

# THERMAL PROPERTIES

## FOR DENSITIES OF 31, 51 & 71

PROPERTIES	UNITS	31	51	71	STANDARD
Dimensional stability under heat	°F	356	356	356	DIN 53424
	°C	180	180	180	
Coefficient of linear thermal expansion*	K <sup>-1</sup>	3.7 x 10 <sup>-5</sup>	3.3 x 10 <sup>-5</sup>	3.5 x 10 <sup>-5</sup>	ASTM D 696-70
	n./in./°F	2.3	2.1	2.2	
Thermal conductivity*	BTU in./ ft <sup>2</sup> h °F	0.215	0.201	0.208	ASTM C 177-63
	(W/mk)**	(0.031)	(0.029)	(0.030)	

\* Tested at 68 F° (20° C)

\*\* 1 W/mK = 0.86 kcal/m h deg.

## DIMENSIONAL STABILITY UNDER HEAT

Normally the ‘dimensional stability under heat’ of a product is adequately described by the practical requirements made on its strength, weight stability and dimensional stability.

The following tables therefore show the changes in weight, volume and linear dimensions of ROHACELL specimens kept in air at different temperatures for 30 days. The measurements were taken, immediately after the specimens had cooled down from the air temperature at which they had been kept.

PROPERTIES		31	51	71
STORAGE TEMPERATURE	°F	212   248   320	212   248   320	212   248   320
	°C	100   120   160	100   120   160	100   120   160
CHANGE IN WEIGHT %		-3.3   -4.4   -5.2	-4.0   -5.1   -6.1	-3.7   -4.2   -6.0
CHANGE IN LENGTH %		-0.8   -1.0   -1.6	-1.0   -1.4   1.8	-0.8   -1.0   1.9
CHANGE IN VOLUME %		-1.7   -3.2   -4.2	-2.3   -3.9   -4.8	-2.3   -3.0   -3.3

Table 2: Changes in weight and dimensions of ROHACELL 31, 51 and 71 after being kept at different temperatures for 30 days.

PROPERTIES		31	51	71
STORAGE TEMPERATURE	°F	212   248   320	212   248   320	212   248   320
	°C	100   120   160	100   120   160	100   120   160
CHANGE IN WEIGHT %		0   -1.2   -1.6	-0.2   -0.6   -2.5	-0.3   -0.9   -2.9
CHANGE IN LENGTH %		0   -0.2   -1.2	0   -0.4   -1.3	-0.2   -0.4   -1.5
CHANGE IN VOLUME %		-0.1   -0.2   -2.7	-0.1   -1.1   -3.7	-0.5   -1.3   -2.0

Table 3: Changes in weight and dimensions of ROHACELL 31, 51, 71 after storage as shown in table 2, followed by keeping under standard conditions (73.4 °F, 23 °C, 50% r.h.) until the weight was approximately constant.

## LINEAR THERMAL EXPANSION

The linear thermal expansion of ROHACELL is unusually low for a plastic material.

TEMPERATURE °F (°C)	ROHACELL 31 IN./IN. °F (K <sup>-1</sup> · 10 <sup>-5</sup> )	ROHACELL 51 IN./IN. °F (K <sup>-1</sup> · 10 <sup>-5</sup> )	ROHACELL 71 IN./IN. °F (K <sup>-1</sup> · 10 <sup>-5</sup> )
-238 (-150)	1.38 (2.5)	1.33 (2.4)	1.66 (3.0)
-148 (-100)	1.38 (2.5)	1.33 (2.4)	1.66 (3.0)
-58 (-50)	1.55 (2.8)	1.49 (2.7)	1.66 (3.0)
+32 (0)	1.66 (3.0)	1.66 (3.0)	1.77 (3.5)
+68 (+20)	2.05 (3.7)	1.83 (3.3)	1.94 (3.5)

Table 4: Coefficient of linear thermal expansion of ROHACELL 31, 51, 71 at various temperatures.

The expansion coefficients are distinctly lower than those of other rigid foams, and the values at very low temperatures in particular are similar to those of metals and fibre-reinforced laminates, thus making the stress-deformation behaviour of sandwich systems very useful.

## THERMAL CONDUCTIVITY

The thermal conductivity values of ROHACELL grades differ only slightly; they are within the ranges given in the table below for different temperatures. These values were determined for aged specimens whose cells contained essentially only air rather than propellant gas. They are therefore stable, ultimate values which no longer rise under normal conditions.

