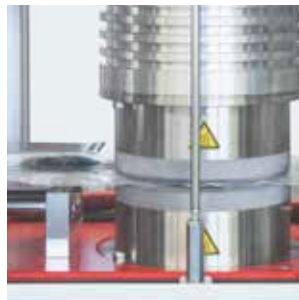


## *Moving Die Rheometer*



**INNOVATIONS IN  
RUBBER TESTING**



# MonTech®

Werkstoffprüfmaschinen GmbH

Carl - Benz - Straße 11

D - 74722 Buchen / Germany

**INNOVATIVE  
TESTING  
SOLUTIONS  
MADE IN  
GERMANY!**

**MonTech Werkstoffprüfmaschinen GmbH is the world's leading premium manufacturer of rubber testing instruments.**

Since 1998, we have been developing, producing, distributing and servicing high quality testing machines and their components as well as related software solutions for materials and component testing. Trust in MonTech's products and services are reflected in their long-term customer loyalty, and by being appointed "preferred supplier" by many of our OEMS.

*The secrets of our success are:*

- ✓ **Highest quality standards for all products**
- ✓ **Proximity to customers**
- ✓ **Highly qualified sales, support and service staff**
- ✓ **Continuous R&D programs**

MonTech's extensive product range spans from solutions for basic to high-end applications for both quality control and R&D. MonTech rubber testing instruments are available in standardized versions or can be built according to individual customer requests and requirements. With manufacturing and HQ located in Buchen, Germany, our state-of-the-art facility supports a 98% in-house fabrication rate and a team of experienced engineers form the foundation of capability for custom solutions.

MonTech is a global family business, wishing to bring the values of working with a family business to the laboratory. Therefore we have created extraordinarily broad global network of branch offices and subsidiaries along with representatives and partners, who guarantee both optimal 24/7 technical service on site and short delivery times.

The MonTech group of companies is internationally certified according to ISO 9001:2015 and accredited in accordance with DIN EN ISO 17025:2018.

The unique modular product design provides advantages of easy maintenance, interchangeable instrument configurations, and a high testing flexibility for all kinds of elastomeric materials. Due to MonTech's wide variety of products and their applications, we have customers in many industries, but most noticeably the automotive, tire, aerospace, rubber compounding, pharmaceutical, chemical, food, packaging, research centers, universities and institutes.



## MonTech Technology: Moving Die Rheometer (MDR and RPA) Series

**Moving Die Rheometers are the standard testing method for characterisation of rubber curing in quality control as well as research and development.**

Therefore these rotorless curemeters are equipped with a closed, sealed, biconical die system according to all relevant ISO, ASTM and DIN standards. During the test the lower die performs a sinusoidal oscillation with a fixed oscillation amplitude and frequency, at either a fixed (isothermal) or variable temperature (non-isothermal).

MonTech Moving Die Rheometer systems are the backbone for reliable and repeatable quality control in the rubber industry - offering a unique design with an extremely rigid test frame and superior temperature control.

Depending on the instrument model, the instrument is either equipped with a mechanical or with a direct drive system. Every machine is supplied with the flexible and easy to operate MonControl Software for managing test specifications, acquiring data, and reporting results.

Furthermore, every instrument can be configured to exactly meet the customers specific needs - this includes a modular platform of automation solutions, cooling options and sample preparation systems.



### Rugged housing and ultra-stiff machine frame

The machine frame of every MonTech Rheometers is constructed from aerospace grade aluminum and stainless steel making MonTech Rheometers the most rugged and stable Rheometer systems in the market.

This design includes baseplates of up to 80 mm thickness, 50 mm stainless steel pullrods, massive 80 mm crossheads with integral stainless steel force crossbeam support for superb die symmetry and alignment as well as up to 20 mm thick side panels. This results in an overall superior instrument stiffness; significantly improving repeatability and result correlation, while reducing signal-to-noise ratio as well as guaranteeing the best damping abilities, especially for high frequency testing and unbeaten dynamic testing performance.

