Hysteresis

Brand/ /Model	Sample #/ /Batch #	**Test Pressure kPa**	D0 (Thickness) mm	D01 (Thickness) mm	D04 (Thickness) mm	D4k/3 (Thickness) mm	D5k/3 (Thickness) mm	D1 (Thickness) mm	D4 (Thickness) mm	D5 (Thickness) mm	I1 (Indentation) µm	I5 (Indentation) µm	Ip1 (Indentation) %	Ip5 (Indentation) %	Comp. Loss %	Gauge Loss @ 1st Cycle µm	Gauge Loss @ 1st Cycle 1st%	Gauge Loss @ 60kPa µm	Gauge Loss @ TP kPa µm	Hysteresis Wk/3 µm	Hysteresis Energy (HE)Nmm	Elastic Energy (EE)Nmm	Damping Capacity (DC) %	Test Time s
U/I	A121/AP0258A	**122,5**	2,00	1,99	1,99	n.a.	n.a.	1,99	1,98	1,98	13	12	0,6	0,6	4,7	4,1	97,7	4,2	3,6	n.a.	n.a.	0,1	n.a.	10,4
U/I	A122/AP0258A	**185**	2,01	2,01	2,00	n.a.	n.a.	1,99	1,99	1,99	22	16	1,1	0,8	25,3	5,8	77,6	7,4	1,9	n.a.	n.a.	0,2	n.a.	13,0
U/I	A123/AP0258A	**310**	1,99	1,98	1,97	n.a.	n.a.	1,95	1,95	1,95	39	26	1,9	1,3	32,4	11,0	72,1	15,3	2,8	n.a.	n.a.	0,4	n.a.	18,8
U/I	A124/AP0258A	**560**	1,99	1,97	1,97	1,94	1,95	1,92	1,92	1,92	66	50	3,3	2,5	24,7	16,4	75,9	21,6	5,2	4,1	0,1	1,5	8,1	32,3
U/I	A125/AP0258A	**1060**	1,98	1,95	1,94	1,88	1,90	1,83	1,82	1,82	148	117	7,5	6,0	20,9	31,4	82,5	38,1	7,1	13,8	0,8	6,2	13,3	69,5
U/I	WR163/AP0258A	**2060**	1,98	1,93	1,92	1,81	1,84	1,72	1,71	1,71	256	205	13,0	10,7	20,2	48,4	77,8	62,2	10,4	29,0	3,6	19,1	18,8	120,0
U/I	WR168/AP0258A	**4060**	2,00	1,91	1,89	1,69	1,74	1,59	1,58	1,58	409	308	20,5	16,3	24,7	90,5	81,9	111,0	9,7	45,0	11,0	48,8	22,5	179,8
U/I	WR164/AP0258A	**6060**	1,98	1,88	1,86	1,59	1,64	1,48	1,47	1,47	503	391	25,4	21,0	22,3	104,0	82,6	125,0	13,4	51,6	22,0	84,8	26,0	225,3
U/I	WR165/AP0258A	**8060**	1,96	1,85	1,82	1,51	1,57	1,44	1,42	1,42	525	403	26,8	22,1	23,3	111,0	79,7	139,0	16,2	56,3	32,6	102,6	31,7	234,8
U/I	WR166/AP0258A	**16060**	1,97	1,83	1,80	1,35	1,43	1,24	1,23	1,22	729	577	37,0	32,0	20,9	143,0	83,2	172,0	19,5	81,8	97,3	271,1	35,9	330,0
U/I	WR167/AP0258A	**32060**	1,97	1,78	1,74	1,05	1,17	0,90	0,86	0,86	1.070	888	54,4	50,9	17,0	188,0	85,0	222,0	39,9	120,0	293,5	793,5	37,0	498,8
U/I	WR163/AP0258A	**64060**	1,98	1,808	1,812	0,50	0,67	0,36	0,18	0,16	1.610	1.650	81,5	91,0	-2,4	168,0	102,6	164,0	202,3	173,0	1.135,5	2.696,4	42,1	862,9

