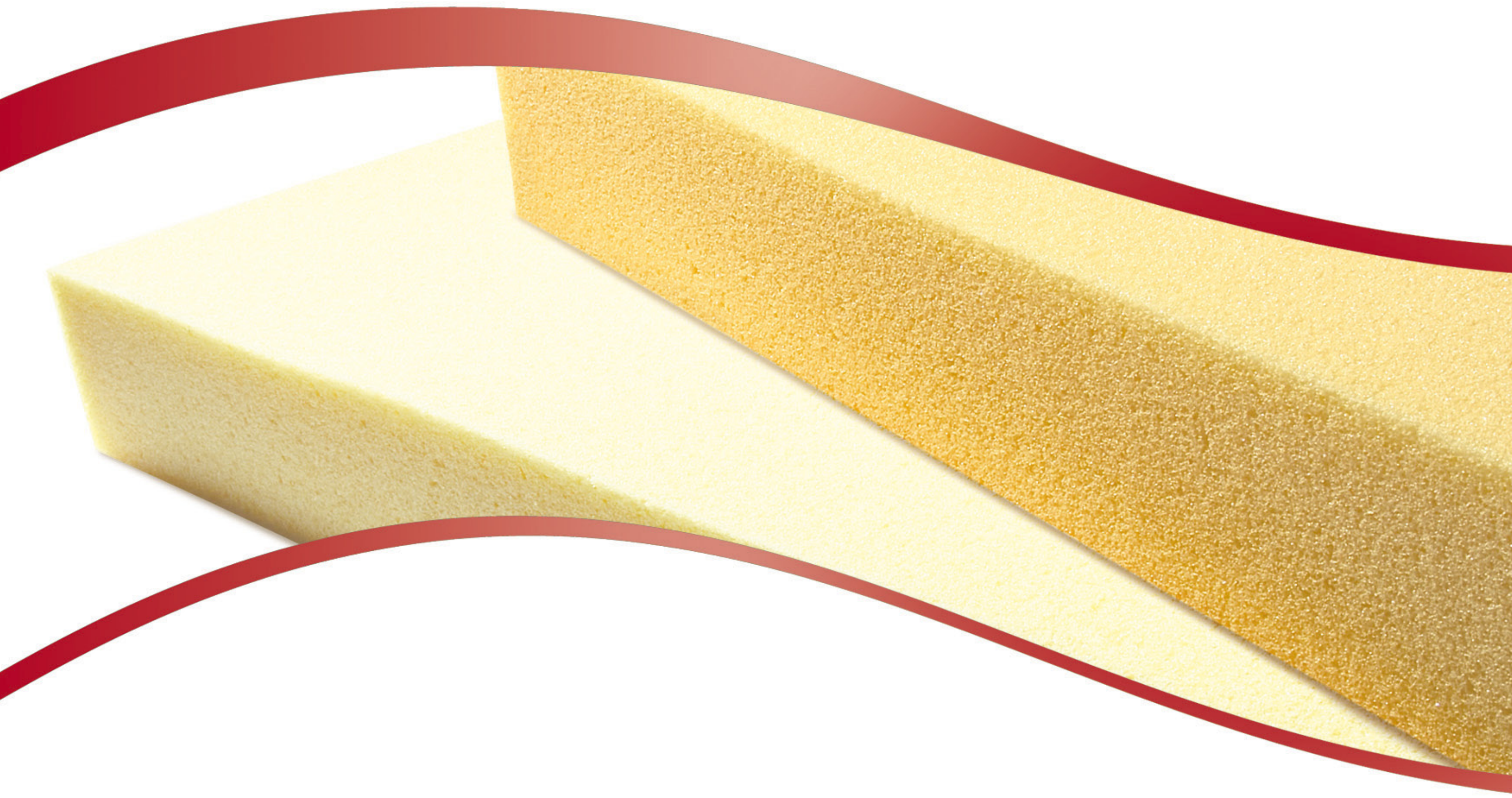
Guide to the Polyurethane Foam



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Introduction

The Polyurethane foam is a cell-structured material containing a high percentage of air.
Polyurethane foams are divided into two main categories: rigid and flexible foams. Rigid foams are specifically used in heat insulation in building sector, in the electrotechnical industry and in packaging.
This short guidebook introduces polyurethane foam properties and a special attention is paid to flexible polyurethane foam (to which Olmo foams belong).
The flexible polyurethane foam is the result of a chemical synthesis and has been industrially produced since 1952.

Historical background

1937 *Prof. Otto Bayer produces the first laboratory polyaddition reaction and develops polyurethane chemistry.*

1940 *Dr. A. Hoechtlen and Dr. W. Droste make the first laboratory polyester foam.*

1942/45 *The first foam is used in the building sector to fill cavities.*

1951 *The first polyether foam is produced in a laboratory.*

1952 *The first machine producing slabstock foams in continuous process at a speed of 20 kg/min is introduced on the market.*

1955 *More than 500.000 kg of polyester foam are produced. The use of this new material for pillows and mattresses met with a favourable response from both operators and general public.*

1956 *Soft polyether foam is industrially produced for the first time.*

1968 *European production of this special product, fruit of polyurethane chemistry, exceeds 200 million kg/year.*

1973 *1.2 billion kg of polyurethane foam are produced and approx. 2 kg per capita are used in Northern Europe.*

1979 *The special Olmo production technology, based on the use of paper coated with a sheet of a special film, is developed.*
This offers various advantages:
- *Waste reduction*
- *Recovery of used paper*
- *Qualitative improvement of the slabstock foam*

1984 *A rule requiring the use of flame retardant polyurethanes in public entertainment places come into force in Italy.*

1989 *The British Government requires the use of modified combustion polyurethanes (CM-HR) in household furnishings.*

1990/95 *First viscoelastic foams are introduced on the market. They are mostly PU-polyester. The main application is in mattresses.*

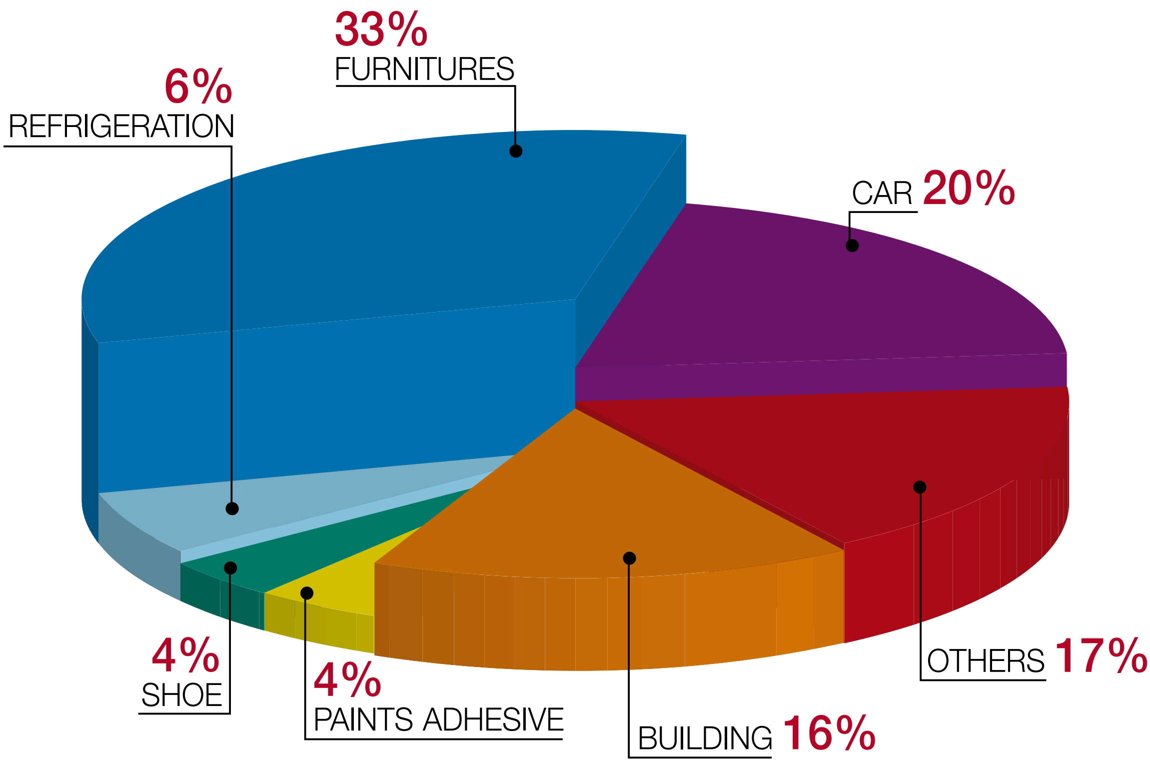
2002 *Olmo completes its LR (Low Resilience) range with a slabstock polyether viscoelastic foam called Casanova®.*

