3. PHYSICAL TESTING

As explained in the previous part of this book, the micro structure of polyurethane foams is not homogeneous. Two cells are never completely identical, and the tri-dimensional assembly of the cells is purely random, leading to a wide dispersion and specification range of the physical and mechanical properties.

Therefore, the key issue of the quality of Technical Foams is to guarantee that the foam can be used for a final use function and for its converting process, based on the conformity to key parameters and not to the secondary properties.

The physical testing of Technical Foams is classified in four groups :

1. **First group : The Density :**

   The density of the foam - which is an "apparent density", since the foam contains more air than material - is a key parameter which influences all the other parameters.
   On a general point of view, the higher the density, the better the physical and mechanical properties. But, the higher the density, the higher the price ...
   Therefore, most of the foams are produced at the lowest possible density, which can still guarantee the quality of its use and function.

2. **Second group : The Mechanical Properties :**

   They are defined as the behaviour of the foams against external force like compressing, tearing, ... Most of the mechanical properties are important for the processing of the transformation and converting of the foam into finished products.

3. **Third group : Functional properties :**

   They are defined as the performances of the foam in its final use and application : air thightness, acoustical performances, antistatic properties, ...

4. **Fourth group : Environmental and external requirements :**

   They are defined as the "conditions" of the use of the foam for a given application in given conditions. Low fogging, low flammability, ageing test, ... are typical examples.

The list of physical testing of Technical Foams is given below :

Group 1
Density

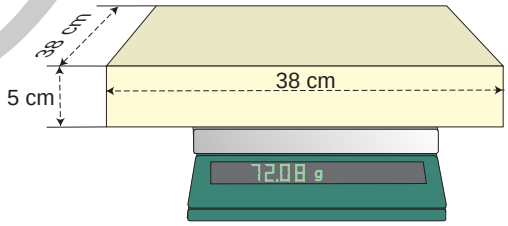
Group 2
Compression Deflection Hardness (CDH)
Indentation Load Deflection (ILD)
Ultimate Elongation (ER) and Tensile Strength (RR)
Tear Resistance (TR)
Clickability
Compression Set (CS)

Group 3
Cell Diameter
Cell Count
Cell Structure of Sponges
Pressure Drop
Air Resistance (Acoustics) (Rs)
Air Resistance (Sealing)
Air Permeability
Water tightness
Water absorption
Electrical Resistivity
Die Cut Weldability

Group 4
Fogging by Reflection
Fogging by Gravimetry
Blue scale colour fastness
Flammability : MVSS 302
Flammability : UL 94 horizontal
Flammability (Epiradiateur)

3.1.1. Density (D) :

- **Definition :** Weight per volume unit. The result is an apparent density since air is included in the volume.
- **Equipment and/or method :** Balance
- **Formula :** Density (D) (kg/m^3) = $\frac{\text{Weight (W) (kg)}}{\text{Volume (V) (}m^3\text{)}}$
- **Norm :** ISO 845

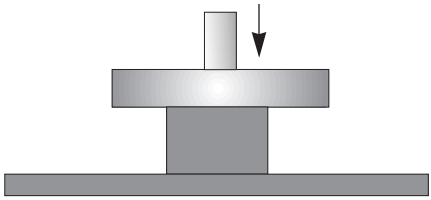


3.2.1. Compression Deflection Hardness (CDH) :

- **Definition :** The force required to compress the foam with a compression plate bigger than the sample (10 cm x 10 cm x 5 cm).
- **Equipment :** Universal tester
- **Formula :** $\text{CDH (kPa)} = \frac{\text{Force (N)}}{\text{Surface of the samples (cm}^2\text{)}} \times 10$
- **Norm :**

