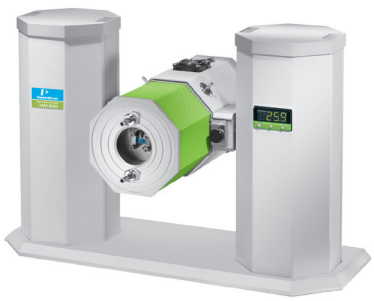
HUMAN HEALTH

ENVIRONMENTAL HEALTH

EXCEPTIONAL DESIGN ENHANCED PERFORMANCE



DMA 8000

Dynamic Mechanical Analyzer

PerkinElmer®

For the Better

INNOVATION IN MATERIALS SCIENCE

INTRODUCING THE DMA 8000

Dynamic Mechanical Analysis (DMA) is widely used to characterize materials' bulk properties such as modulus, compliance, and damping (tan delta).

It measures changes of rheological behavior under dynamic conditions as a function of temperature, time, frequency, stress, atmosphere, or a combination of these parameters.

Stress-strain, creep recovery, thermomechanical, and stress relaxation measurements are just a few examples of the uses of DMA.

How can you improve accuracy, sensitivity, and performance? Let us show you.

DMA 8000

Quick Glance

- Unparalleled flexibility with rotating analysis head
- Enhanced performance due to a lightweight analytical train
- TMA capability
- Superior cooling design
- Integrated Fluid Bath option
- Controlled humidity studies with a unique humidity generator
- Optional furnace window for viewing the sample
- Analysis of powders or other difficult to prepare samples

The PerkinElmer DMA 8000 is the most flexible, cost-effective Dynamic Mechanical Analyzer available today.

Its innovative design, high functionality, and flexible operation make the DMA 8000 ideal for advanced research and routine quality testing. The flexibility arises from a number of powerful accessories that are available. For handling a wide range of samples, multiple geometry configurations are offered. Other options allow performance of UV curing tests, visually monitoring and/or recording samples during experiments, precise control of the humidity and temperature of a sample as its properties are studied, and immersing a sample in a fluid during testing. With the smallest footprint in the industry, the instrument reduces laboratory space requirements while operating on a standard laboratory bench.

The exceptional design, unconstrained by existing DMA approaches, was rewarded an R&D 100 Innovation Award for its advancement.

Innovation

Rotating analysis head

One of the most unique and useful features of the DMA 8000 is its rotating analysis head, which can be oriented through a full 180°. Unlike traditional DMAs, which have a single, fixed configuration, this rotational design essentially permits the DMA 8000 to be configured in the best possible orientation. Benefits include:

- Easy access to, and mounting of, samples
- Rapid changing of samples and clamps (typically less than 2 minutes)
- Immersion experiments in any geometry
- Optimal analysis head configuration for virtually any test type and sample geometry:

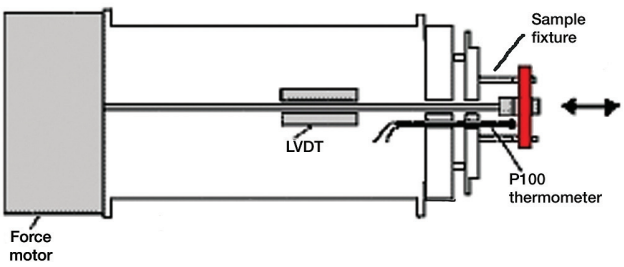
Geometry	Typical Orientation
3-Point Bending	Vertically up
Cantilever	Horizontal
Compression	Vertically up/down
Shear	Horizontal
Tension	Horizontal
All geometries (immersion)	Vertically down

THE ULTIMATE IN DESIGN AND INNOVATION

Lightweight drive and clamp system

The novel lightweight analytical train incorporated in the DMA 8000 has minimal compliance and requires no stabilizing springs or air bearing. Due to the design, no shaft support system is required, in contrast to most other DMA instruments, which require either an air bearing or drive support springs. This design offers several advantages for the working laboratory:

- Enhanced performance since the drive system compliance does not significantly contribute to the measurement,
- No risk of damage to the instrument associated with dirty or damp air,
- No requirement for compressed air, hence no compressor to maintain,
- High sensitivity due to low mass, yet very rigid titanium clamps and drive components,
- Low maintenance due to inherent simplicity and chemically inert materials.