2003 *The line of moulded viscoelastic pillows Venice by Olmo® is introduced on the market.*

2008 *Olmo implements the first Lympha® foams which are produced with polyols from vegetable renewable resources.*

Worldwide polyurethane market

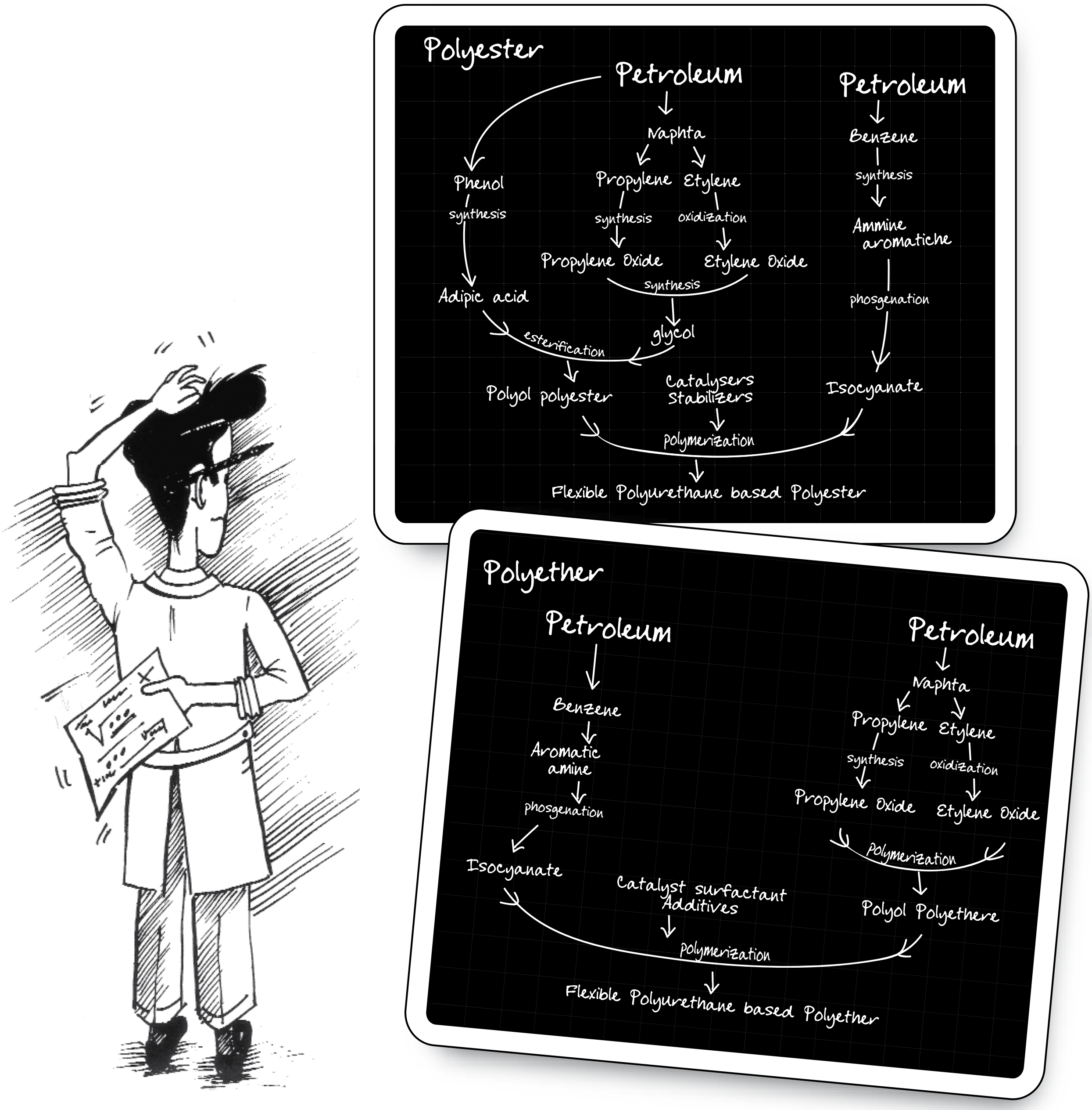
The grafic refers to the whole polyurethane family



- *FURNITURES*
- *CAR*
- *OTHERS*
- *BUILDING*
- *PAINTS ADHESIVE*
- *SHOE*
- *REFRIGERATION*

From Oil
to Polyurethane Foam

The following tables give a brief description of the main production processes. Besides the main raw materials isocyanates and polyols some others chemical products are necessary like stabilizers, surfactants, catalysts, dyes and propellants. They improve the quality of the final products and allow to obtain PU-foams with a wide range of density, softness, mechanical resistance, elongation and elasticity.

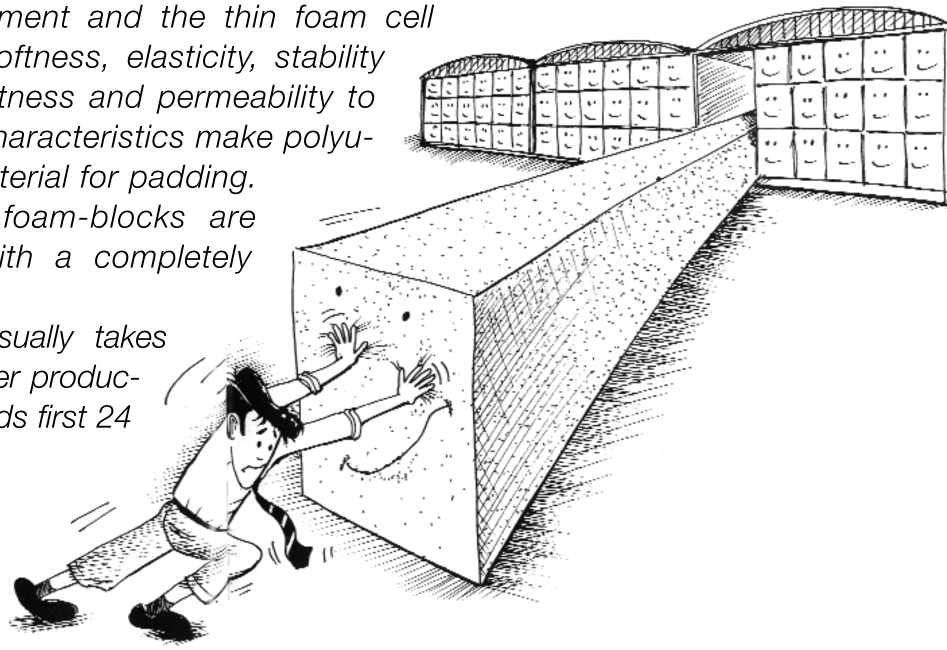


Production of Polilatex® and Elast® foams

Each component is directly taken from the storage tanks by high pressure pumps.
The dosage accuracy is very important in this critical phase in order to guarantee a uniform product. At **Olmo** *the input of each component is controlled by high precision instruments in real time and the values are constantly recorded.*
The components are mixed in a special head and uniformly distributed on a special paper belt placed on a conveyor. The initial liquid layer with a thickness of 0.5-1.5 cm expands and becomes a uniform slab which is more than one meter high.
The gas necessary for the expansion of the resin is developed during polymerization. This reaction is exothermic, i.e. heat is developed. The polymerization is achieved after few meters from the mixing head outlet. The formulation is properly adjusted so that a constant quality of the foam is granted.
The production of polyurethane foam is a chemical and physical process, therefore the following physical-synergic factors have to be taken into account:

- *Temperature of raw materials*
- *Gas released and dispersed in raw materials*
- *Atmospheric pressure and humidity*
- *Room temperature*

These parameters are additional elements that can affect product quality.
The honeycomb arrangement and the thin foam cell walls give the material softness, elasticity, stability and an extraordinary lightness and permeability to air and humidity. These characteristics make polyurethane foam an ideal material for padding.
At **Olmo** *the 60-meter-foam-blocks are automatically stocked with a completely computerized system.*
The further processing usually takes place at least 72 hours after production because the foam needs first 24 hours to stabilize.



Foam characteristics

GENERAL INFORMATION

Flexible PU-foams can be divided into two main families: polyether and polyester polyurethanes.

Polyether

- *Polilatex® conventional foams;*
- *Elast® HR foams, i.e. High Resilient;*
- *Casanova® low resilience viscoelastic foams.*

Polyester

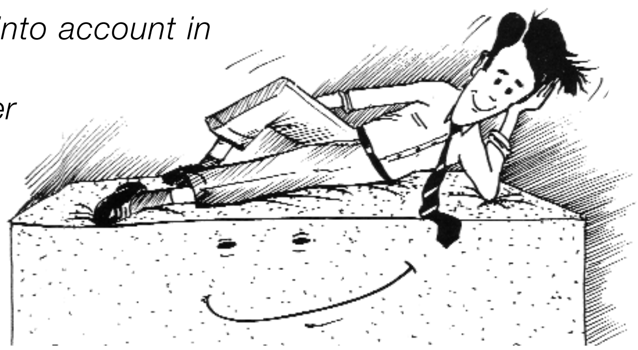
- *Conventional foams on polyester base;*
- *Porous foams similar to sea sponges.*

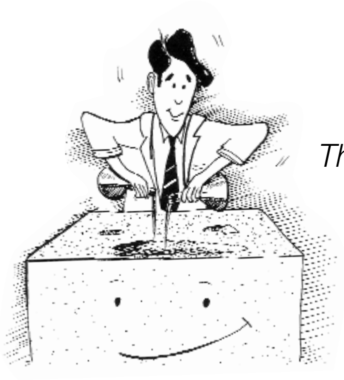
PHYSICAL CHARACTERISTICS

Here the main differences between PU polyether and polyester foams:

- *Polyether foams are very elastic, whereas polyester foams have a higher shock resistance;*
- *Polyester foams can be intrinsically flame-laminable;*
- *Polyester foams better resist to organic solvents;*
- *Polyether foams better resist to hydrolysis;*
- *Both foams have excellent heat insulation properties.*

The coefficient of thermal conductivity of soft polyurethane foam is about 0.04 Kcal/h. Moreover, the good sound absorption values at medium and high frequencies have to be pointed.
***Olmo's** Polyurethane foams are produced in different hardness and densities (from 20 to 110 kg/m3).*
Humidity absorbency is approximately 2% (at 90% of air relative humidity). The humidity absorbency depends on the molecular structure of the foam and may vary during the production cycle. Dynamic and static stress soften both polyether and polyester foams, whereas polyester is more deformable but less lacerable.
The following rule can be take into account in optimal processing conditions: the higher the density, the lower the deformability.

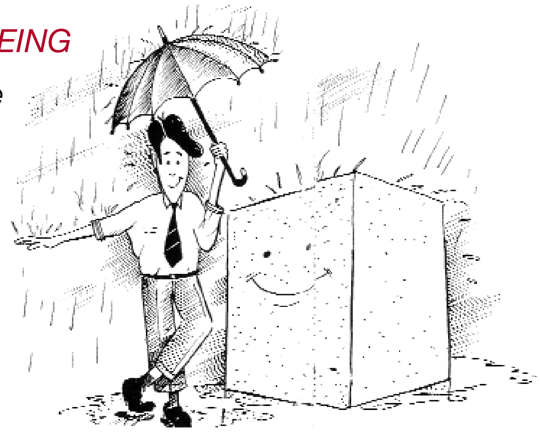




RESISTANCE TO CHEMICAL AGENTS

The tables on page 15/18 report the behaviour of polyurethane foams versus different chemical agents. Polyether-based foams have a good resistance to acidic and alkaline media whilst polyester-based foam better resist to almost all organic solvents.

HYDROLYSIS-INDUCED AGEING



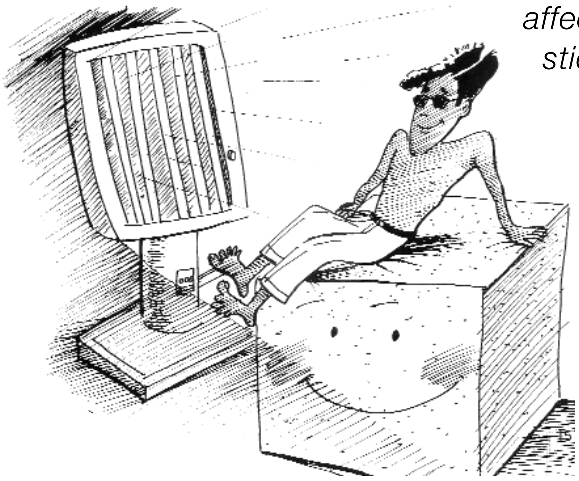
The term hydrolysis refer to the scission of a molecule when it comes in contact with water. The humidity contained in the air condensates into water and may give rise to hydrolysis. The relative humidity of air increases by raising the temperature. Polyester-based foams resist less to hydrolysis compared with polyether-based foams.

OXIDATION-INDUCED AGEING

Both polyether and polyester foams are oxygen-resistant.

LIGHT-INDUCED AGEING

Polyurethane foams become yellow by effect of the light (both daylight and artificial light). The change in colour is due to the oxidation of specific molecular groups contained in the foam. The yellowing caused by light is lower in polyester foam than in polyether one. The heavier the foam, the smaller the colour change; however, this does not affect the physical-mechanical characteristics of the foam.