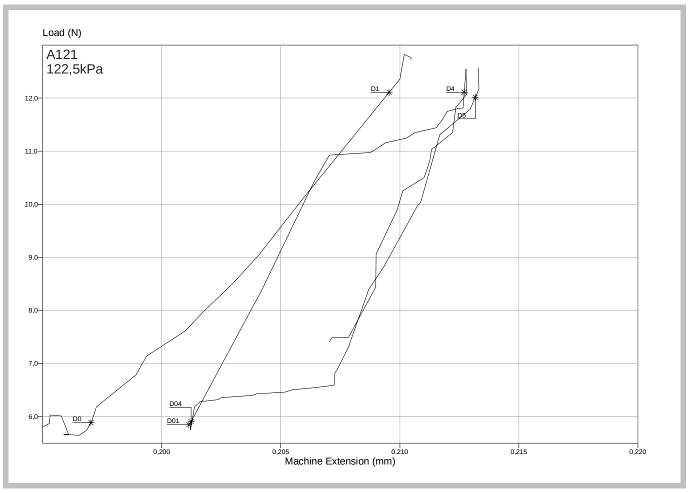
Whip Reaction

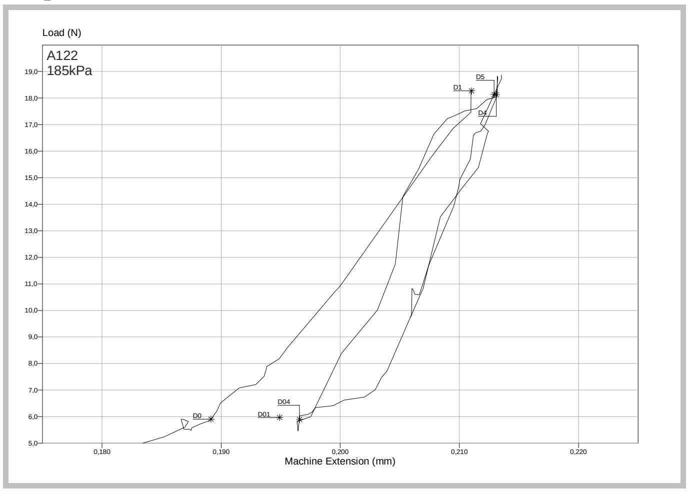
Brand/ /Model	Sample #/ /Batch #	**Test Pressure kPa**	D0 (Thickness) mm	D04 (Thickness) mm	D5 (Thickness) mm	I5 (Indentation) µm	Ip5 (Indentation) %	GLoss @60kPa µm	Elastic Energy Nmm	Test Time s	Whip Energy Nµm	Feed Properties
U/I	A121/AP0258A	**122,5**	2,01	2,00	1,99	12	0,6	7,3	0,1	11,3	-22,3	++
U/I	A121/AP0258A	**185**	2,01	2,00	1,99	16	0,8	8,5	0,2	13,3	-35,7	++
U/I	A124/AP0258A	**310**	1,99	1,98	1,95	26	1,3	11,5	0,4	17,7	-47,2	++
U/I	A124/AP0258A	**560**	1,99	1,96	1,91	50	2,6	32,6	1,4	32,8	-15,2	++
U/I	A125/AP0258A	**1060**	1,99	1,94	1,83	113	5,8	49,8	6,0	67,5	-3,6	+
U/I	WR163/AP0258A	**2060**	2,00	1,93	1,72	205	10,6	73,5	18,9	118,7	21,4	- -
U/I	WR164/AP0258A	**4060**	1,99	1,89	1,58	308	16,3	104,0	48,4	176,9	n.a.	n.a.
U/I	WR167/AP0258A	**6060**	1,98	1,85	1,46	387	21,0	138,0	84,3	223,7	n.a.	n.a.

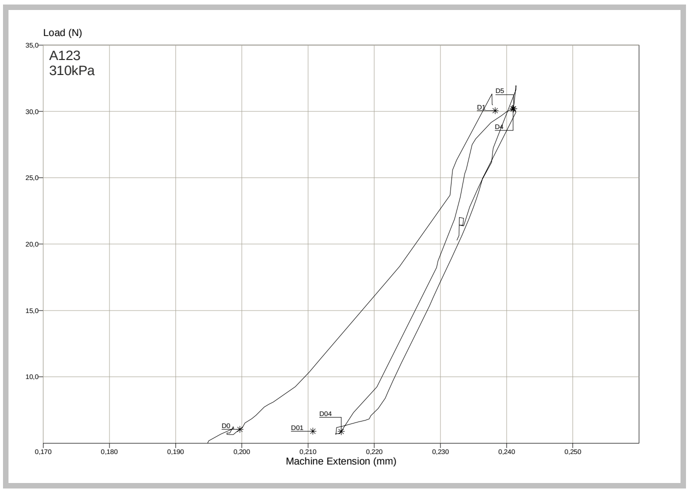
LEGEND:

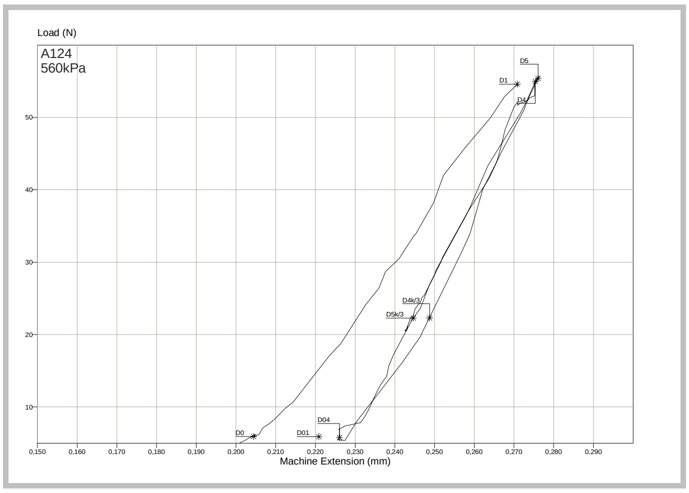
n.a.	not applicable
++ / - -	Positive/ Negative
+ / -	Slightly Positive/ Negative
o	Neutral