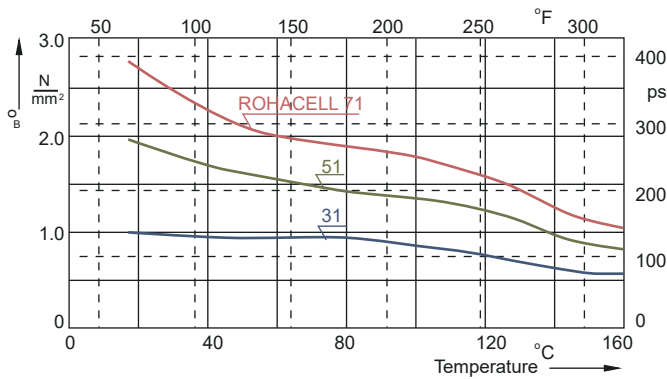
ROHACELL 31, 51 & 71		
TEMPERATURE °F (°C)	BTU in./ft <sup>2</sup> h°F	W/mK*
-256 (-160)	0.104 - 0.132	0.015 - 0.019
-148 (-100)	0.132 - 0.146	0.019 - 0.021
-40 (-40)	0.159 - 0.194	0.023 - 0.028
+68 (+20)	0.194 - 0.234	0.028 - 0.034
+176 (+80)	0.243 - 0.284	0.035 - 0.041
+284 (+140)	0.291 - 0.333	0.042 - 0.048

Table 5: Thermal conductivity of ROHACELL 31, 51, 71 at different temperatures.

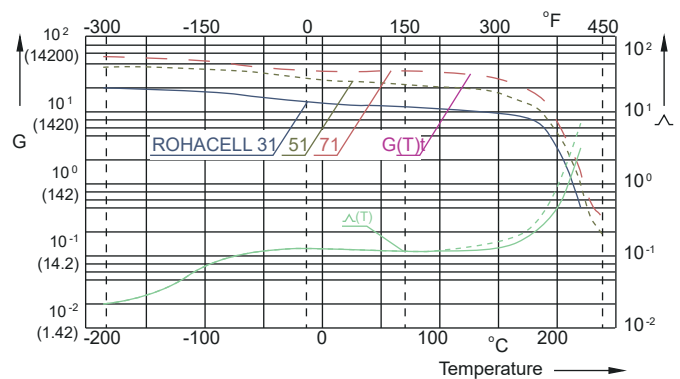
\* 1 W/mK = 0.86 kcal/m h deg.

# MATERIAL BEHAVIOUR AT ELEVATED TEMPERATURES

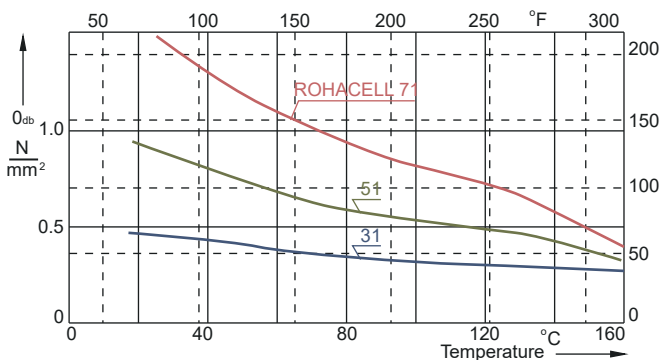
The illustrations show the tensile, compressive and flexural strengths, the moduli of elasticity and shear of ROHACELL as functions of temperature as well as the creep behaviour as a function of the compressive stress at 266 °F (130 °C). For special techniques, like the manufacture of sandwich panels in the autoclave, the creep behaviour of ROHACELL may not be adequate. In this case we recommend the use of ROHACELL WF.



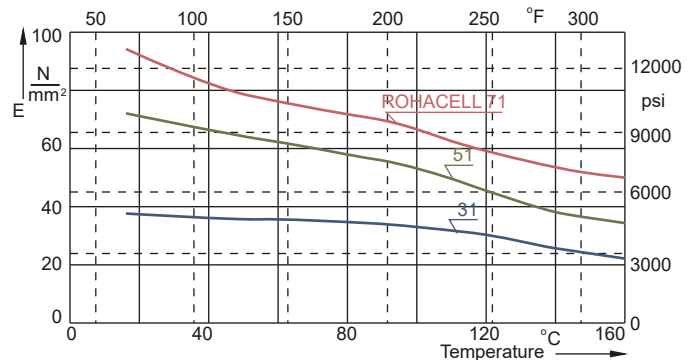
Tensile strength ASTM D 638-68) as a function of temperature