PHYSIOLOGIC CHARACTERISTICS

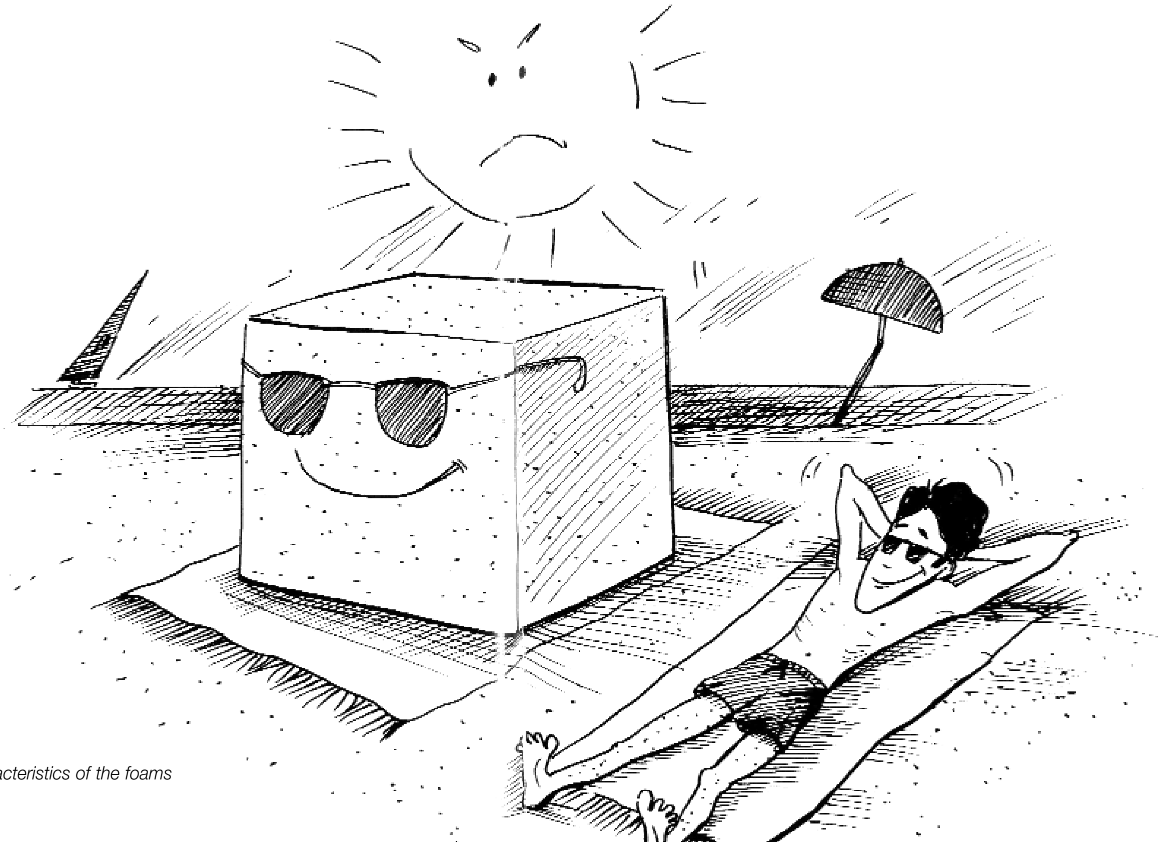
*Polyurethane foam causes neither dermatosis nor skin irritation.
Specific tests showed that polyurethane foam does not cause damage even if accidentally swallowed.*

RESISTANCE TO MICROBES

*Thorough tests showed that in rooms with a high humidity certain moulds and bacteria may damage the foam.
To avoid this drawback, bacteriostatic substances such as Sanitized®-additives can be added to the foam.*

THERMAL STABILITY

*Polyurethane foam can be used at temperatures up to 100°C without substantial change of the physical properties.
Wash cycles at 90°C obviously mean a big thermal, mechanical and chemical stress, but quality materials resist with only slight changes in volume.
If the foams contain flame retardants it has to be considered that these additives tend to migrate. Therefore their fire resistance characteristics can be strongly affected.*



GAS EMISSION FROM POLYURETHANE COMBUSTION

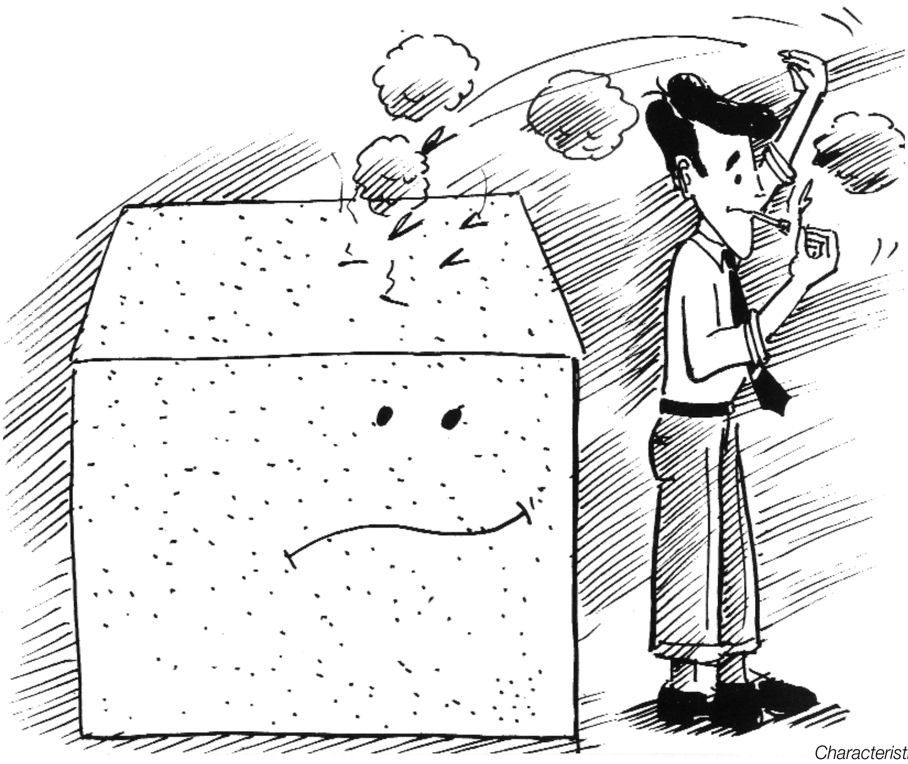
As well other natural products (wood, wool and leather), carbon monoxide, nitric oxide and carbon dioxide are released during foam combustion. However, the amount of harmful substances released during foam combustion does not exceed that of the above mentioned natural materials.

CHLORO-FLUORO-HYDROCARBONS (CFC)

Olmo polyurethane foams are entirely produced without chloro-fluoro-hydrocarbons (CFC), sign that the products are environmental-friendly.

INFLAMMABILITY OF POLYURETHANE FOAM

Polyurethane foam is inflammable like the majority of organic materials. The use of additives and raw materials specifically modified during foam processing helps to reduce inflammability. Olmo products Elast®, Elast® Performance FR, Polilatex® RC, Polilatex® CM, Polilatex® HT, Ecoelast *meet the highest international standards concerning fire prevention.*