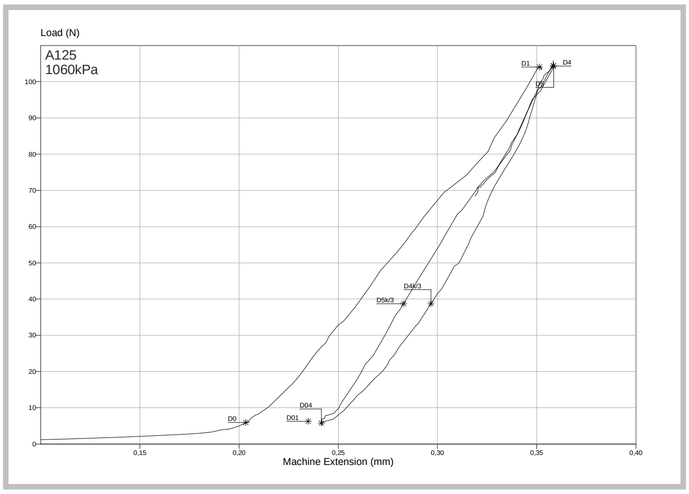
Indentation Graphs

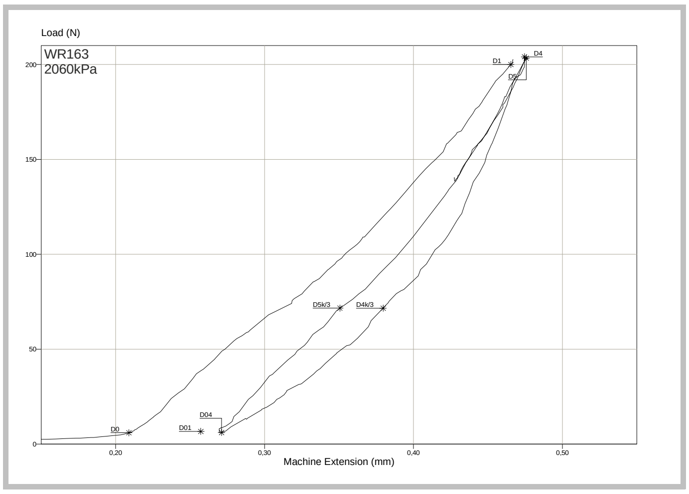


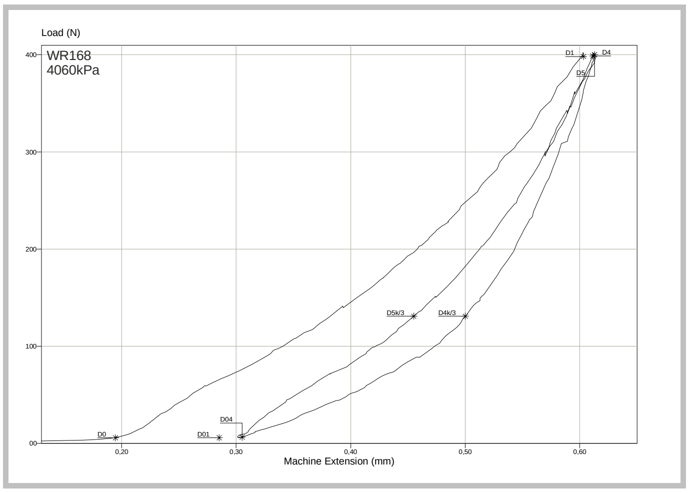


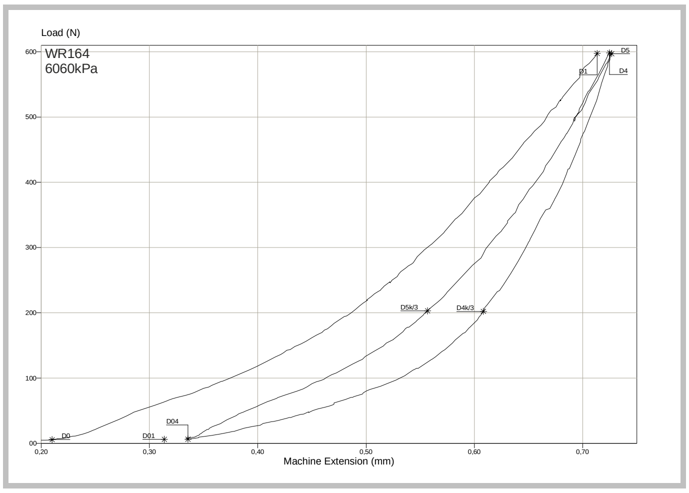




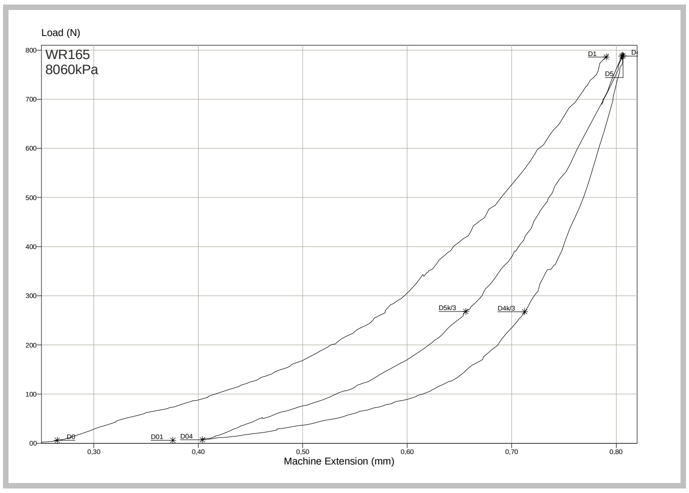


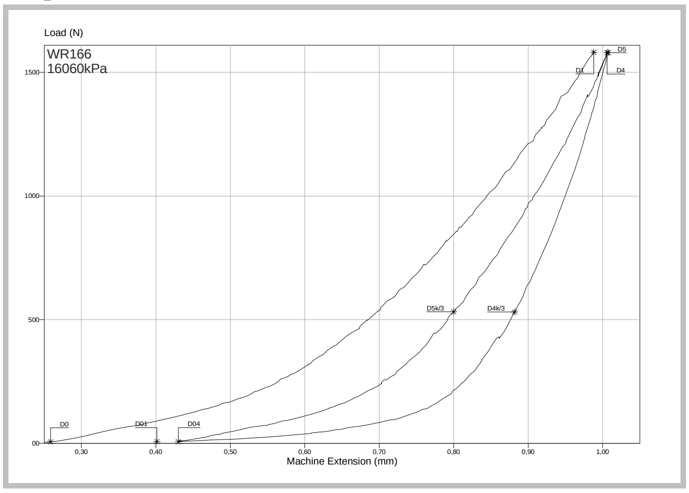


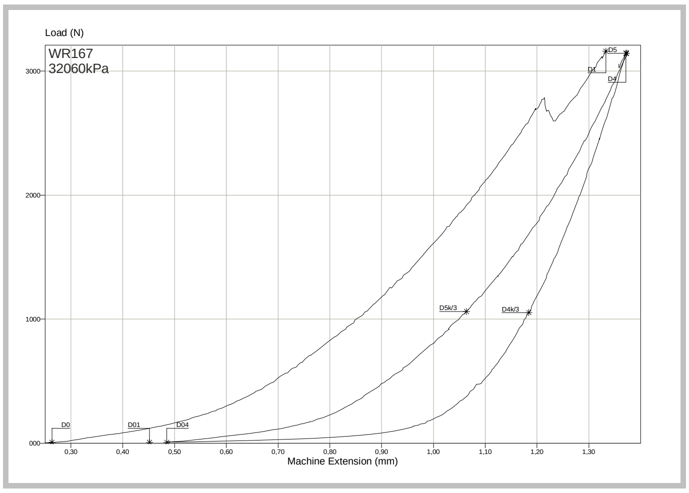


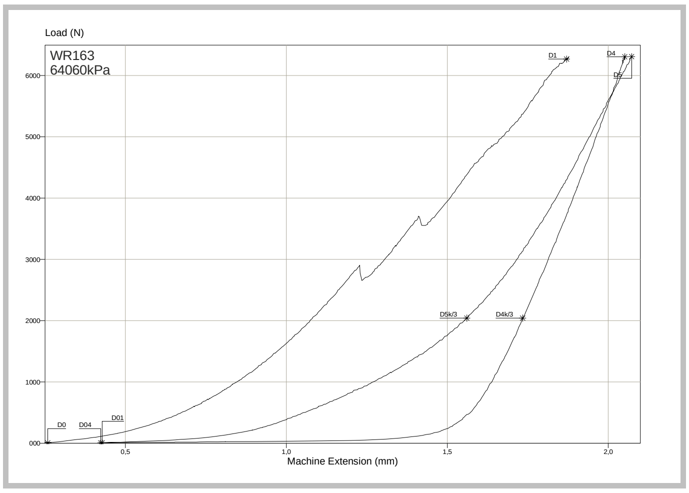


Indentation Graphs









Notes:

1 - The objective of the test data gathered in Hysteresis data table of page 1 is to determine indentation-compressibility and hysteresis related blanket properties under varying load values. In order to try and cover the full window range of possible rubber reactions to quasi static indentation-compression, loads varying by a ratio in excess of 500 times had to be applied to the samples.