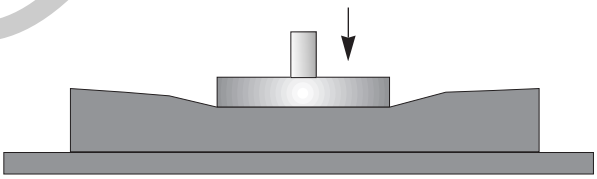
	ISO 3386/1 or DIN 53577	Renault 1003	Rect. (*) SS/T.006.0	Rect. (*) SS/T.005.3
Precompression	3 x 70 %	4 x 75 %	No	No
Measurement	25 % 40 % 60 %	25 % 50 % 65 %	25 % 40 % 65 %	- 40 % -

(*) Specific for S.R. foams



3.2.2. Indentation Load Deflection (ILD) :

- **Definition :** The force required to compress the foam with a compression plate (diameter : 20 cm) smaller than the sample (38 cm x 38 cm x 5 cm)
- **Equipment :** Universal tester.
- **Formula :** Results are expressed in Newton (N)
- **Norm :** ISO 2439 B or BS 4443, part 2, method 7



3.2.3. Ultimate Elongation (ER) and Tensile Strength (RR) :

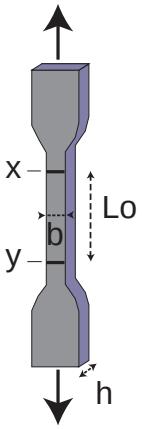
- **Definition :** By extension, measurement of elongation at the rupture point (ultimate elongation) and maximum strength reached at this point (tensile strength).
- **Equipment :** Universal tester.
- **Formula of ultimate elongation (ER) :** $ER\ (\%) = \frac{L1 - Lo}{Lo} \times 100$

  Lo = initial length (distance xy in cm)
  L1 = length at rupture point (cm)

- **Formula of tensile strength (RR) :** $RR\ (kPa) = \frac{F1}{b \times h} \times 10$

  F1 = the force at rupture point (N)
  b = width of the sample (cm)
  h = thickness of the sample (cm)

- **Norm :** ISO 1798

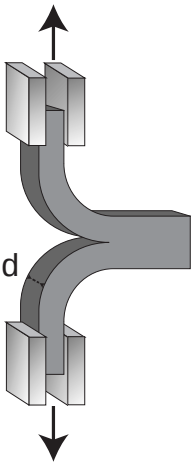


3.2.4. Tear Resistance (TR) :

- **Definition :** Determination of the maximum forces at which the tear rupture takes place.
- **Equipment :** Universal tester
- **Formula :** $TR\ (N/cm) = \frac{Force\ (N)}{d}$

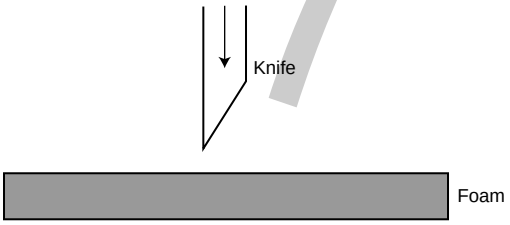
  d = width of the sample in cm

- **Norm** : ASTM D 3574/F



3.2.5. Clickability :

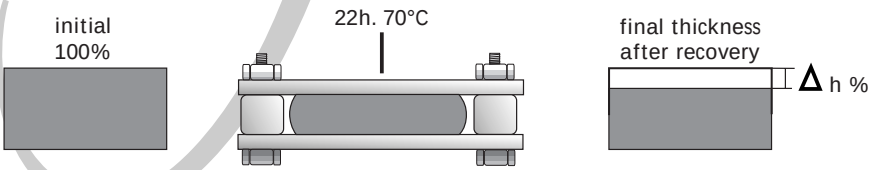
- **Definition :** Evaluation of the edges deformation after die-cutting.
- **Equipment :** Normalized die-cutter
- **Evaluation :** Class 1 : Thickness loss of the edge < 10 %
  Class 2 : Thickness loss of the edge between 10 and 30 %
  Class 3 : Thickness loss of the edge > 30 %
- **Norm :** Recticel SS/T.012.0



3.2.6. Compression Set (CS) :

- **Definition :** Loss of thickness after compression in given conditions of time, temperature and humidity.
- **Formula :** $CS\ (\%) = \frac{H_O - H_1}{H_O} \times 100$

  H_O = original thickness (mm)
  H1 = thickness after compression
- **Norm :** ISO 1856/A (compression at 50, 75 or 90 % ; 22 h - 70°C ; measurement 30 minutes after decompression).



