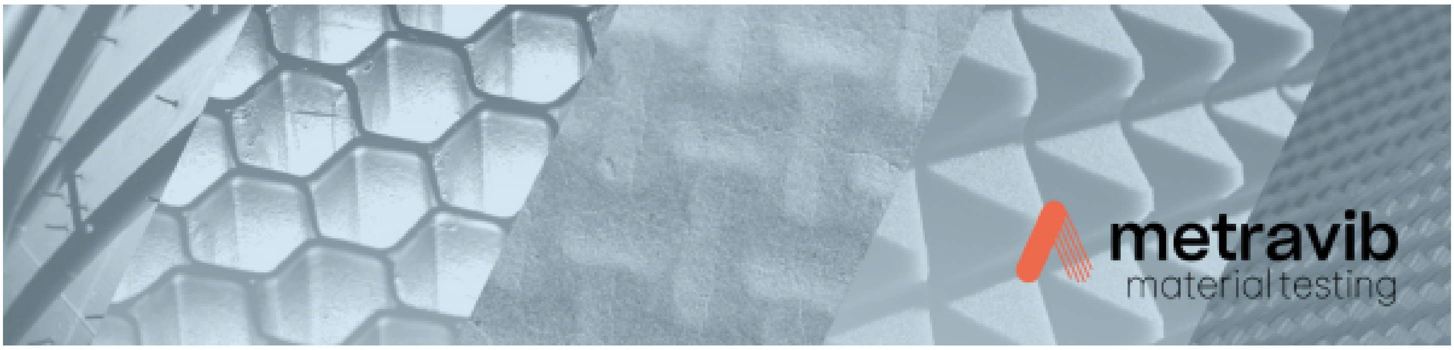


Effect of Frequency on Viscoelastic Properties of Materials

Keywords: DMA, Glass Transition, Temperature Ramp, Viscoelastic Properties, Frequency Dependent

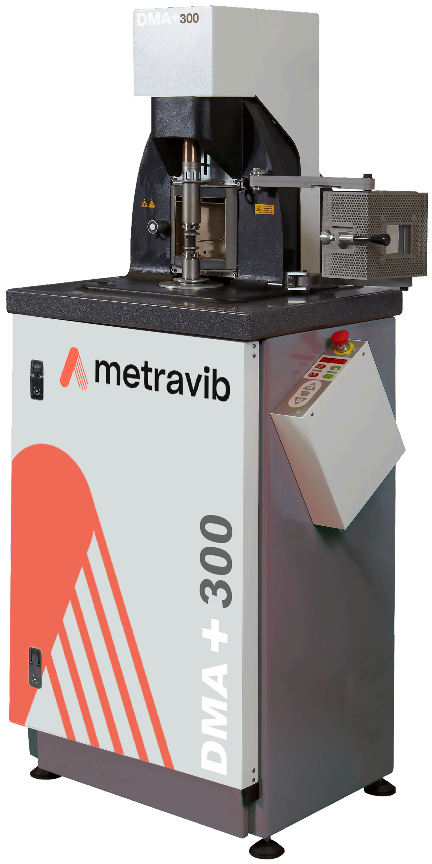


Figure 1. Metravib DMA+300

Introduction

To understand the viscoelastic behavior of a material, Dynamic Mechanical Analysis (DMA) is one of the most useful and interesting characterisation techniques. It helps in understanding the response of material structure to different environmental conditions (for example frequency, temperature, load etc), resulting in the optimisation of the mechanical properties.

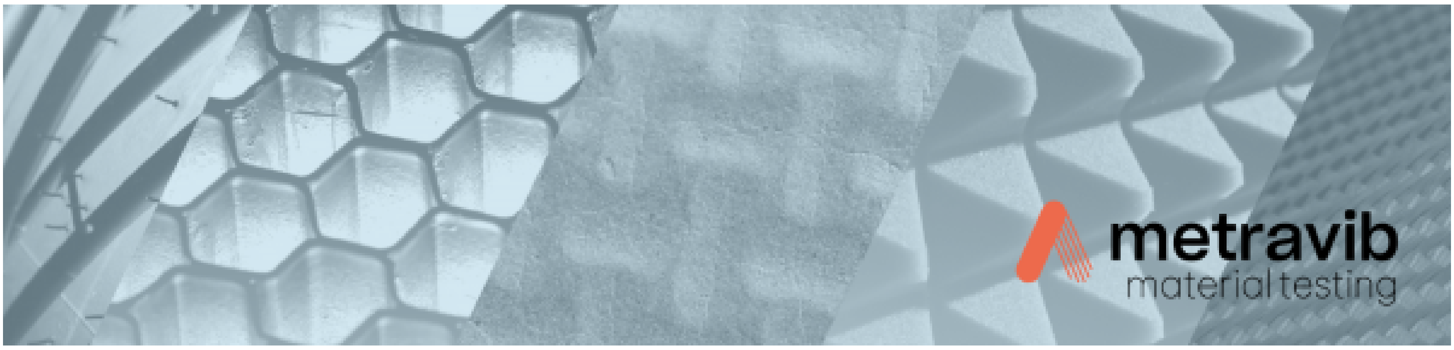
Among the different conditions, this document is focused on the effect of frequency on the glass transition temperature (Tg) of an EPDM material.

All the presented tests were performed with a METRAVIB's DMA+300.

Materials & methods

The material tested is an EPDM (Ethylene Propylene Diene Monomer). EPDM is a type of durable synthetic rubber, commonly used across many industries, such as Tire Industries. The specimens used were of the standard Goodrich Cylindrical Blocks, i.e., diameter – 18mm and height – 25 mm.