This ultra-rigid instrument design has even more advantages: The whole instrument frame is used as a heatsink for all major electronic components so that the instrument does not need any fans or air ventilation for cooling, allowing the complete electronic cabinet to be sealed against pollution and especially conductive carbon black dust.

As only high-strength aluminum and stainless steel are used for every single component in the instrument, corrosion is no issue at all, making MonTech instruments a secure investment.

**MonTech rubber testing instruments - truly built to last !**

## Test dies and die closing system

MonTech Moving Die Rheometers are equipped with a biconical die assembly with integrated direct heating, accurate sample temperature measurement, superior temperature control with unbeaten accuracy, highest heating and cooling rates, and minimized response times.

The specific die and crosshead design ensures a perfect alignment and uniform closing as well as parallelism of both test dies, significantly reducing result variations.

MonTech Rheometer test dies are entirely made from superior, lot-traceable stainless steel, hardened, precision ground and polished, making the dies built to last with an extreme stiffness and durability even against the most abrasive rubber compounds.

The test dies are sealed off with easily changeable long-life seals to provide superior lifetimes of up to 12 months, minimizing maintenance and instrument downtime.

Every MonTech Rheometer is equipped with a pneumatic die closing system for a reliable closing and sealing of the die cavity.

Optionally, instruments can be equipped with variable closing force, cavity pressure and variable die gap control.

In combination with the MonTech loadframe, this instrument design guarantees compliant testing results at the highest possible level of accuracy and precision paired with perfect reproducibility and reliability.



## Integrated calibration and diagnostics

MonTech Instruments feature internal diagnostic and condition monitoring routines for every critical process, enabling the instrument to detect, report and even solve problems before they occur.

Along with MonTech precision calibration tools, customers are guided through a software sequence, making the verification of the instrument really easy in order to always guarantee the highest instrument precision and most accurate test data.

Once the verification process is completed, a detailed PDF Report with all critical verification and calibration is generated, assuring traceability to any reference standard used.

Readings of most reference standards and performance parameters are taken by the software, minimizing operator involvement for providing objective results.



# MonTech Technology: Moving Die Rheometer (MDR and RPA) Series

## Precision torque measurements and transducer systems

Torque / force transducers and loadcells are the most critical part when it comes to precision of the instrument because raw torque and force signals, as well as derived modulus and viscosity signals are directly used for test result calculation. This is exactly the reason why MonTech designs and manufactures all transducers in-house. This guarantees the widest measurement ranges along with clean-room applied strain gauge technology paired together in ultra-rugged and stiff assemblies.

MonTech's intelligent transducer technology possesses various unique features such as variable amplifications, stiffness control and temperature compensation — proof again that MonTech systems are the most advanced testing systems available; guaranteeing the highest accuracy and precision from the smallest Milli-Newton torque readings to the highest dynamic loads over the complete torque range.

## Integrated data acquisition and processing

Programmable Logic Controllers form the backbone of every MonTech testing instrument, providing customers with proven technology and the highest system reliability.

The highly complex set of stress, strain and other raw data streams and results that are all time-critical to each other are analyzed in real-time with the most advanced 24-bit electronics and a 10 kHz high speed data sampling rate. This superior oversampling technology paired with the superior signal to noise ratio eliminates the need for data filtering or further data processing, providing the user with actual true measured data and results.

MonTech's advanced rubber testing machines support customers with as much valuable material information as possible, with features including measurement of higher harmonics, nonlinearities, and behavior at extreme processing conditions.

Every MonTech Rheometer and Mooney Viscometer is equipped with a rugged, well-proven and reliable Programmable Logic Controller (PLC) system as well as standard automation components.

Every instrument is directly equipped with an Ethernet interface, allowing direct integration of the machine into the customers network as well as linking host systems and computers by standard TCP/IP protocol with extremely high data rates and throughput.



## Powerful drive technology

MonTech Rheometer systems are equipped with the latest, closed-loop digital drive technology. The quality and performance of the instruments' rheological measurements are highly influenced by the precision of the applied deformation and thus the motor positioning. Therefore all MonTech Rheometer testing systems are equipped with the latest high-precision drive systems:

The MDR 3000 Basic instrument features a geared, brushless DC motor with integrated drive control systems, digitally connected to the instrument PLC unit, making this drive the ideal system for static testing at fixed frequencies.