2 - Further to the 1^{st} compression, graphs on pages 2 and 3 show the reaction segment lines corresponding to the decompression of the 4^{th} cycle and the compression of the 5^{th}cycle, that define blankets' hysteresis.

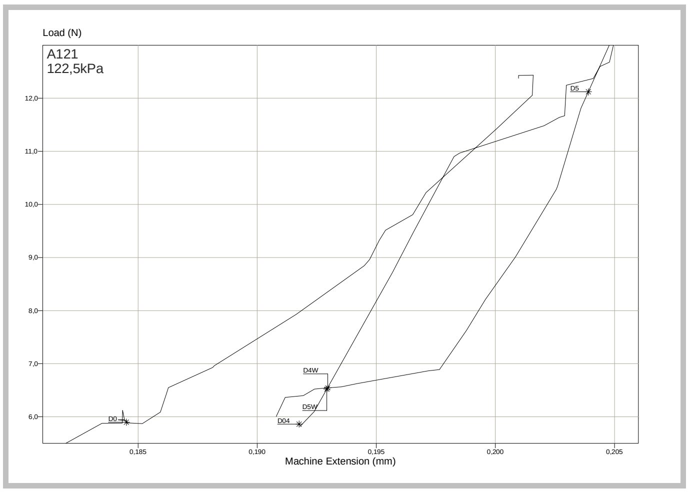
3 - Graphs obtained when test pressures of 122,5; 185 and 310 kPa were used are clearly not relatable to hysteresis.

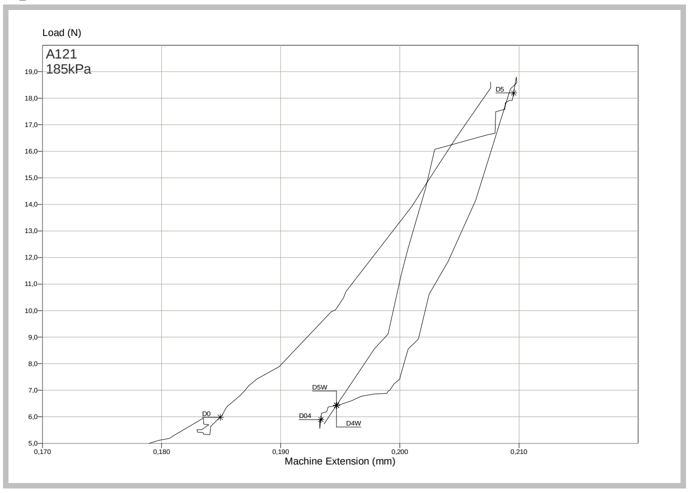
Hysteresis graphs obtained with test pressures of 560; 1.060 and 2.060 kPa, respectively, show a varying degree of distortion, namely on its upper part.

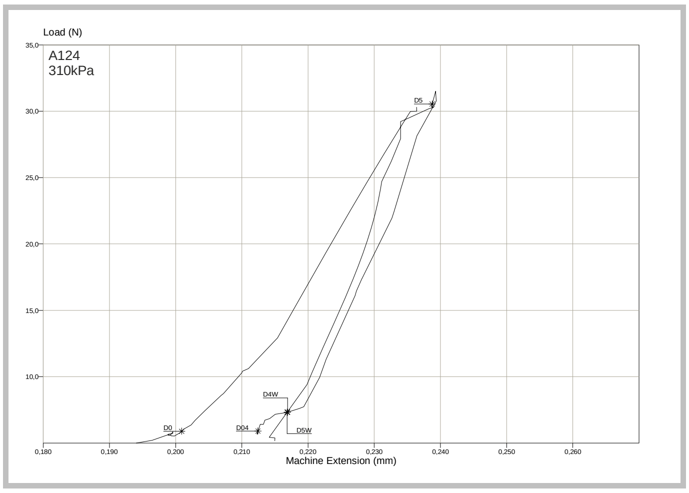
4 - Graphs obtained with test pressures of 4.060; 6.060; 8.060 and 16.060 kPa show "clean" hysteresis curves together with increasing damping capacity values.

