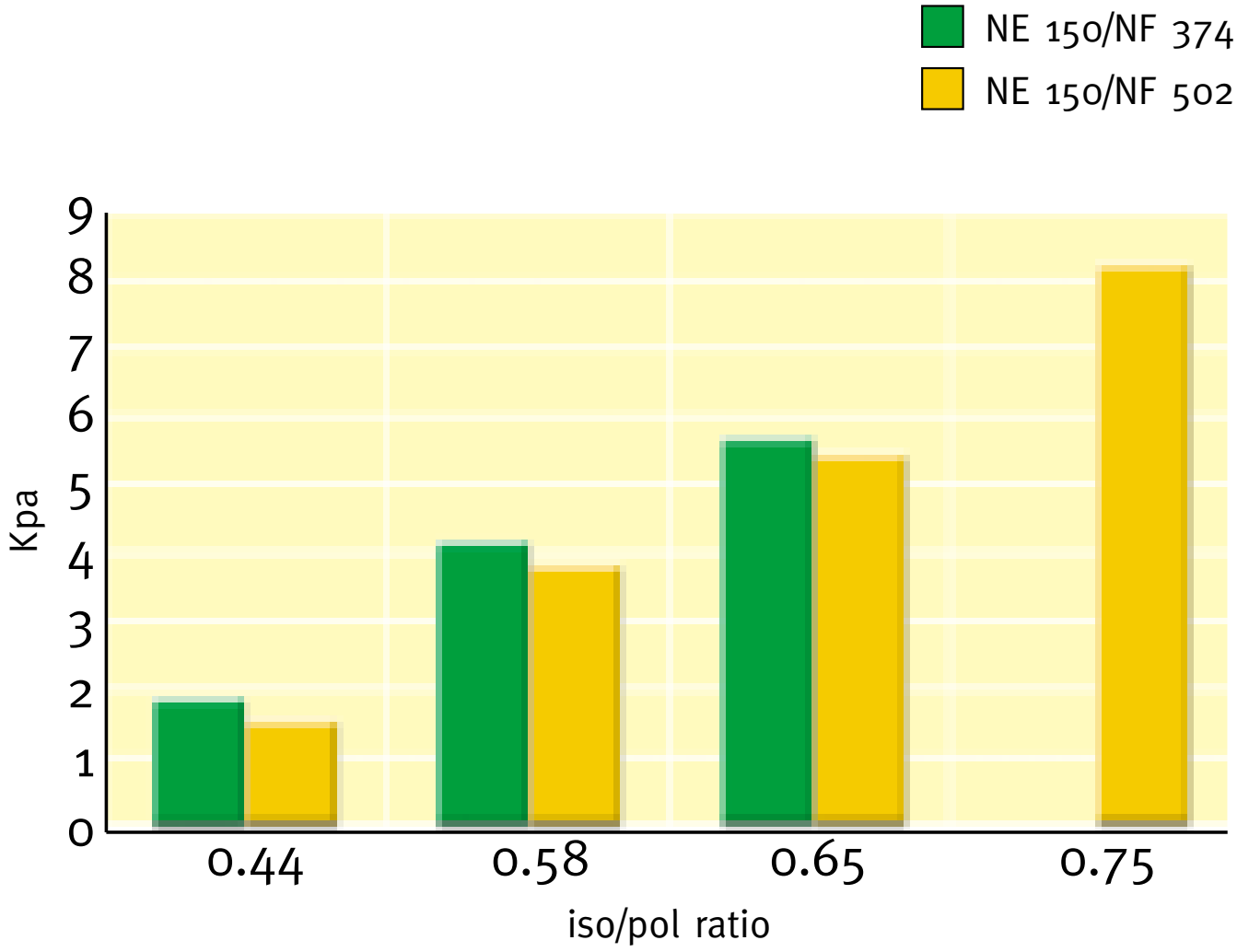

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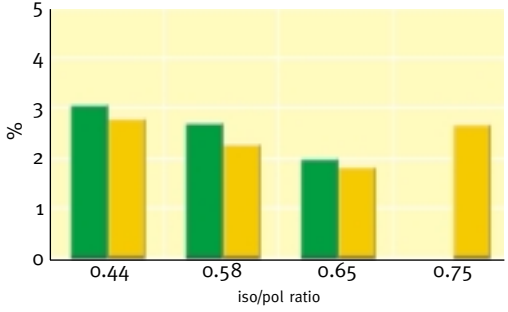
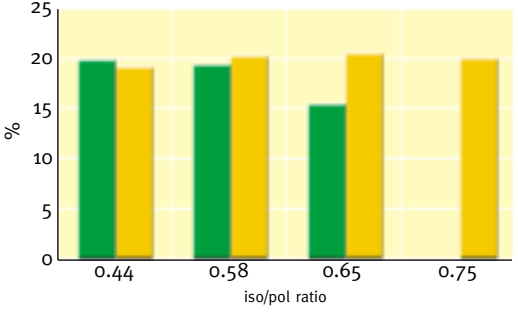


Force Deflection loss



Conclusions

As a result of this study Dow was able to broaden its current systems offering for furniture applications to better meet specific production conditions and final foam properties requirements. Easy processing, easy crushability, low density, wide foam load-bearing range and generally high durability are the branding features of these new all-MDI fully water blown systems. Moreover special tailored solutions also provide the possibility to further reduce the applied density, reaching an actual core density down to 2.50 pcf (40 kg/m^3) at the customer plant, to widen the foam load-bearing range and to achieve a demolding time of 2 minutes and 45 seconds. Furthermore, this work also resulted in the development of simulation tools and methodologies that provide us with the capability to respond in a fast and effective way to many different customers' needs, especially as far as processing is concerned, having only a limited need for plant processing equipment.

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September 2000