3.3.1. Cell diameter : Visiocell

See part 4

- **Norm :** Recticel SS/T.013.4

3.3.2. Cell Count :

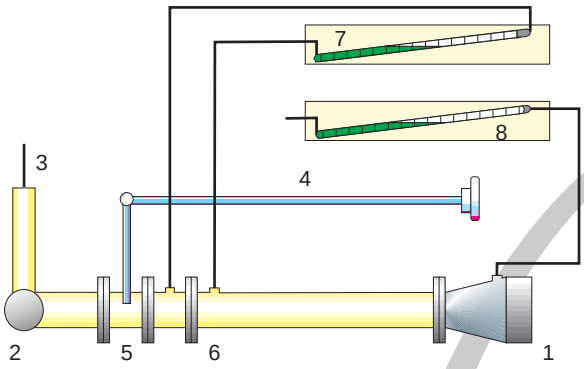
- **Definition :** Determination of the number of pores per inch (ppi) by visual comparison with reference sample or by 3 point measurement of the cell size.
- **Equipment :** Microscope.
- **Formula :** Results are given in PPI.
- **Norm :**
  - Visual comparison : Recticel SS/T.013.0
  - Microscope : by 3 point measurement : Recticel SS/T.013.3

3.3.3. Cell structure of sponges :

- **Definition :** Determination of the double cell structure of sponges by visual comparison with reference samples.
- **Formula :** Classification is done by sponges grade, namely :
  - EF = extra fine
  - F = fine
  - M = Medium
  - C = Coarse
  - EC = extra coarse
- **Norm :** Recticel SS/T.013.2

3.3.4. Pressure Drop :

- **Definition :** Measurement of the pressure drop at a fixed air flow speed. This measurement was previously used for cell count measurement.
- **Equipment :** Specific pressure drop device.
- **Formula** : The evaluation is done by direct measurement of the pressure drop in inch water column.
- **Norm :** Recticel SS/T.013.1



1. Sample holder
2. Blower
3. Exhaust
4. Air flow adjustment
5. Slide valve
6. Aperture
7. Aperture manometer
8. Sample manometer

3.3.5. Air Resistance (Acoustics) (R) :

- **Definition :** Air flow resistance, calculated from the measurement by the air velocity to reach a pressure drop of 1 inch water column.

- **Equipment :** Specific device.

- **Formula :**

$$R\ (N.sec/m^3) = \frac{P \times 249{,}174}{V}$$

R = air resistance

P = pressure drop in inch of water

V = velocity (m/sec)

- **Norm :** Recticel SS/S.015.2

3.3.6. Air Resistance (Sealing) :

- **Definition :** Measurement of the air resistance at a fixed air flow through O-ring sample compressed at 75 %.

- **Equipment :** Specific device.

- **Formula :** Results are expressed in cm water column.

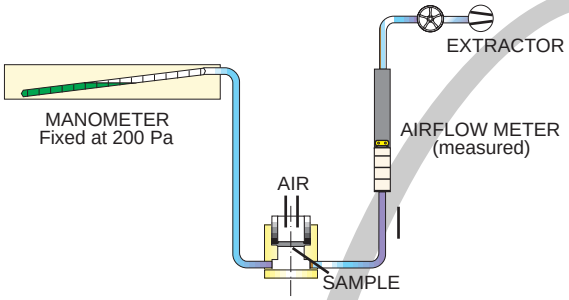
- **Norm :** Recticel SS/T.015.1.