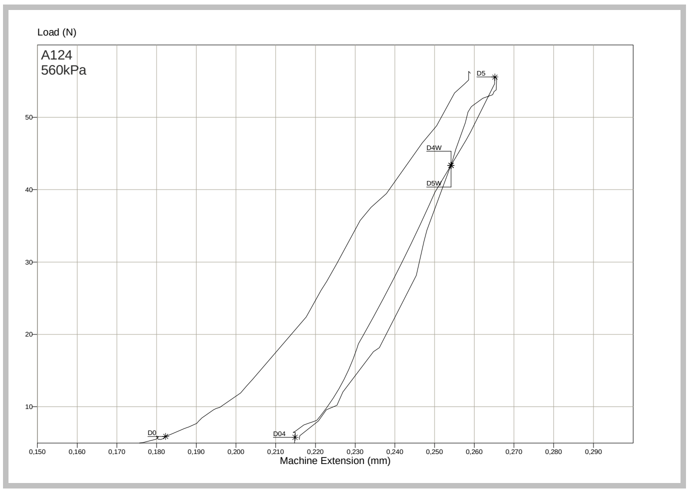
5 - Besides showing hysteresis curves, graphs corresponding to test pressures of 32.060 and 64.060 kPa, respectively, show that 1 and 2 structural failures occurred during the 1^{st} compression cycle, which failures were confirmed by visual inspection. Rupture and displacement of the fabric threads on the blankets' carcass under the indenter sharp edge were the cause of these failures.

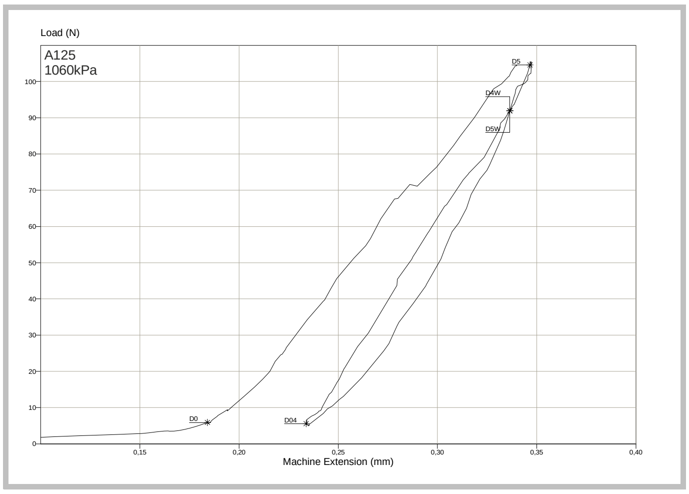
Whip Graphs

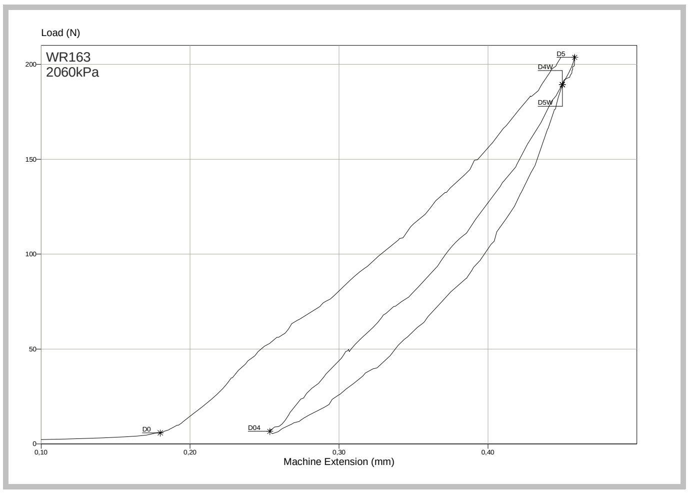

Load (N)
A121
122,5kPa
D0
D04
D4W
D5W
D5
Machine Extension (mm)

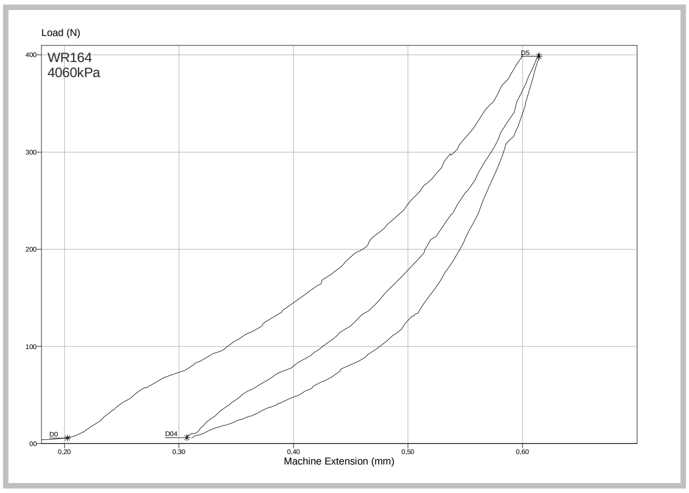

Load (N)
A121
185kPa
D0
D04
D5W
D4W
D5
Machine Extension (mm)

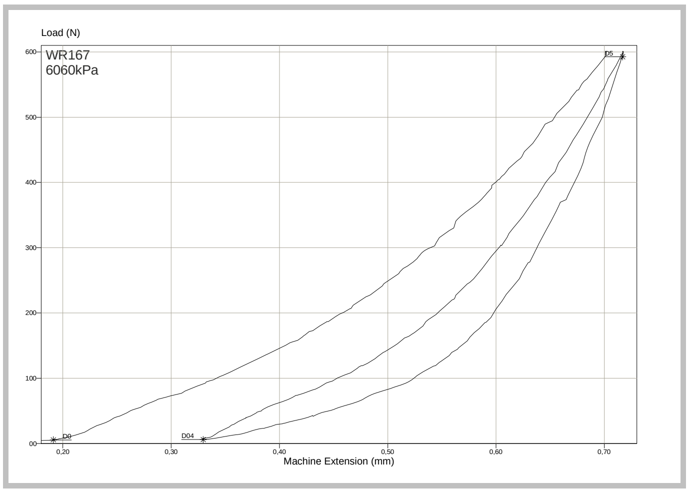

Load (N)
A124
310kPa
D0
D04
D4W
D5W
D5
Machine Extension (mm)


Load (N)
A124
560kPa
D0
D04
D4W
D5W
D5
Machine Extension (mm)