All other MonTech Moving Die Rheometers and Rubber Process Analyzers feature the patented MonTech wearless direct torque drive system which ensures highly precise, stepless, and variable movement of strains, frequencies and other types of controlled sequences. This unique and powerful drive is the only motor system that has been specially designed for MDR and RPA applications. Unbeaten dynamic performance can be achieved as the drive is mounted directly underneath the lower die, minimizing the moving mass and eliminating the need of any clutches, drive shafts or couplings. Finally, this means that there are absolutely no start delays or backlashes, continuously assuring exact and repeatable movements for the most accurate rheological measurements. Ceramic and magnetic bearings form the backbone of the drive's high durability, stiffness, rigidity and reliability, resulting in superior precision for the smallest strains to the highest frequencies.

In-line to the main drive system, a specially designed high-precision angular displacement sensor with an accuracy of  $0.000001^\circ$  is mounted, measuring the slightest movements and forming a digital, closed-loop control circuit with a response time of less than 20 nanoseconds.

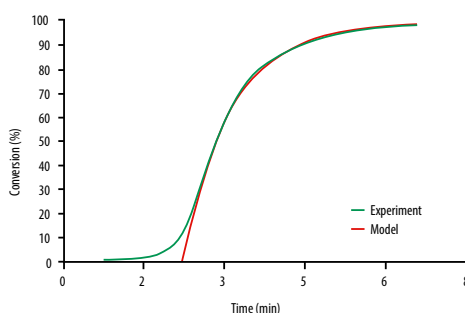
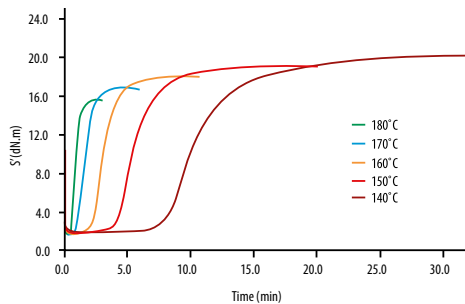
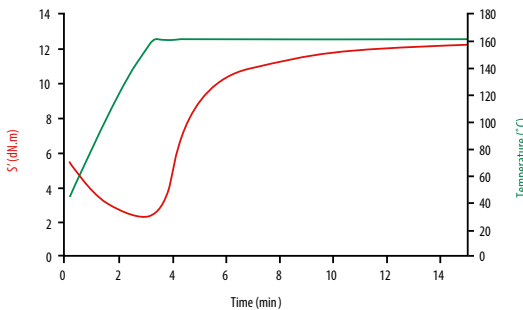
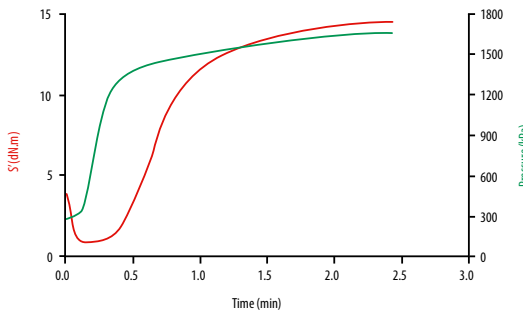
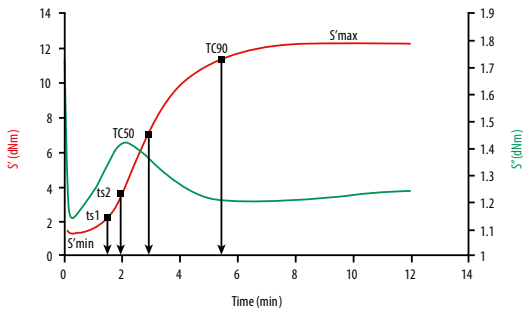


MonTech Moving Die Rheometers are the world-leading instrument series for reliable cure measurements in the rubber industry.