Lightweight drive system.

Unmatched cooling capability

Because low temperature operation is so important in mechanical testing, the DMA 8000 was designed with an ultra-efficient cooling system. In normal operation the instrument can cool both rapidly and with a minimum of liquid nitrogen, providing industry-leading performance.

The ability to cool down to -190 °C without immersion is exceptional and particularly important because most beta and gamma relaxation processes occur at ultra-low temperatures.

The speed of cooling, or cool down time, is vital for high sample throughput and in laboratories where reduced liquid nitrogen consumption is important.

Start Temperature	Cool Down Time from RT	LN_2 Usage
-100 °C	5 minutes	~ 0.3 Liter
-150 °C	10 minutes	< 1 Liter
-190 °C	15 minutes	~ 1 Liter

The cooling system utilizes a low-pressure liquid nitrogen vessel for simple, convenient operation.

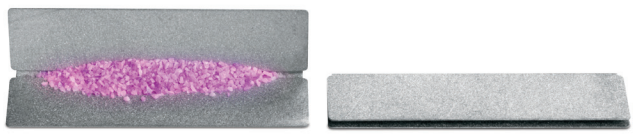
For many laboratories the 1 L Dewar is the most simple and convenient system. Quickly pressurized, it offers rapid, safe use and its convenient size can be accommodated in many laboratories.

A 50 L Dewar is also available for storage of larger quantities of liquid nitrogen for prolonged experiments, controlled cooling, or multiple experiments without refilling. All cooling systems can be equipped with an Autocryo accessory for fully automated unattended operation.

UNPARALLELED FLEXIBILITY TO ACCOMMODATE VARIOUS SAMPLE TYPES

Analysis of powders, gels, and natural products

Our Material Pockets are a unique sample preparation tool specifically designed to work with the DMA 8000. These innovative pockets allow powdered or non-self-supporting materials, such as powdered drugs, gels, natural products (like tea, coffee, herbs, etc.), and low viscosity materials, to be investigated by DMA. Applications include detecting small amounts of amorphous material in samples that cannot be formed into a bar or a material naturally occurring in a powder-like state. They can also be used by creating a film or coating on the inside surface to allow the film to be studied easily. This is especially useful for extremely fragile, thin, or "sticky" films. An example would be the curing of a cyanoacrylate adhesive.



Material pocket.

Mesh Material Pockets, a patented enhancement of the previous version, are available for humidity work, experiments where the loss of solvent from the sample is important, and other specialized applications.

Material Pockets are used in a bending mode geometry. Multi-frequency analysis reveals the character of any observed transition; the amorphous Tg response will be frequency dependent, whereas melting or chemical degradation will be independent of frequency.

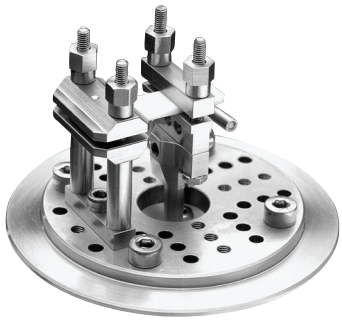
Our Material Pockets are a unique sample preparation tool specifically designed to work with the DMA 8000.

Watch your samples

The standard furnace of the DMA 8000 is configured with a quartz window that provides a number of useful capabilities. The window allows visual inspection of the sample and clamping system throughout the experiment without interrupting the temperature profile or other experimental conditions. It also allows video recording of the sample during an experiment, which can provide useful information when later analyzing data.

Irradiate your samples

The quartz window furnace also allows UV/Vis irradiation for curing and other studies. A special Shear clamping design offers unique capabilities for these studies. These measurements are also possible in tension. DMA investigations into the behavior of photo-curing and photo-reactive systems have never been easier.