Load (N)
A125
1060kPa
D0
D04
D4W
D5W
D5
Machine Extension (mm)

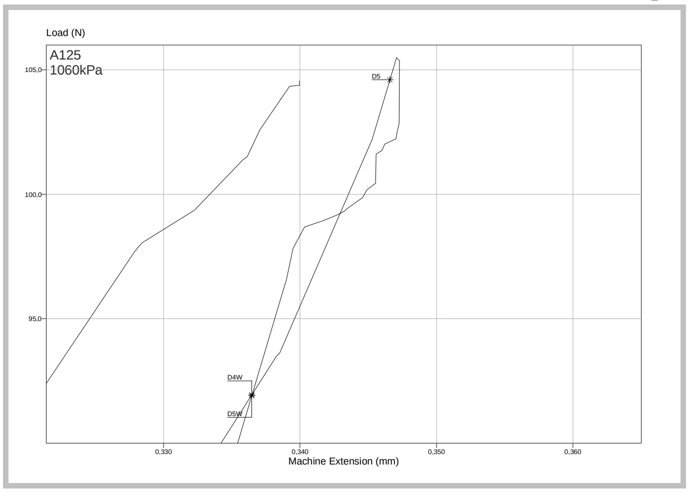

Load (N)
WR163
2060kPa
D0
D04
D4W
D5W
D5
Machine Extension (mm)

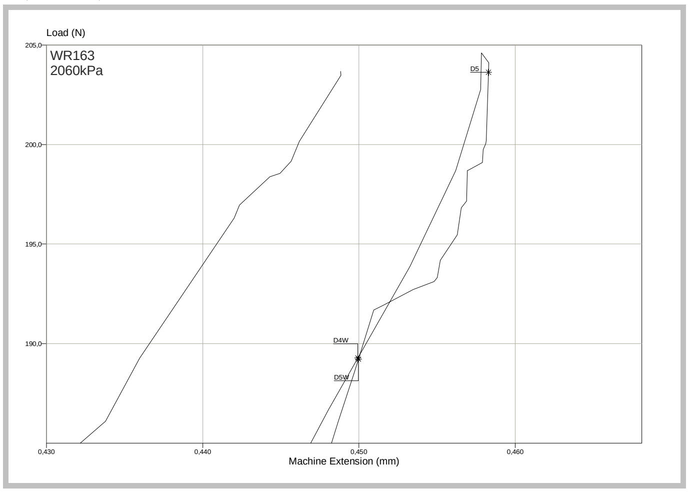

Load (N)
WR164
4060kPa
D0
D04
D5
Machine Extension (mm)


Load (N)
WR167
6060kPa
D0
D04
D5
Machine Extension (mm)

Compressibility-Indentation
Feed Properties - U/I

Whip Graphs (Zoom)





Notes:

1 - Tests series objective gathered in Whip Reaction data table of page 1 is to determine the Whip Energy variation and respective blanket Feed Properties under varying load values.

2 - Further to the 1st compression, graphs on page 4 show the reaction segment lines corresponding to the complete 5th compression cycle *including the decompression segment (which is not considered on the Indentation Test)*, used to define the Whip Energy.

The Whip Energy is defined at the lowest crossing point ζ (zita) of compression and decompression segments of the 5th compression cycle (markers D4W and D5W) relating to the Whip Reaction, which does not occur at a constant load value.

3 - WE = F(Test Load) graphs in pages 6 and 7 includes a doted line which was added as a guess of the expected whip reaction at very low test loads.

4 - Graphs obtained with test pressures of 122,5; 185 and 310 kPa show the existence of a clear Whip Reaction.

5 - The upper part of the graphs obtained with test pressures of 560; 1.060 and 2060 kPa equally correspond to the Whip Reaction. The lower part of these graphs relate to the Hysteresis Energy but for the HE graphs please refer to pages 2 and 3.

On page 5 Zoomed Whip Reaction graphs are shown relative to tests conducted at 1.060 and 2.060 kPa for easier results comparison and interpretation.

6 - Present test method and the Configuration used do not always enable to obtain Whip Energy values, especially as they approach Neutral or Negative Feed. But the presence of the characteristic Whip Reaction is still detectable, as applicable.

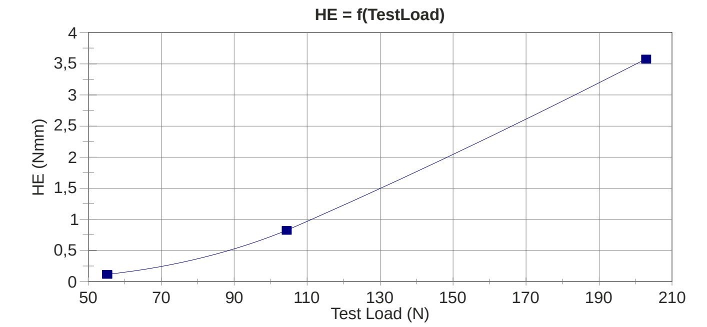
7 - Graphs obtained with test pressures of 4060 and 6060 kPa show that a Whip Reaction is no longer present. As the elongation strain values increase with increasing test pressure values, Whip Reaction becomes no longer quicker than the Hysteresis Reaction and thus Whip Reaction does no longer appear in the indentation graphs.

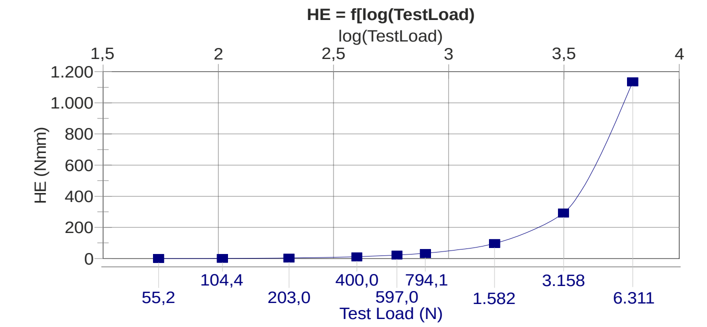
8 - Data presented in page 7 refers to blanket models from other manufacturers, expressly chosen because of their quite different compressive properties. However, a common overall Whip Energy dependance pattern with the test load is still clearly recognisable.