3.3.7. Air Permeability :

- **Definition :** Measurement of the air flow through a sample at constant air resistance of 200 Pa for a test surface of 20 cm^2.
  Other air permeability methods can be correlated to this one.

- **Formula :** Results are expressed in liter/dm^2 min.

- **Norm :** DIN 53887.



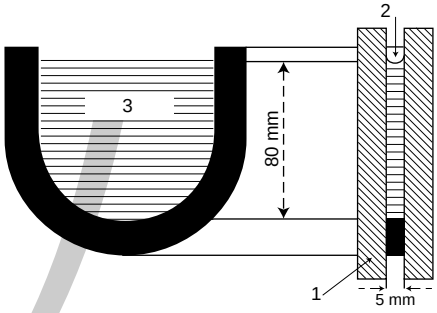
3.3.8. Water tightness :

- **Definition :** Measuring of the water sealing properties of U-shape sample, compressed at 50 % and variable water column level for a period of 24 hours.

- **Equipment :** Specific device

- **Formula :** Results are given in “Pass” or “Not Pass”, mentioning the water column level, the compression factor of the foam and the duration of the test.

- **Norm :** Recticel SS/T.020.2.



1. Acrylic plate
2. Sample
3. Water

3.3.9. Water absorption :

- **Definition :** Measurement of the absorption of water in a sample compressed and immerged in water for a given duration.

- **Equipment :** Specific device.

- **Formula :** - Absorption in weight (%) $W\% = \frac{W_1 - W_0}{W_0} \times 100$

W_1 = final weight (g)
W_0 = initial weight (g)

- **Absorption in volume (%) =** $V\% = \frac{W\% \times d}{1000}$

  d = density of the foam (kg/m³)
  Compression of sample, height of the water and duration of the test are reported.

- **Norm :** Recticel Method SS/T.019.0

3.3.10. Electrical Resistivity :

- **Definition :** Electrical resistance determined by measurement of the current or by the voltage drop.
- **Equipment :** Ohm-meter.
- **Formula :** The volume resistivity is expressed in Ohm.cm while the surface resistivity is expressed in Ohm.
- **Norm :** ASTM D 257

3.3.11. Die Cut Weldability :

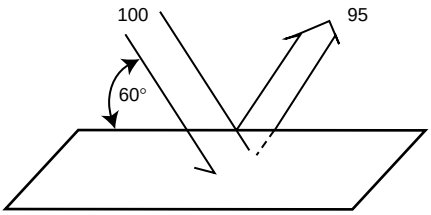
- **Definition :** Weldability of the edges by die-cutting
- **Formula :** The performance is classified as follows :

  - Class K : The complete contour remains sticky
  - Class KN : No sticking or partially sticking
  - Class K1 : Valid for SF 272 EW : partially sticking.

- **Norm :** Recticel SS/T.012.1

3.4.1. Fogging by Reflection :

- **Definition :** Measurement of the condensed volatiles on a glass plate by reflection of incident light.
- **Equipment :** Specific device.
- **Formula :** The reflected light is expressed in %
- **Norm :** DIN 75201/A



3.4.2. Fogging by gravimetry :

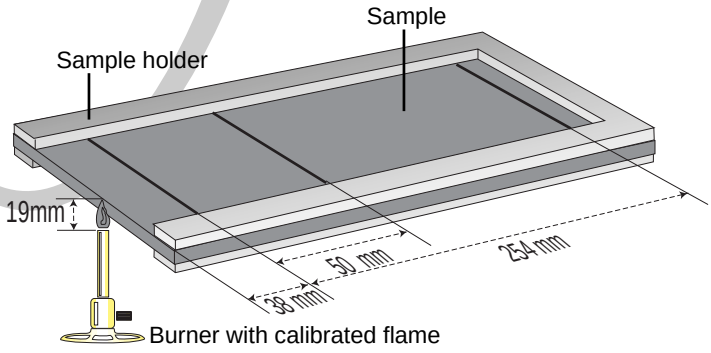
- **Definition :** Measurement of volatile components on an aluminium film by weight.
- **Equipment :** Specific device.
- **Formula :** The results are expressed in weight (mg)
- **Norm :** DIN 75201/B.