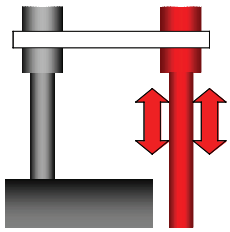
Single cantilever fixture.

Flexibility

Geometry options

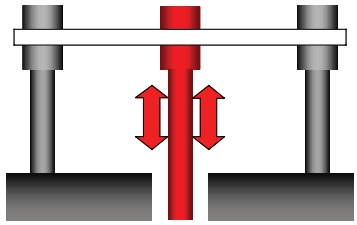
There are six common geometry modes that can be used for performing DMA experiments, covering the full range of sample testing needs. The geometry selected for an experiment is dictated by the nature and size of the sample being analyzed as well as its intended use. The fixtures can easily be adjusted to a variety of sample sizes.

Single Cantilever Bending



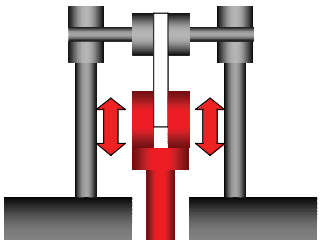
The sample is anchored on one end by a fixed clamp and by the drive shaft on the other. Bending stress is applied by the motor.

Dual Cantilever Bending



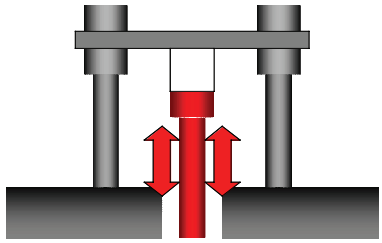
The sample is anchored on both ends by a fixed clamp and by the drive shaft at the mid point. Bending stress is applied by the motor.

Tension



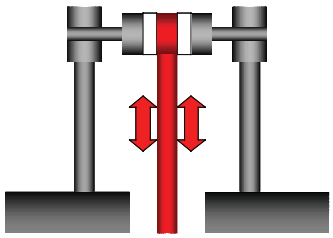
Sample is anchored on one end by a fixed clamp and by the drive shaft on the other. Tension stress is applied by the motor.

Compression



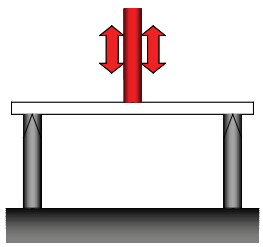
Sample is sandwiched between a fixed plate and a plate mounted on the drive shaft. Compression stress is applied by the motor.

Shear



Two samples are sandwiched between two fixed plates and two plates mounted to either side of the drive shaft. Shear stress is applied by the motor.

3-Point Bending



Sample is supported on both ends by a fixed bar and the drive shaft at the mid point. A Bending stress is applied by the motor.

Single Cantilever Bending mode is excellent for general characterization of most polymeric bar samples above and below their Tg. This mode is also ideal for examining powdered or flaked materials in the Material Pockets.

Dual Cantilever Bending mode is useful for low stiffness samples, such as thin films, using a small free length.

Tension mode is very useful for the analysis of thin films and fibers or can be used for bar samples with no static force if expansion information is required.

Compression mode is used with polymer foams, gels and natural materials such as bread dough, meat and confectionery. It is also used for performing constant force (TMA) experiments. Special tablet clamps allow the handling in compression of tablets and pills.

Shear mode is useful if examining low stiffness materials such as elastomers, pressure sensitive adhesives, asphalts, bitumen, and tars, or the cure of materials such as epoxy resins.

3-Point Bending mode is used for accurate modulus work on stiff samples, such as composites or thermoplastics below their Tg and for cured thermosets. This mode's ease of loading makes it especially useful for quality control applications.

NUMEROUS EXPERIMENTS, ONE EASY SOLUTION

Immersion experiments

The DMA 8000 environmental Fluid Bath option has been designed as an integral part of the analyzer. The accessory allows true immersion studies on a sample while measuring the dynamic mechanical properties. All geometry modes are supported in immersion mode. The temperature range of the Fluid Bath is from subambient temperatures to 150 °C. A further unique capability is that the low-end temperature can be extended to -196 °C when liquid nitrogen is used as the immersion fluid. The immersion fluid can be temperature controlled by one of three methods:

- Using the built-in electrical heater control system,
- Using a circulating fluid from a circulation bath or chiller,
- Using liquid nitrogen as the immersion fluid.