9 - Contrarily to Hysteresis, Whip Reaction is very prompt at low compressive loads, quickly increasing from zero to a maximum positive feed value, to reverse afterwards its tendency to negative feed characteristics. Most manufacturers endeavour to design their blanket models in such a way that they have approximately neutral feeding characteristics at normal printing pressures.

Hysteresis Energy (HE) dependance on Test Load

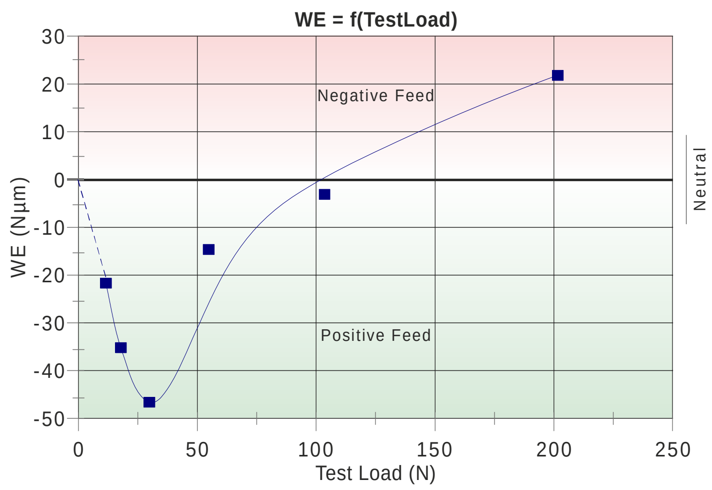
Brand/ /Model	Sample #/ /Batch #	Test Pressure KPa	Test Load N	Hysteresis Energy (HE) Nmm	Damping Capacity (DC) %
U/I	A121/AP0258A	122,5	12,1	n.a.	n.a.
U/I	A122/AP0258A	185	18,2	n.a.	n.a.
U/I	A123/AP0258A	310	30,5	n.a.	n.a.
U/I	A124/AP0258A	560	55,2	0,1	8,1
U/I	A125/AP0258A	1.060	104,4	0,8	13,3
U/I	WR163/AP0258A	2.060	203,0	3,6	18,8
U/I	WR168/AP0258A	4.060	400,0	11,0	22,5
U/I	WR164/AP0258A	6.060	597,0	22,0	26,0
U/I	WR165/AP0258A	8.060	794,1	32,6	31,7
U/I	WR166/AP0258A	16.060	1.582	97,3	35,9
U/I	WR167/AP0258A	32.060	3.158	293,5	37,0
U/I	WR163/AP0258A	64.060	6.311	1.135	42,1





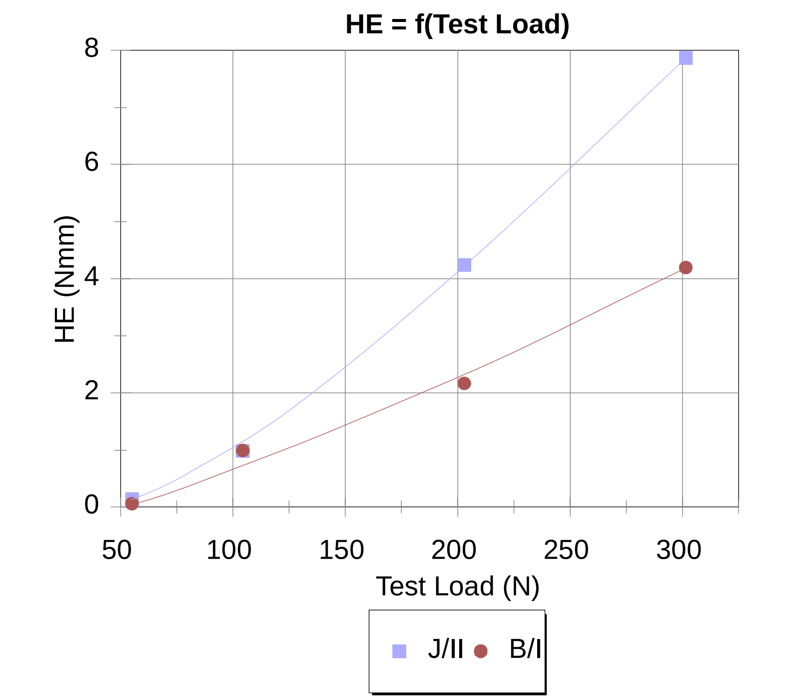
Whip Energy (WE) dependance on Test Load

Brand/ /Model	Sample #/ /Batch #	Test Pressure KPa	Test Load N	Whip Energy (WE) Nμm
U/I	A121/AP0258A	122,5	12,1	-22,3
U/I	A121/AP0258A	185	18,2	-35,7
U/I	A124/AP0258A	310	30,5	-47,2
U/I	A124/AP0258A	560	55,2	-15,2
U/I	A125/AP0258A	1060	104,4	-3,6
U/I	WR163/AP0258A	2060	203,0	21,4
U/I	WR164/AP0258A	4060	400,0	n.a.
U/I	WR167/AP0258A	6060	597,0	n.a.