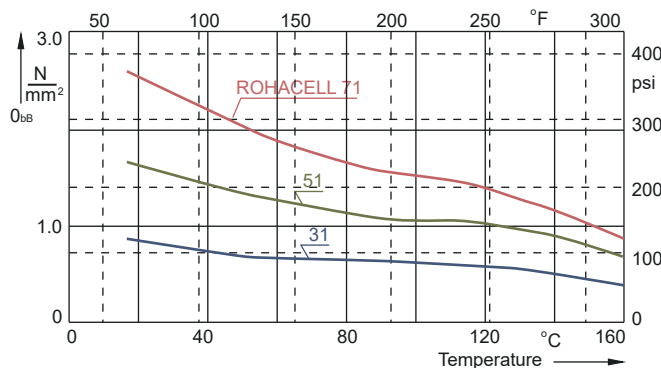
Shear modulus G and mechanical damping Δ(T) (ASTM D 2236-69) as a function of temperature



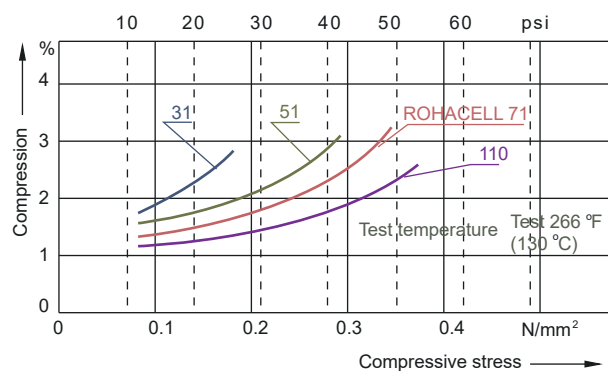
Compressive strength (ASTM D 1621-64) as a function of temperature.



Modulus of elasticity (ASTM D 638-68) as a function of temperature.



Flexural strength (ASTM D 790-66) as a function of temperature.



Creep behaviour of ROHACELL; test period 2 hrs, specimen inserted cold, initial compression c. 0.6 mm.

## MATERIAL BEHAVIOUR AT LOW TEMPERATURES

The following table presents a few properties of ROHACELL 31, 51 and 71 which permit an assessment of these materials for use at low temperatures. It is of particular interest that the elongation at break at -320.0 °F (-196 °C) is still above 1%.

The moderate heat expansion and cold contraction of ROHACELL is emphasized by the following example: for a temperature change between room temperature of + 73.4 °F (+ 23 °C) and -320.8 °F (- 196 °C) the expansion or contraction is only .005 in./in. to .006 in./in. (5 to 6 mm/m).

These low values are normally only reached by fibre-reinforced materials and metals. As a result, sandwich systems with a ROHACELL core show a very favourable stress-deformation behaviour.

PROPERTIES	UNITS	TEMP.	31	51	71	STANDARD
Tensile Strength	psi N/mm <sup>2</sup>	73.4°F (23°C)	142 (1.0)	270 (1.9)	398 (2.8)	ASTM D 638-68
		-94°F (-70°C)	156 (1.1)	284 (2.0)	427 (3.0)	
		-320.8°F (-196°C)	156 (1.1)	313 (2.2)	455 (23°C)	
Compressive Strength	psi N/mm <sup>2</sup>	73.4°F (23°C)	56.9 (0.4)	128 (0.9)	213 (1.5)	ASTM D 1621-64
		73.4°F (23°C)	58.3 (0.41)	142 (1.0)	256 (1.8)	
		73.4°F (23°C)	62.6 (0.44)	156 (1.1)	284 (2.0)	
Elongation at Break	%	73.4°F (23°C)	3.5	4.0	4.5	ASTM C 638-68
		73.4°F (23°C)	2.5	2.7	3.0	
		73.4°F (23°C)	1.4	1.4	1.5	

## WATER VAPOUR DIFUSSION

PROPERTIES*	UNITS	31	51	71	STANDARD
H2O Diffusion Resistance Factor	1	400	650	900	ASTM D 638-68

\* Test Conditions 68°F (20°C) and 85% relative humidity

The values given in the table are surprisingly high.

Measurements have shown that the water vapour difussion of ROHACELL above 65% relative humidity increases with the humidity reading.