Fluid bath.

Humidity controller.

Controlled humidity experiments

The Humidity Generator and Controller are powerful and flexible options, which deliver the capability to apply and accurately control relative humidity to the sample environment in the DMA 8000. They offer an easy means of obtaining mechanical properties of materials under defined RH conditions.

The system operates by mixing and proportioning streams of dry and moist air. Direct feedback from a humidity sensor with close proximity to the sample provides a continuous means to monitor and control the exact humidity at the sample.

Features include:

- Unique "sample site" humidity feedback control,
- Capability to vary the humidity level during the run,
- Heated transfer line to avoid condensation,
- DMA response plotted against humidity.

Applications include:

- Moisture induced phase transitions,
- Moisture sensitive materials like paper, natural fibers, and food products,
- Swelling, shrinking and stiffness changes as humidity changes,
- Plasticizing and Tg effects as seen in nylon and polyurethanes.

MEETING YOUR APPLICATION NEEDS

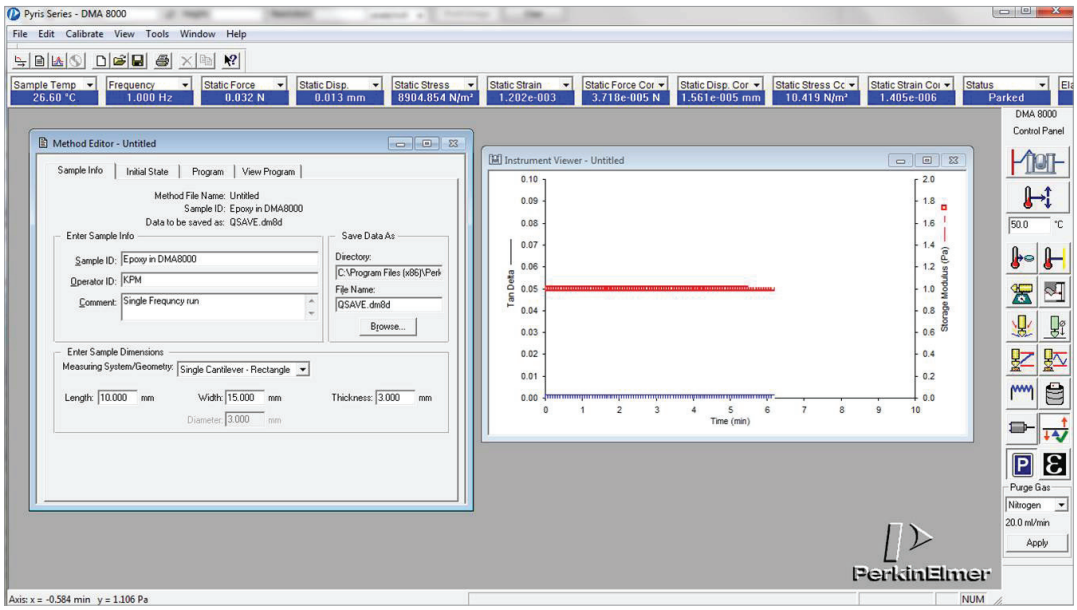
Instrument control

Operation of the DMA 8000 is through PerkinElmer's well known Pyris Software. This software operates our thermal analysis line and allows overlay of data from various instruments. For the DMA, it allows easy-to-use operation and analysis.

- Runs in Windows® 7, 64-bit,
- Easy to set up experiments,
- Allows monitoring all signals during run,
- Gives calculated values like E', E" and tan delta real time,
- Allows calculations during the run,
- Easy exportation of data as ASCII or as tables.

Advanced Experimental Procedures

Time Temperature Superposition Software (TTS) and Stress Relaxation Software are also included with the DMA. TTS allows the prediction of material properties at frequency ranges not obtainable in any commercial instrument. Stress Relaxation allows a greater understanding of how material responds to a load as a function of time.