Due to the rugged design and superior design quality, MonTech instruments clearly offer superior accuracy and precision, proven by our certifications and accreditations including ISO 9001:2015 and ISO/IEC 17025:2018.

These calibrations services are offered throughout the world by our highly qualified team of MonTech field engineers in order to make sure that the calibrations of your instruments are fully traceable and comply to all local, company, and international standards.

# Moving Die Rheometer Application Examples



## Isothermal Cure

Isothermal cure experiments are the most common type of test for quality control in rubber and elastomer processing. MonTech Moving Die Rheometers provide high precision data as well as a simple operation of the instruments. All the important characteristics, such as minimum / maximum elastic torque, scorch times, cure times and reaction rates are precisely calculated, with over 3500 different datapoints. All data is available in numerical as well as graphical form; limits, control gates and tolerance graphs can easily be set, and Pass / Fail status is automatically evaluated after each test.

## Cure with simultaneous Sponging / Foaming / Blowing Reaction

Especially for sealing applications, blowing agents form a vital part of compound recipes in order to produce a cellular structure via a foaming process that runs in parallel to the cure reaction. The cellular matrix structure which is created during the foaming process reduces density, increases thermal and acoustic insulation, and affects the relative stiffness of the mix. Therefore, MonTech Rheometers can be fitted with a precision normal force measurement transducer in the die cavity in order to calculate cavity pressure simultaneously during the curing and reaction in a single test, and revealing interrelations between the two reactions.

Key datapoints such as PMin, PMax, PR, MPR, TP10, T50, TP90, P@ML, P@MH, ... are automatically calculated

## Non-isothermal Cure

In addition to isothermal static cure testing, MonTech MDRs and RPAs can perform tests at variable temperatures.

These non-isothermal sequences can be programmed in order to follow virtually any temperature profile, making them especially valuable for the simulation of manufacturing processes which are usually not isothermal. Typical processes that can be simulated are mixing, milling, extrusion, compression moulding, injection moulding, and storage conditions. Of course, non-isothermal test sequences can be executed in a single test with any other static or dynamic sequence, such as strain and frequency sweeps, providing the most accurate data of the material's behavior at any production stage and material state.

## Advanced cure kinetics modeling

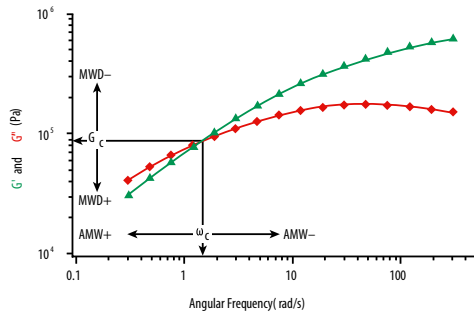
Test data from similar static or dynamic test sequences executed at different temperatures can automatically be evaluated and modelled for an advanced cure kinetics analysis, providing information about:

- Reaction Rate
- Order of Reaction,  $n$
- Rate Constant,  $k$
- Activation Energy,  $E$
- Incubation Time,  $t_i$

Check out our "MonKinetics Software" system for more insights into cure kinetics modelling and simulation.

# Rubber Process Analyzer

## Raw Material Applications

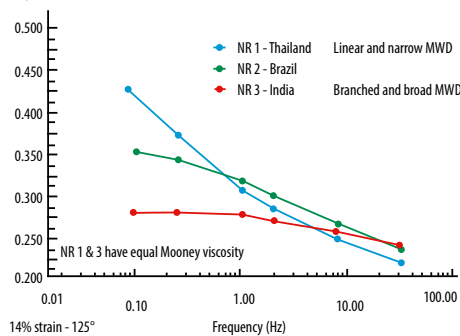


### Frequency sweep material analysis

In general, the mechanical properties of materials depend on frequency. A good understanding of the influence of frequency on a material is therefore very important for its practical use. For example, a material appears stiff under the action of a force at high frequency, but soft when the force is applied slowly. Isothermal frequency sweeps provide information about the weight distribution MWD (crossover modulus) as well as average molecular weight AWM (crossover frequency). But the behavior of viscoelastic materials like polymers not only depends on frequency, it also depends on temperature.