3.4.3. Blue scale colour fastness :

- **Definition :** Resistance to UV light, compared with a standard blue scale.
- **Equipment :** Weatherometer.
- **Formula :** The results are reported in the blue scale from 1 to 8.
- **Norm :** GM 9125 P

3.4.4. Flammability : MVSS 302 :

- **Definition :** Flame behaviour of the foam by measurement of the horizontal propagation of a calibrated flame after 50 seconds ignition.
- **Equipment :** Specific device.
- **Formula :** The results are reported in burning rate (mm/min) at a given thickness (mm).
- **Norm :** MVSS 302

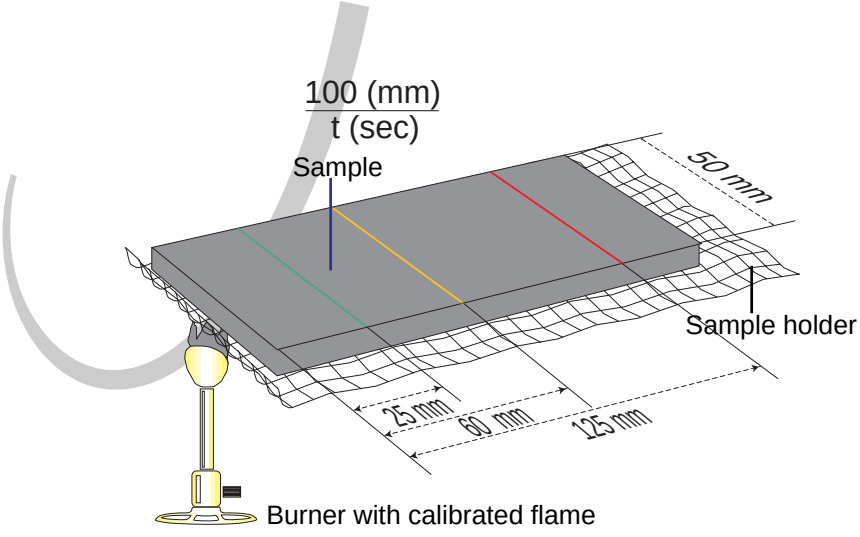


3.4.5. Flammability : UL 94 horizontal :

- **Definition :** Flame behaviour by the horizontal propagation of a calibrated foam after 1 minute ignition.
- **Equipment :** Specific device.
- **Formula :** The foam classified in 3 classes as follows :

Classification	Criteria
HF1	t max. 2 sec : 4/5 samples t max. 10 sec. 1/5 samples l max. 60 mm
HF 2	Idem HF 1 Ignition of cotton by falling drops acceptable
HBF	60 mm < l < 125 mm or l = 125 mm ; v < 40 mm/min over a distance of 100 mm with v (mm/min) = $\frac{100\ mm}{t(s)} * 60$

- **Norm :** UL 94 (Underwriters Laboratory)



3.4.6. Flammability (Epiradiateur) :

- **Definition :** Behaviour of the foam irradiated by a radiator of 500 W during 20 minutes.

- **Equipment :** Specific device.

- **Formulation :** Index $Q = \frac{\sum h}{ti \times \sqrt{\Delta t}} \times 100$

  ti = ignition time
  $\sum h$ = sum of height of the flames
  Δt = burning time

  The foam is classified as follows :

  - M1 for $Q < 2.5$
  - M2 for $2.5 <= Q < 15$
  - M3 for $15 <= Q < 50$
  - M4 for $50 <= Q$

- **Norm :** NFP 92-501