DMA software.

Use of Material Pockets for mechanical analysis of powders

Polystyrene

Figure 1 shows tan δ data from two DMA experiments with polystyrene. The original sample was the same, but the red line shows an experiment run with a bar sample in Single Cantilever Bending. The black line shows an experiment run with grated polystyrene in a Material Pocket. Both were run at 1 Hz. It is clear that the glass transition, shown as a peak in the tan δ data, is the same for both experiments. The peak value is less for the Material Pocket, but this is a reflection of the lower sample mass. This experiment demonstrates that it is possible to use the Material Pocket to obtain relaxation data on a sample and that the stainless steel of the pocket is unaffected.

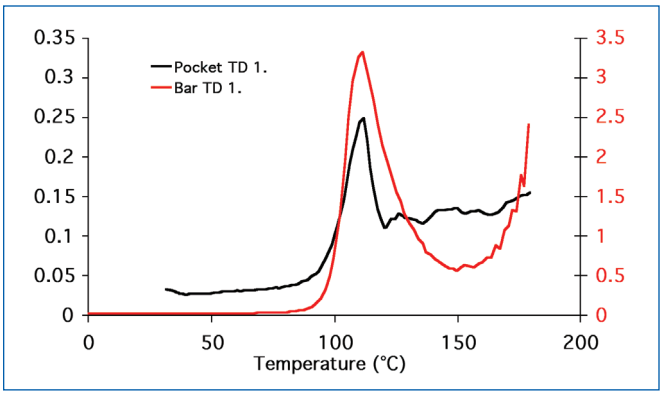


Figure 1. Tan δ for polystyrene.

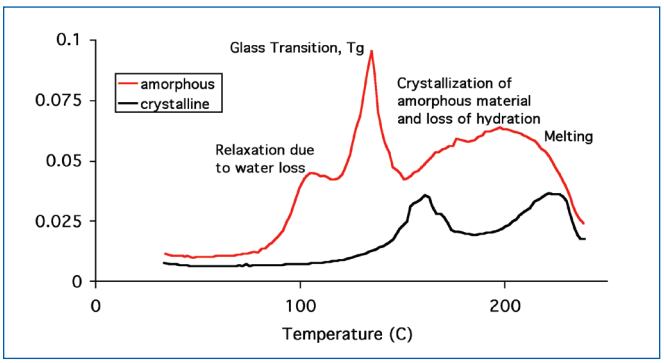


Figure 2. Tan δ for lactose.

Lactose

Tan δ data for two samples of lactose are shown in Figure 2. The red line is for 100% lactose amorphous and the black line for 100% crystalline. Amorphous lactose is more hygroscopic than crystalline lactose, hence, there is a peak in the graph at around 100 °C corresponding to latent water being driven off. A glass transition is observed in the amorphous sample and then an event corresponding to recrystallization of the amorphous material. Also, under this event is a loss of hydration water, which is also shown in the crystalline sample. As the temperature is increased further, the sample begins to melt.

Multi-frequency analysis of Epoxy-based PCB (Printed Circuit Board)

The sample was mounted in the 3-Point Bending clamps and cooled to -150 °C prior to starting the DMA experiment. The measurement was run with a heating rate of 3 °C/min.

Figure 3 shows the glass transition of this sample as a peak in the tan δ and a drop in modulus. A clear frequency dependence is seen confirming the transition as a relaxation. The modulus of the material before and after this transition is relatively constant at approximately 2.3 x 10^{10} and 5.0 x 10^{9} Pa, respectively. The glass transition temperature, as defined by the peak in the tan δ, is shown to be between 142.6 °C and 151.8 °C depending on the frequency.