MonTech has incorporated further advanced testing capabilities such as the Time-Temperature Superposition principle (TTS), which is based on the equivalence between frequency and temperature behavior during transition processes, forming the basis of WLF master-curve modelling available on MonTech dynamic Rheometers, even for predicting material performance at frequencies outside the range that can be measured with a dynamic mechanical analyzer.

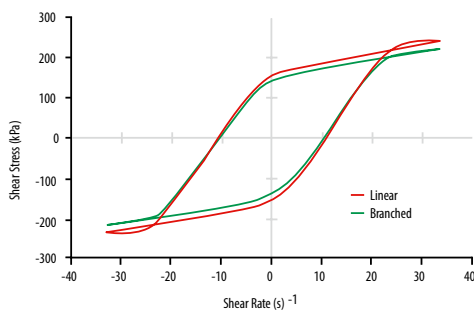
Natural rubbers from different sources - comparison  
Tangent Delta



### Structural characteristics and processability

The rheological properties of rubbers are related to their structural characteristics and will influence the behavior of the rubber during processing and the performance of the final product. While Mooney testing does not provide sufficient information to clearly differentiate branching and Molecular weight distribution the Rubber Process Analyzer can easily be used as a tool for solving production problems. Using frequency sweeps to scan the material over the whole shear rate range can reveal substantial material differences and variations e.g. causing a particular material to be very sticky and therefore difficult to process while others can be perfectly processed.

These test can be performed in the linear and also non-linear viscoelastic range to cover all different processing methods and material states. ISO 13145 suggests a simple and quick test procedure utilising a rotorless sealed shear rheometer (RPA) for rheological evaluations as an alternative to traditional Mooney Viscometer testing.



### Non-Linear material response at high strain (LAOS)

Dynamic oscillatory shear tests are common in rubber rheology - more specifically, small-amplitude oscillatory shear (SAOS) tests are the most common test method for measuring linear viscoelastic properties of rubber compounds and polymers.

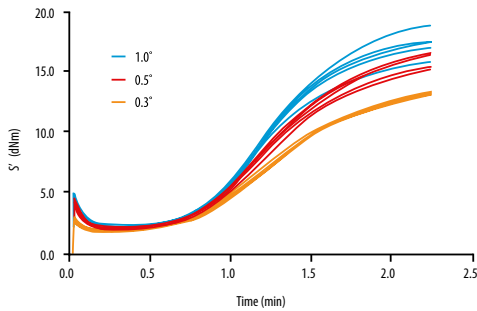
But in processing operations, the shear rates can be large and rapid; non-linear material properties form an even more important part in understanding material response. Therefore, MonTech Rheometers provide Fourier transformation analysis capabilities of periodic data, along with full raw-data access, for in-depth analysis to investigate and quantify the nonlinear viscoelastic behavior by using large-amplitude oscillatory shear (LAOS) testing in order to characterize and quantify material stress response which is no longer purely sinusoidal (linear), allowing a better understanding of filler content and structure, as well as the polymer architecture.

More details on the analyses of non-linear material properties can be found in our "MonLAOS Software" brochure.



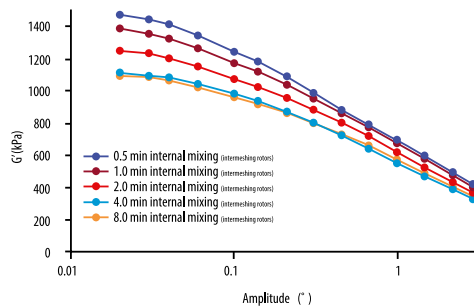
# Rubber Process Analyzer

## Advanced Cure and Processability Applications



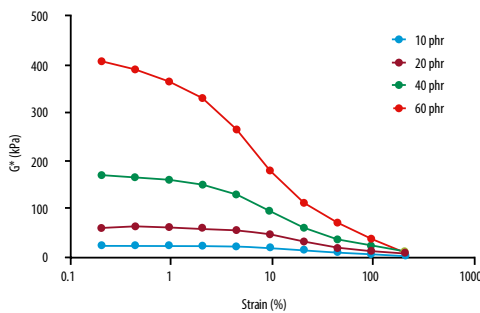
### Isothermal Curing at Variable Strain