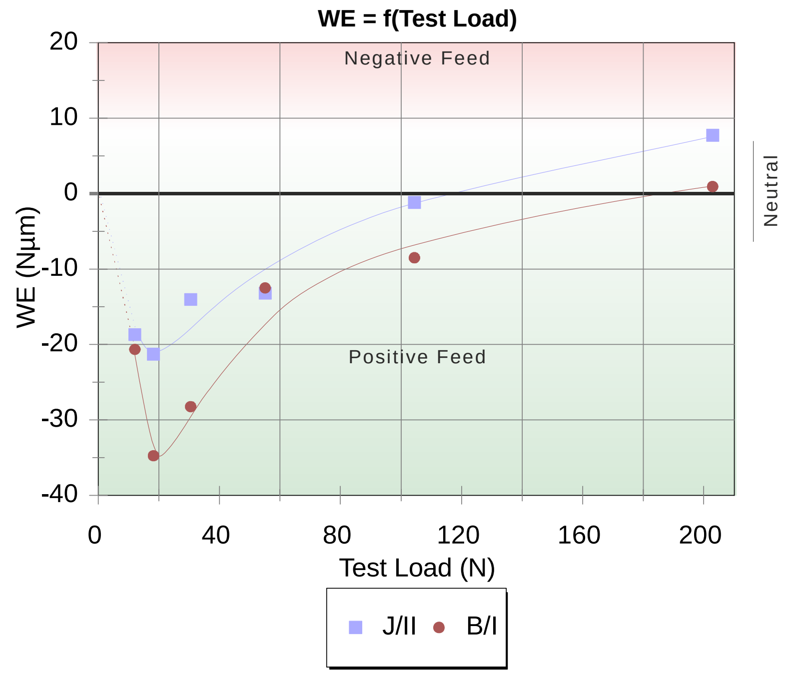
Hysteresis Energy (HE) dependance on Test Load

Brand/ /Model	Sample #/ /Batch #	Test Pressure KPa	Test Load N	Hysteresis Energy (HE) Nmm	Damping Capacity (DC) %
J / II	WR133/06374/1	122,5	12,1	n.a.	n.a.
J / II	WR134/06374/1	185	18,2	n.a.	n.a.
J / II	WR135/06374/1	310	30,5	n.a.	n.a.
J / II	WR136/06374/1	560	55,2	0,1	7,5
J / II	WR137/06374/1	1060	104,4	1,0	14,7
J / II	WR139/06374/1	2060	203,0	4,2	20,3
J / II	WR141/06374/1	3060	301,5	7,9	21,6
B / I	WR146/01121060/1	122,5	12,1	n.a.	n.a.
B / I	WR147/01121060/1	185	18,2	n.a.	n.a.
B / I	WR148/01121060/1	310	30,5	n.a.	n.a.
B / I	WR149/01121060/1	560	55,2	0,1	1,8
B / I	WR150/01121060/1	1060	104,4	1,0	8,2
B / I	WR152/01121060/1	2060	203,0	2,2	8,7
B / I	WR154/01121060/1	3060	301,5	4,2	11,6



Whip Energy (WE) dependance on Test Load

Brand/ /Model	Sample #/ /Batch #	Test Pressure KPa	Test Load N	Whip Energy (WE) Nµm
J / II	WR133/06374/1	122,5	12,1	-18,9
J / II	WR134/06374/1	185	18,2	-21,2
J / II	WR135/06374/1	310	30,5	-14,0
J / II	WR136/06374/1	560	55,2	-13,7
J / II	WR137/06374/1	1060	104,4	-1,2
J / II	WR138/06374/1	2060	203,0	7,8
J / II	WR140/06374/1	3060	301,5	n.a.
B / I	WR146/01121060/1	122,5	12,1	-20,6
B / I	WR147/01121060/1	185	18,2	-34,6
B / I	WR148/01121060/1	310	30,5	-26,6
B / I	WR149/01121060/1	560	55,2	-12,5
B / I	WR150/01121060/1	1060	104,4	-4,6
B / I	WR151/01121060/1	2060	203,0	1,0
B / I	WR153/01121060/1	3060	301,5	n.a.



Final assessment

In Compressibility-Indentation (CI) Whip Reaction results from a non static frontier condition - or domain wall - fully falling within a rubber format.

In these conditions rubber may be considered and behaves as a low quality, highly amortised, resonant circuit.

Blankets' Whip Reaction is a totally independent concept, present during CI early decompression stage and connected to the secondary elastic recovery from rubber elongation in the presence of a frontier condition.

The lower the Hysteresis associated with its rubber compounds, the stronger the Whip Reaction will be and more rebound cycles are likely to show up during its gauge recovery.

Whip Reaction is typically an excessive rubber reaction - when released from CI the material will tend to return beyond its original position - clearly associated to Positive Feed characteristics.

In the study of CI the following reaction effects should be considered:

Elastic Energy, in the combined form of compressive plus secondary elongation reactions (similar to an accordion).

Energy loss during the course of rubber shape alteration - or Hysteresis - as a result of matter attrition.

Rubber bulges geometry, resulting from the shape of the indenter, the compressive configuration and the dynamic conditions.

Attrition of the materials in presence of each other - such as steel, rubber composite and paper - and the resulting "bumpy", or not smooth overall reaction.

Among others, the following tools are available to the blankets designer in order to achieve the desired Feed Properties:

Rubber compound formulation used on blankets' top layer, specially its damping capacity (DC or tg δ), are in the basis of the Feeding behaviour of that blanket for a given set of printing pressure and conditions.

Foam, hard or soft rubber layers will conveniently assist in controlling both the size and the respective reactive capacity of the rubber bulges associated with compression indentation.

Although blankets Feed Properties fall definitely short of a metaphysical nature, the following challenges must still be successfully overcome if one is to proudly announce, batch after batch, blanket models with really constant performing properties:

Hysteresis Energy values being very small, they come with an associated comparatively large error, making it extremely hard to obtain blankets with a really constant Damping Capacity.

To make matters harder, Whip Energy values are still 20 to 100 times smaller than those obtained for Hysteresis Energy. Although reliable average figures and tendencies are obtainable, the same sample will often return a second result which value is double or half the previous one.

The blanket composites considered in the present study have cotton fabrics based carcasses and these represent a clear limit as to the possible homogeneity - and the respective performance stability - of the final product.

One option to have products with a more predictably stable Feed performance than just an "average behaviour" lies eventually in the choice of alternative carcass materials, such as those used on sleeves or metal-backs.

While fabric texture contribute to a noticeable scattering of laboratory test feed values, the stiffness of the carcass contributes to the overall blankets' feed properties: Higher stiffness values will contribute to positive feed.