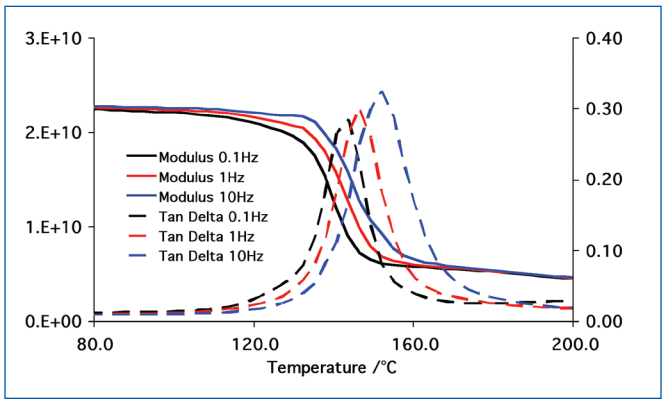


Figure 3. Glass transition.

DMA 8000
SPECIFICATIONS

Rotating Analysis Head	• Vertically up (forward) and 45° in between these positions	• Vertically down	• Horizontal
Temperature Range	Standard furnace High temperature furnace Immersion bath	-190 °C to 400 °C -190 °C to 600 °C -196 °C to 150 °C	
Scanning Rates	Heating rate 0 °C to 20 °C/min* (standard furnace) Cooling rate 0 °C to 40 °C/min* (standard furnace) **at mid range (100 °C), may not be achieved at elevated temperatures*		
Liquid Nitrogen Coolant Consumption	-100 °C -150 °C -190 °C	5 minutes 10 minutes 15 minutes	0.3 LN_2 <1 LN_2 <1 LN_2
Frequency	Range Max. number Resolution	0 to 600 Hz (depends on sample) up to 100 per experiment 0.001 Hz	
Dynamic Displacement	0 to ±1000 µm		
Stiffness Range	2 x 10^2 to 1 x 10^8 N/m resolution 2 N/m		
Modulus	Resolution Range	0.0001 Pa ~10^3 to 10^{16} Pa	
Tan Delta	Resolution	0.00001	
Force	Range Minimum Resolution	-10 N to +10 N (range of 20 N) 0.002 N 0.002 N	
Displacement/Strain	Resolution Range	1 nm ±1000 µm	
Sample Size	Maximum 52.5 mm x 12.8 mm x 8.0 mm		
Geometry Options	Mode	Options	Range
	Single Cantilever Bending	18	1.0 – 17.5 mm
	Dual Cantilever Bending	18	2.0 – 35.0 mm
	3-Point Bending	6	20.0 – 45.0 mm
	Tension	unlimited	<10 mm
	Compression	unlimited	<10 mm
	Shear	10 mm diameter plate	
	Material Pockets	powders/non self-supporting samples	
TMA Mode	Measurement range Geometry Sensitivity Force load min/max Sample size	±1000 µm tension and compression 10 nM 0.002 N / ±10 N up to 10 mm	
Atmosphere	Static; controlled flow with air or inert gas; fluid (immersion); humidity		

DMA 8000
SPECIFICATIONS

OPTIONS	**Fluid Bath**	
	Temperature Range	-196 °C to 150 °C (dependent on immersion fluid used) Optional K-type thermocouple available for accurate fluid temperature control
	Bath Material	Standard PTFE coated Aluminium and optional Pyrex® Glass
	Humidity Generator	5% to 90% (25 °C)
	Humidity Range	10% to 80% (80 °C)
	Temperature Range	5 °C to 80 °C Care must be taken regarding dew points for low temperature studies
Standard Environmental Conditions	Temperature – operating Relative Humidity	+15 °C to +35 °C 20% to 80%, non-condensing
Optical Windows	Standard configuration with 400 °C furnace: quartz Optional lateral windows or apertures available	
Instrument Weight	15 kg (33 lbs)	
Instrument Dimensions	170 mm depth x 475 mm width x 340 mm height 6.7 in depth x 18.7 in width x 13.4 in height	
Connections	Electrical Interface Purge gas Cryogenic fluids	120 VAC or 230 VAC ±10%, 50/60 Hz. ±1%, 600 VA (maximum) 1 USB input 4 mm purge gas inlet 6 mm inlet port
Conformance	Low voltage directive 73/23/EEC EMC directive 89/336/EEC	EN 55011 Class B 1992 EN 61000-3-2 1997 EN 61000-3-3 1998 EN 61326 2000

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