Typically, cure experiments on rubber compounds - especially for quality control purposes - are performed with a fixed oscillation angle of  $\pm 0.5^\circ$  and a frequency of 1.67 Hz. However, for specific rubber compounds or challenging materials such as silicones or epoxy resins, this might not be ideal as either reaction torque readings are too low, providing only a limited ability to distinguish between different batches, or might be too high causing high result variability as the material is damaged as strain already exceeds the linear viscoelastic range. MonTech Rheometers provide the possibility of testing with variable oscillation angles to allow measurements within the ideal strain amplitude for optimal signal-to-noise ratio and the most precise test results, while avoiding any structural breakdown or slippage of the sample in the die cavity.



### Structural Breakdown of rubber compounds - process simulation

Rubber compounds are extremely sensitive to processing operations such as milling. Increasing strain causes the carbon black network - which is held together by Van der Waals-London attraction forces to break, causing a decrease in shear modulus of filled rubber vulcanizates. Therefore, MonTech Rheometers provide simulation capabilities for almost any possible production process, providing irreplaceable data for developing rubber compounds, as well as understanding and simulating manufacturing processes and environments.



### Strain Sweep for Filler Loading "Payne-effect"

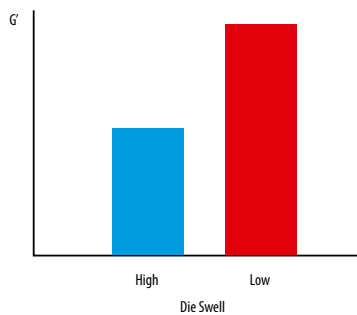
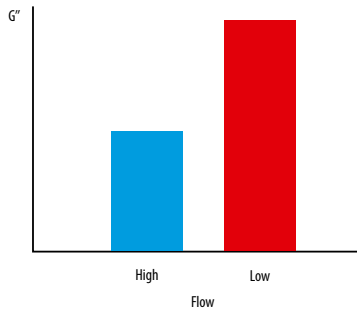
The Payne effect is a particular feature of the stress-strain behavior of rubber, especially rubber compounds containing fillers such as carbon black and silica. Physically, the Payne effect can be attributed to deformation-induced changes in the material's microstructure, i.e. to breakage and recovery of weak physical bonds linking adjacent filler clusters. Measurement of modulus vs. strain is therefore essential to understanding and quantifying filler loading, filler dispersion and filler-filler interaction in the low strain region, and polymer-filler interaction at higher strain. The resulting characterizations of material structure are essential as they directly impact dynamic stiffness and damping behavior of final products such as rubber bushings, automotive tires and all other rubber goods. Similar to the Payne effect under small deformations is the Mullins effect, which is observed under larger deformations in the non-linear viscoelastic range.

Stay updated about latest trends and topics in rubber testing and visit us online or subscribe to our channels!



# Rubber Process Analyzer

## Processability and post-cure Applications

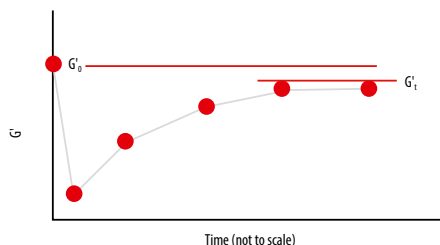
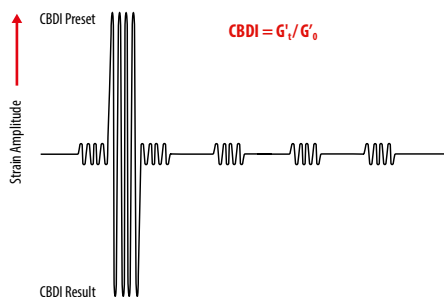


### Prediction of processability: Extrusion

Good processing performance is influenced by three main criteria: throughput flow, die swell and surface finish. The rubber is required to flow through the extruder. The flow will be controlled by the viscosity of the rubber. The shear rate from an extruder and extrusion die can easily be calculated and used as the specific test parameters in a Rubber Process Analyzer test setup. The shear rate in MonTech Rubber Process Analyzer is proportional to the frequency multiplied by the oscillation angle.