Resistance
of PU-Polyether to chemical agents

Nr.	Chemical agent	Concentration	Tensile Strength		Compression set	Compression Load Deflection	Volume variation		Notes
			humid	dry			humid	dry	
1	Acetone		◕	◔	◑	◑	◕	○	
2	Ammonium hydroxide	10%	○	○	◔	○	◔	○	
3	Ammonium hydroxide	2%	○	○	◔	○	◔	○	
4	Formic acid	conc.		◕	◕	◕	●	●	
5	Aniline		●	◕	◕		●		Practically destroyed
6	Ethyl alcohol conc.	conc.	◑	◔	◑	◑	◑	○	
7	Ethyl alcohol	50%	◑	◔	◔	◔	◔	○	
8	Ethyl acetate		◕	◔	◔	◔	◕	○	
9	Ethyl chloride		◕	◔	◕	◑	◕	○	
10	Ether		◔	◔	◔	◔	◑	○	
11	Gasoline with 10% Benzol		◑	◔	○	◔	◑	◔	
12	Benzol		◕	○	◔	◑	◕	○	
13	Clorophen A 60		◕	◑			◑	◑	
14	Chlorobenzene		◕	◔	◑	◑	◕	○	
15	Glycolmonoethylether		◕	◔	◕	◑	◕	○	
16	Chromic acid	10%	●						
17	Dekalin		◑	◕	◕	◔	◑	◔	
18	Desavin		◕	◕	○	◕	◑	◑	
19	Dimethylformamide		●						
20	Dibutylphtalate		◕	◕	○	◕	◑	◑	
21	Diesel DIN 51601		◕	◑	○	◔	◔	◔	
22	Glacial acetic acid		◑	◔	◕	◕	●	○	Yellowing
23	Diluited acetic acid	5%	○	○	○	◔	○	○	
24	Diluited hydrofluoric acid	5%	○	○	◔	◔	○	○	
25	Formaldehyde	30%	◔	◔	○	○	○	○	Light yellowing
26	Formaldehyde	1,5%	○	○	○	○	◔	○	Light yellowing
27	Glutolina		◔	◔	○	○	○	○	
28	Timber oil		◑	◕	◕	◑	◔	◔	Strong yellowing
29	Potassium hydroxide	conc.	◑	◕	◑	◕	○	○	
30	Potassium hydroxide	10%	○	○	◔	◔	○	○	
31	Slaked lime (satured)	saturated	◔	◔	○	○	○	○	
32	M. cresol		●	◔	○	◔	◔	○	
33	Animal oil		○	◔	○	◔	◔	◔	
34	Linseed oil		◔	○	○	◔	◔	○	Strong yellowing
35	Lignin		◑						
36	Seawater		○	◔	○	○	◔	○	
37	Methylethylketone		◕	◔	◕	◑	◑	○	
38	Mineral oil		○	◔	○	○	◔	○	
39	Smooth caustic soda	conc.	○	◔	◑	◑	○	○	
40	Smooth caustic soda	10%	○	◔	◔	◔	○	○	
41	Smooth caustic soda	1%	○	○	◔	◔	○	○	
42	Sodium hypochlorite	1%	◔	◔	◑	◔	◔	○	Browning

TENSILE STRENGTH:
- ○ Unchanged
- ◔ Worsening of 10-30%
- ◑ Worsening of 30-50%
- ◕ Worsening of more than 50%
- ● Sample destroyed

COMPRESSION SET:
- ○ Unchanged
- ◔ Increase of 2-3 times
- ◑ Increase of 3-5 times
- ◕ Increase of more than 5 times
- ● Sample destroyed

NOTE

The information contained in these tables has to be considered as indication. The foams have to be tested in the real usage conditions.

Nr.	Chemical agent	Concentration	Tensile Strength humid	Tensile Strength dry	Compression set	Compression Load Deflection	Volume variation humid	Volume variation dry	Notes
43	Sodium chloride	saturated	○	◔	○	○	○	○	
44	Sodium chloride	20%	○	○	○	○	○	○	
45	Sodium chloride	5%	○	○	○	○	○	○	
46	Sodium carbonate	20%	○	◔	◔	◔	○	○	
47	Sodium carbonate	2%	○	◔	◔	◔	○	○	
48	Wetting agents (nekal BX)	2%	◔	○	◔	◔	◔	◔	
49	Nitrobenzene		◕	◔	◑	◑	◕	◑	Yellowing
50	Oleic acid		◕	◕	◕	○	◕	◔	Strong yellowing
51	Paraffin oil		○	◔	○	◔	◔	○	
52	Phenol solution	8%	◕	◕	◕	◕	◕	◑	
53	Phosphoric acid	conc.	●						
54	Phosphoric acid	10%	○	◔	◑	◔	◔	○	
55	Phosphoric acid	2%	○	○	○	○	○	○	
56	Hydrochloric acid	conc.	●						
57	Hydrochloric acid	10%	◔	◑	◕	◑	○	○	
58	Hydrochloric acid	5%	○	◔	◔	◔	○	○	
59	Nitric acid	conc.	●						
60	Nitric acid	10%	●						
61	Sulfuric acid	conc.	●						
62	Sulfuric acid	10%	○	◑	◕	◑	○	○	
63	Sulfuric acid	3%	○	○	◔	○	○	○	
64	Sweat solution DIN 53957	alkaline	◔	◔	◔	◔	◔	○	
65	Sweat solution DIN 53957	acid	◔	◔	◔	◔	◔	○	
66	Carbon disulphide	2%	◔	○	◔	◔	◑	○	
67	Soap solution	10%	◔	◔	○	○	○	○	
68	Sodium carbonate solution		○	◔	○	◔	◔	○	
69	Seed oil		◑	◑	○	◑	○	○	
70	Carbon tetrachloride		◕	◔	◔	◑	◕	○	Yellowing
71	Gasoline DIN 51636		◑	◔	◔	◔	◑	◔	
72	Turpentine oil		◑	◑	◔	◔	◑	◔	
73	Toluene		◕	○	◔	◑	◕	○	
74	Mixture of volatile: 50% gasoline, 40% benzene, 10% ethanol		◕	◔	◕	◑	◕	○	
75	Trichloroethylene		◕	◔	◕	◑	◕	○	
76	Tricresylphosphate		◕	◕	◔	◕	◑	◑	
77	Distilled water		◔	○	○	○	○	○	
78	Hydrogen Peroxide	10%	○	○	◔	◔	○	○	Light yellowing
79	Hydrogen Peroxide	3%	○	○	◔	◔	○	○	Light yellowing
80	Softening		◔	◑			◔	◔	
81	Xylene		◕	◔	◔	◑	◕	○	
82	Citric acid (10%)	10%	○	○	◔	◔	○	○	

COMPRESSION LOAD DEFLECTION:

○ Unchanged
◔ Decrease of 10-20%
◑ Decrease of 20-50%
◕ Decrease of more than 50%
● Sample destroyed

VOLUME VARIATION:

○ Swelling of 0-5%
◔ Swelling of 5-30%
◑ Swelling of 30-100%
◕ Swelling of 100-200%
● Swelling of more than 200%

Resistance
of PU-Polyester to chemical agents

Nr.	Chemical agent	Concentration	Tensile Strength		Compression set	Compression Load Deflection	Volume variation		Notes
			humid	dry			humid	dry	
1	Acetone		◕	○	◑	◔	◑	○	
2	Ammonium hydroxide	10%	◔	◔	◔	◔	○	○	
3	Ammonium hydroxide	2%	◔	○	◔	◔	○	○	
4	Formic acid	conc.		◕	◕		●		
5	Aniline		◕	◔	◕	◕	◕	◔	
6	Ethyl alcohol conc.	conc.	◑	○	◑	◔	◔	○	
7	Ethyl alcohol	50%	◑	○	◑	◔	◔	○	
8	Ethyl acetate		◕	◔	◑	◔	◑	○	
9	Ethyl chloride		◕	○	◕	◑	◕	○	
10	Ether		○	○	◔	○	◔	○	
11	Gasoline with 10% Benzol		○	○	◑	○	◔	○	
12	Benzol		◕	◔	◔	◔	◑	○	
13	Clorophen A 60		◑	◑			◔	◔	
14	Chlorobenzene		◕	○	◑	◑	◑	○	
15	Glycolmonoethylether		◕	◔	◔	◑	◑	○	
16	Chromic acid	10%	●						
17	Dekalin		◕	◔	◑	◔	○	○	
18	Desavin		◑	◕	○	◕	◑	◑	
19	Dimethylformamide		●						
20	Dibutylphtalate		◔	◑	○	◑	◔	◔	
21	Diesel DIN 51601		◔	◔	◔		◔	○	
22	Glacial acetic acid		◔	◔	◕	◑	◕	○	Light yellowing
23	Diluited acetic acid	5%	◔	◔	◑	◔	○	○	
24	Diluited hydrofluoric acid	5%	◕	◕	◕	◕	○	○	
25	Formaldehyde	30%	○	◔	○	◔	○	○	Light yellowing
26	Formaldehyde	1,5%	○	○	○	◔	○	○	Light yellowing
27	Glutolina		○	○	○	◔	○	○	
28	Timber oil		○	◔	○	◔	○	○	Yellowing
29	Potassium hydroxide	conc.	●						
30	Potassium hydroxide	10%	●						
31	Slaked lime (satured)	saturated	◕	◕	◑	◕	○	○	
32	M. cresol		●						
33	Animal oil		○	○	○	○	○	○	
34	Linseed oil		○	○	◑	○	○	○	Yellowing
35	Lignin		○	○	◔	○	○	○	
36	Seawater		○	○	◔	◔	○	○	
37	Methylethylketone		◕	○	◑	◑	◑	○	
38	Mineral oil		○	○	◑	○	○	○	
39	Smooth caustic soda	conc.	●						
40	Smooth caustic soda	10%	●						
41	Smooth caustic soda	1%	◕	◕	◑	◑	○	○	
42	Sodium hypochlorite	1%	◑	◔	◑	◔	○	○	Browning