The specimens were studied in compression mode (see Figure. 2). The dynamic force of 10 N was applied on the specimen, with 20 N of



static force to make sure that the specimen stayed in contact with the specimen holders.

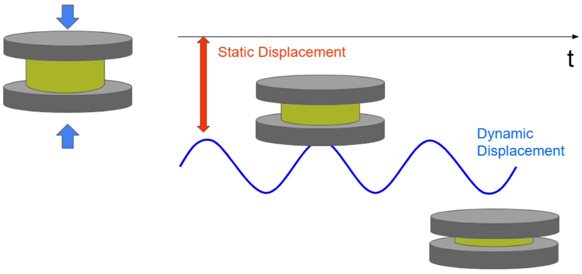


Figure 2. Schematic diagram of Compression mode

Since, the goal is to demonstrate the effect of frequency on a material's glass transition temperature, a temperature ramp (-60˚C to 100˚C) was performed at 3 different frequencies i.e., 1, 10 and 50 Hz. This test mode was chosen as it is especially fast and provides more data points than a classic frequency sweep test applied on several temperature stages. The parameters used for the test are mentioned in Table 1.

Dynamic Force (N)	10
Frequency (Hz)	1, 10 and 50
Static Force (N)	-20
Temperature (˚C)	-60 to 100, 60 minutes stabilization at -60.
Rate (˚C/min)	2
DMA	DMA+300
Test Mode	Compression

Table 1. Test parameters

Results

Figure 3 shows the results obtained for the temperature ramp at the three selected frequencies. The results are presented in terms of storage modulus (E') and loss factor (tan δ) as a function of temperature. The decrease of E' as a function of temperature indicates the molecular dynamic rearrangements of elastomer chains between the glassy state (localized molecular movement) and the rubber-like state (high amplitude movement) [1].

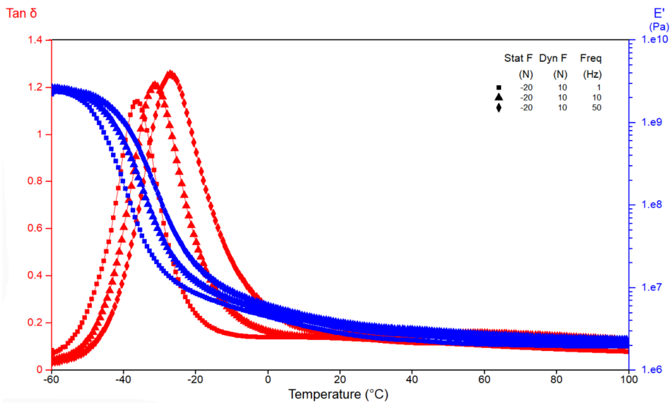
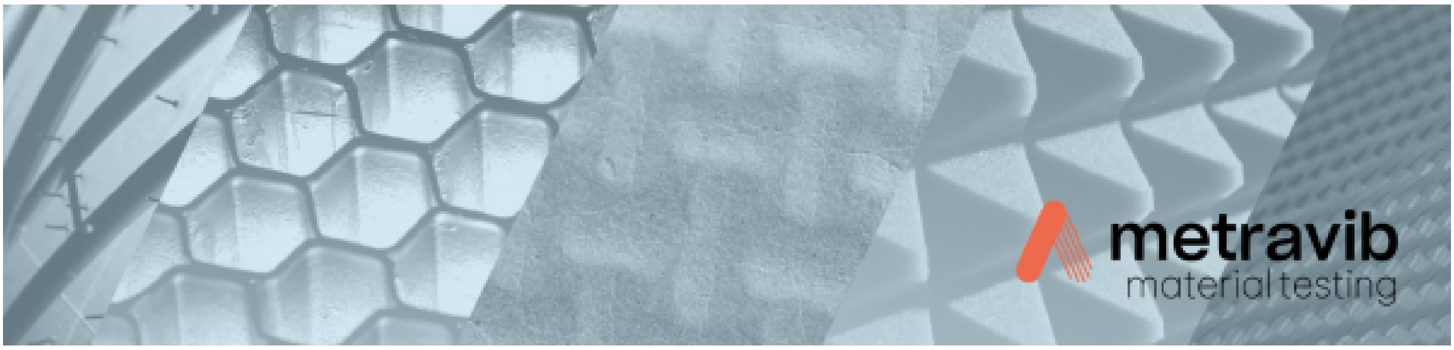


Figure 3. E' and tan δ as a function of temperature at 1, 10 and 50 Hz.

In Figure 3, the change in frequency has an effect on the glass transition temperature of the material i.e., an increase in glass transition temperature with increasing frequency was observed. The glass transition temperature increased from -36˚C to -27˚C as the frequency was increased from 1 Hz to 50 Hz.

An increase in Tan δ with frequency has also been observed. As the elastomer chains have



more time to relax and respond at low frequencies, the material behaves more like viscous and hence low magnitude of Tan δ, whereas, at higher frequencies, the elastomer chains have less time to relax and respond, the material behaves more like elastic and hence high magnitude of Tan δ.

Conclusions

This note shows the ability of Metravib's DMA+300 to characterize elastomer materials. The temperature ramp performed at different frequencies has brought important information on the effect of frequency on glass transition temperature of elastomer material. Moreover, the behavior of storage modulus (E') and loss factor (Tan δ) was studied as a function of temperature.

The glass transition temperature and Tan δ magnitude increased with increasing frequency, this effect is correlated to the differences in the relaxation time allowed to the polymer chains.

References

1. Kevin P. Menard. Dynamic Mechanical Analysis : A practical introduction.

Standards

ISO - 6721

ASTM - E 1640

Authors: Pankaj YADAV | pankaj.yadav@acoem.com

More info: www.metravib-materialtesting.com