TENSILE STRENGTH:
- ○ Unchanged
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- ◑ Worsening of 30-50%
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COMPRESSION SET:
- ○ Unchanged
- ◔ Increase of 2-3 times
- ◑ Increase of 3-5 times
- ◕ Increase of more than 5 times
- ● Sample destroyed

NOTE

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Nr.	Chemical agent	Concentration	Tensile Strength		Compression set	Compression Load Deflection	Volume variation		Notes
			humid	dry			humid	dry	
43	Sodium chloride	saturated	○	○	◔	◔	○	○	
44	Sodium chloride	20%	○	○	◔	◔	○	○	
45	Sodium chloride	5%	○	○	◔	◔	○	○	
46	Sodium carbonate	20%	◔	◔	◔	◔	○	○	
47	Sodium carbonate	2%	◔	○	◔	◔	○	○	
48	Wetting agents (nekal BX)	2%	◔	○	◑	○	◔	○	
49	Nitrobenzene		◕	○	◑	◑	◑	◔	Yellowing
50	Oleic acid		◔	◔	◔	◔	◔	○	
51	Paraffin oil		○	○	○	○	○	○	
52	Phenol solution	8%	◕	◕	◕	◕	◕	◑	
53	Phosphoric acid	conc.	●	◔	◔	◑	○	○	
54	Phosphoric acid	10%	○	◔	◔	◔	○	○	
55	Phosphoric acid	2%	○						
56	Hydrochloric acid	conc.	●						
57	Hydrochloric acid	10%	●						
58	Hydrochloric acid	5%	●						
59	Nitric acid	conc.	●						
60	Nitric acid	10%	●						
61	Sulfuric acid	conc.	●						
62	Sulfuric acid	10%	●						
63	Sulfuric acid	3%	◔	◑	◕	◑	○	○	
64	Sweat solution DIN 53957	alkaline	◔	◔	◔	◔	◔	○	
65	Sweat solution DIN 53957	acid	◔	○	◔	◑	◔	○	
66	Carbon disulphide	2%	○	○	◔	◔	◔	○	
67	Soap solution	10%	○	○	◔	◑	○	○	
68	Sodium carbonate solution		○	◔	◔	◔	◔	○	
69	Seed oil		○	○	◔	◔	○	○	
70	Carbon tetrachloride		◔	○	◔	◔	◔	○	
71	Gasoline DIN 51636		○	○	◑	○	◔	○	
72	Turpentine oil		◔	◔	◔	◔	◔	○	
73	Toluene		◕	◔	◔	◔	◑	○	
74	Mixture of volatile: 50% gasoline, 40% benzene, 10% ethanol		◔	◔	◔	◑	◑	○	
75	Trichloroethylene		◕	○	◕	◑	◑	○	
76	Tricresylphosphate		◕	◕	○	◕	◔	◔	
77	Distilled water		◔	○	○	○	○	○	
78	Hydrogen Peroxide	10%	○	○	◑	◔	○	○	Light yellowing
79	Hydrogen Peroxide	3%	○	○	◔	○	○	○	
80	Softening		◕	◕			◔	◔	
81	Xylene		◑	○	◔	◔	◔	○	
82	Citric acid (10%)	10%	◔	◔	◑	◔	○	○	

COMPRESSION LOAD DEFLECTION:

- ○ Unchanged
- ◔ Decrease of 10-20%
- ◑ Decrease of 20-50%
- ◕ Decrease of more than 50%
- ● Sample destroyed

VOLUME VARIATION:

- ○ Swelling of 0-5%
- ◔ Swelling of 5-30%
- ◑ Swelling of 30-100%
- ◕ Swelling of 100-200%
- ● Swelling of more than 200%

Test methods for assessing physical-mechanical properties

In order to assess the characteristics of foams, the following physical values are determined:

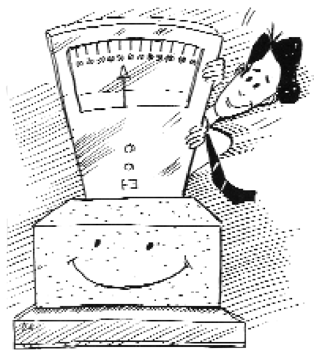
DENSITY

Density is the foam weight per volume unit and is expressed in g/l or kg/m3. After having cut the skin away, the sample block is cut into several layers perpendicular to the growth axis. The mean of their densities gives the density of the block. The following standard methods are used to assess density:

UNI 6349   ***DIN 53420***   ***ISO 1855***

TOLERANCE ± 5%

INDENTATION DEFLECTION

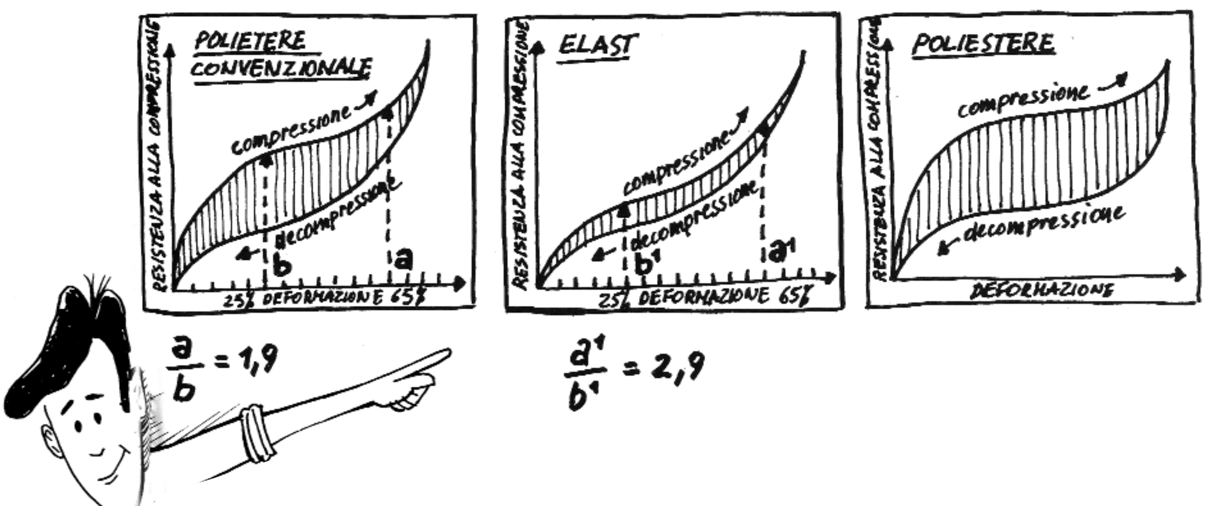


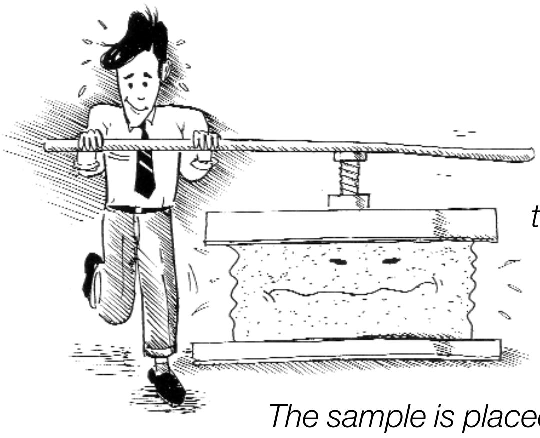
Indentation deflection or sag strength rate is the load that causes the sinking of an indentor (with specific dimensions and form) into the foam specimen for 25%, 40% and 65% of its thickness. The specimen, that is bigger than the indentor, is placed in the middle of the dynamometer's platform.The load is maintained for 30 seconds every time the specimen is compressed by 25, 40 and 65% of its thickness, then the sag resistance force is measured.The results are given in Newton (N), as 25, 40 and 65% sag strength or indentation deflection. The sag factor is the ratio between the indentation deflection at 65% and 25% and is a reliable index for assessing comfort. The higher the value, the higher the comfort. Conventional polyethers show sag factors around 1.9 whilst ELAST foams (i.e. High Resilience) around 2.9 (see pictures). The highlighted dashed section corresponds to hysteresis: the lower the hysteresis the higher the elasticity. The standard methods used to assess indentation are:

BS 4443 Pt.2 M.7   ***UNI 6353***

DIN 53576/B   ***ISO 2439***

TOLERANCE ± 15%





COMPRESSION LOAD DEFLECTION

Compression load deflection is the pressure (in Kilo Pascal=kPa) needed to compress the initial thickness of a specimen up to 40% by an indentor with specific dimension and form.
The specimen is a parallelepiped 100 x 100 x 50 mm; the sample is accurately measured and the area that undergoes the compression is determined.
The sample is placed in the middle of the instrument platform and is compressed up to 40% of its initial thickness. The required pressure is measured by the instrument.
The result is expressed in kPa.

kPa = 1000 Pa
kPa = 10,2 g/cm^2
kPa = 0,1 N/cm^2

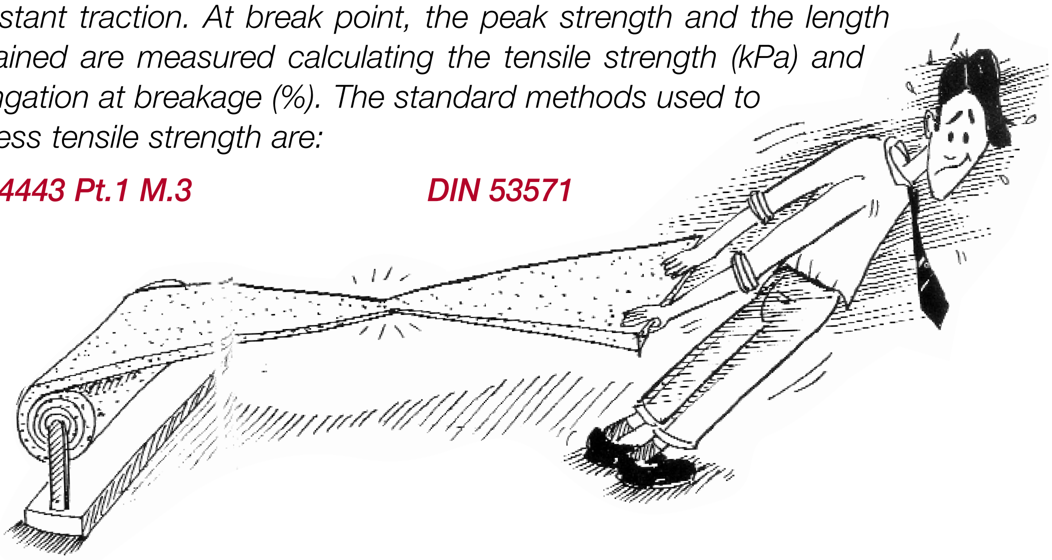
The standard methods used to assess compression load deflection are:

BS 4443 Pt.1 M.5
DIN 53577
TOLERANCE ± 15%
UNI 6351
ISO 3386

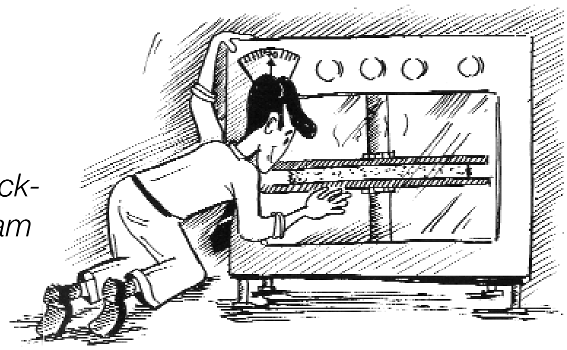
TENSILE STRENGTH AND ELONGATION AT BREAK

Tensile strength is given in kPa or kg/cm^2 and represents the ratio between the peak strength required to break the sample and the area of its transversal section.
Elongation at break is the percentage change between the initial length and the length at break. The specimen must be obtained by die cutting from sheets with a thickness of 10-15 mm.
The specimen is placed between dynamometer's terminals and undergoes a constant traction. At break point, the peak strength and the length obtained are measured calculating the tensile strength (kPa) and elongation at breakage (%). The standard methods used to assess tensile strength are:

BS 4443 Pt.1 M.3
DIN 53571



COMPRESSION SET

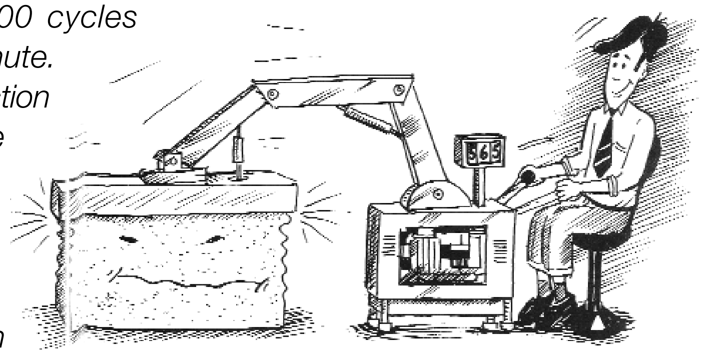


Compression set is the loss of thickness caused by compressing the foam under particular conditions.
The specimen is a parallelepiped with a square base and a thickness of 50 mm.
It's placed between two parallel plates and is compressed up to 50, 75 and 90% of its initial thickness. Then the sample it is placed into an oven with air circulation at 70°C for 22 hours. Afterwards it is extracted from the compressing plates and left to rest for 30 minutes. The thickness is now measured.
The loss of thickness at 50, 75 and 90% compression is given in percentage.
The standard methods used to assess compression set are:

BS 4443 Pt.1 M.6A ***UNI 6352*** ***DIN 53572***

DYNAMIC FATIGUE

Dynamic fatigue is in percentage loss of thickness and compression load deflection of a sample after being compressed by 75% of its initial value for 75.000 cycles with a frequency of 60 cycles per minute.
First of all, compression load deflection and initial thickness of the sample are determined. After 75.000 compression cycles and a recovery time of 30 minutes, thickness and load compression deflection are measured again. The results are given in percentage loss of thickness and percentage loss of compression load deflection.
The method to assess dynamic fatigue is:

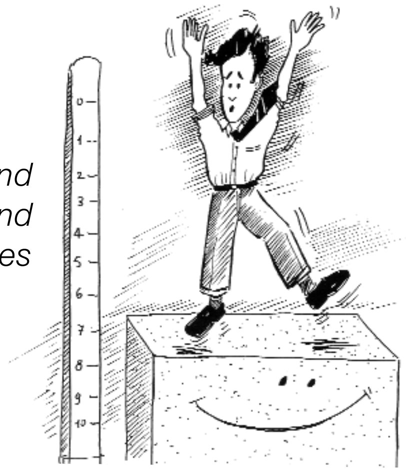


UNI 6356 Pt.2

RESILIENCE

Resilience is the ratio between rebounding and starting height of a ball with preset dimensions and weight, when falling from a given height, bounces after having perpendicularly hit the material surface considered.
The method to assess resilience is:

UNI 6357



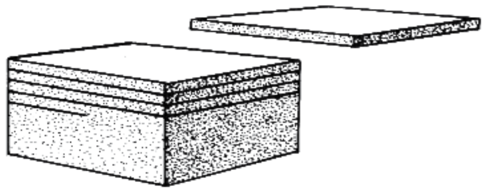
AIR PERMEABILITY

Resilience and hardness of a foam also depend on the size and opening of the cells.
Other values being equal, larger and more opened cells, (i.e. connected to one another), are needed to obtain more elastic foams.
A particular instrument measures the flow difficulty (load loss) of the air through a foam sample.
Small and closed cells cause substantial load losses, with subconsequent low air permeability. Large and open cells cause only a slight load loss which means a high degree of air permeability.

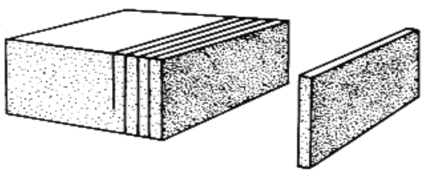
Processing of flexible PU-foams

Soft polyurethane foam is automatically cut with belt blades that are constantly sharpened. The main types of cut are shown below.

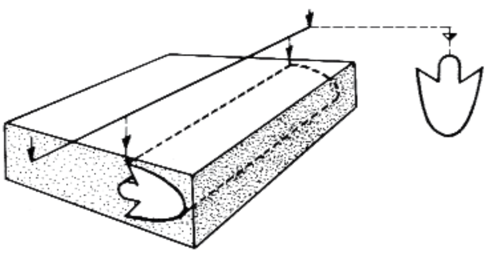
CUTTING TECHNIQUES



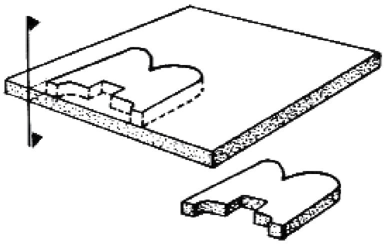
Horizontal cut



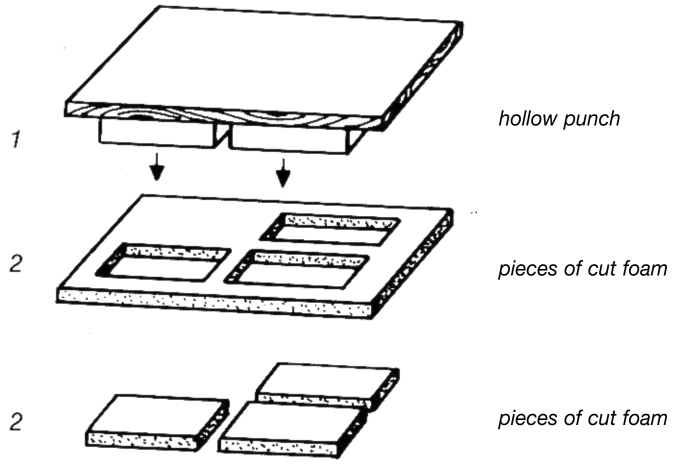
Vertical cut



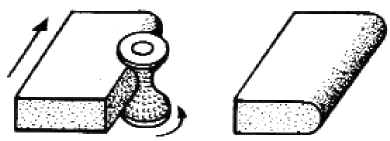
Shaped cut (horizontal)



Shaped cut (vertical)

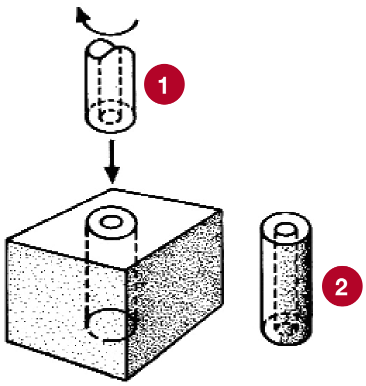


Die-cut



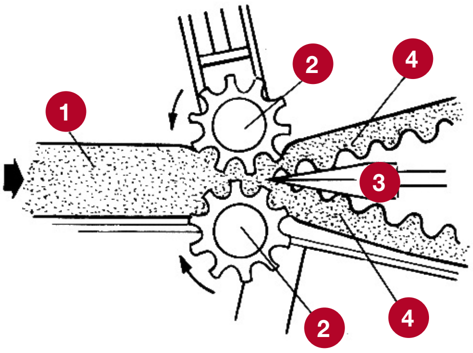
Milling

1. Piercing utensil
2. Finished products



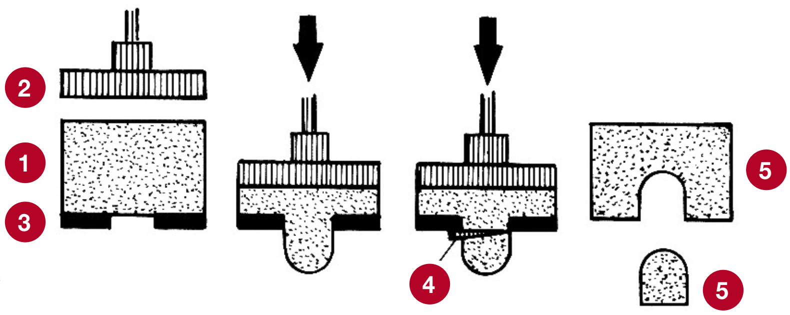
Reaming

1. Foam sheet
2. Rollers profiling
3. Blade
4. Finished slabs



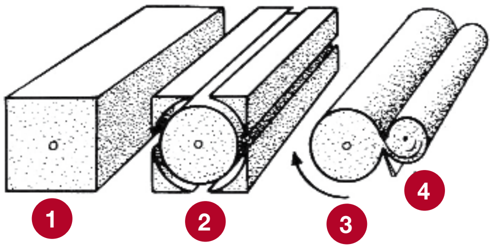
Cut for continuous profiling

1. Foam
2. Press
3. Profiling utensil
4. Blade
5. Finished article after profiling



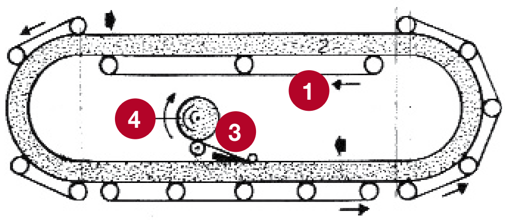
Cut for discontinuous profiling

1. Slab stock
2. Pre-cut
3. Peeling
4. Blade



Rools (peeling)

1. Conveyor belt
2. Foam
3. Blade
4. Foam rolls after cutting



Rools (loop)

Other type processing

Flame lamination (special glueing process) consists in melting by flame a low thickness of the PU-foam that acts as a perfect glue for fabrics and/or other materials.
Glue coating consists in glueing the polyether foam with fabrics or other materials through an appropriate glue.