A low viscosity will mean that rubber will easily flow through the extruder with low die pressure. Once the rubber is extruded it is required to be in the correct size – however as the rubber is extruded through the die it is in compression across the direction of flow and extension in the direction of flow. When leaving the die, the elastic nature of the compound will cause the rubber to expand, resulting in die swell. MonTech Rubber Process Analyzers can obtain the Storage shear Modulus  $G'$  at high strains (typically 100%) allowing an excellent prediction of die swell.

The surface finish of the extrudate is required to be smooth, and not rough. Roughness tends to occur when a stick-slip resonance is set up between the speed of the extruder and the elastic response of the compound. Testing at variable shear rates using a frequency sweep allows the comparison of compounds that extrude with smooth and rough finishes revealing processing differences in the storage shear modulus  $G'$ .



### Mechanical properties: Carbon Black Dispersion

In filled rubber compounds carbon-black particles form a network of mutually interactive agglomerates. These effects can be measured and quantified using a simple D-RPA 3000 Matrix test. Storage shear modulus ( $G'$ ) results at low strains (e.g. +/- 1%) are typically high and get reduced after a larger strain amplitude (e.g. +/-50%) is applied for a short period of time. With lower strain amplitudes applied over time, the reduced Storage shear modulus ( $G'$ ) will partially recover. This effect relates to the Van der Waals forces linking the agglomerates, getting broken at higher strain amplitudes and the partially recovering over time.

The extent of recovery of the Storage shear modulus ( $G'$ ) directly relates to the Dispersion Rating (DR) of the rubber compound. If the carbon black is poorly dispersed, the recovery of the Storage shear modulus ( $G'$ ) will be much lower indicating a much weaker filler structure and therefore reduced mechanical performance properties.

A simple CDBI performed by a Rubber Process Analyzer allows consistent testing and quality control on the Carbon Black Dispersion rating:  $CDBI = \text{Initial storage shear modulus } G' (50^\circ\text{C}, 1\text{Hz}, 1\%) / \text{Final storage shear modulus } G' (50^\circ\text{C}, 1\text{Hz}, 1\%)$ .

The higher the CDBI value, the better the carbon black dispersion.

# MonTech Moving Die Rheometers and Rubber Process Analyzers

Static Curemeters are designed to test mixed rubber compounds under isothermal test conditions with fixed strain and frequency.

Dynamic Curemeters are Dynamic Mechanical Rheological Testers (DMRT) designed to measure material properties of raw elastomers or mixed rubber – before, during and after cure in a single test.



## STATIC TESTING

	MDR 3000 Basic	MDR 3000
<b>Instrument description</b>	Compact, entry model instrument for repetitive quality control testing as well as simple R&D applications	High-end instrument for QC and static R&D testing for a broad range of materials (from LSR, all kinds of elastomers to composite materials)
<b>International standards</b>	ISO 6502, ASTM D 5289, DIN 53529	ISO 6502, ASTM D 5289, DIN 53529
<b>Die configuration</b>	Biconical, closed die system, sealed	Biconical, closed die system, sealed
<b>Drive system</b>	Mechanical, brushless DC eccentric drive	Direct, wearless servo drive system
<b>Oscillation frequency</b>	1.667 Hz	1.667 Hz
<b>Oscillation strain</b>	+/- 0.1°, 0.2°, 0.5°, 1°, 3° or 7.17° Mechanically adjustable	+/- 0.01° to 5° Programmable via Software
<b>Temperature range</b>	Ambient to 232 °C	Ambient to 232 °C
<b>Measured Data</b>	Torque, temperature, frequency Optional: Normal force	Torque, temperature, frequency, strain Optional: Normal force
<b>Calculated Data</b>	S', S'', S', tan δ	S', S'', S', tan δ

Let us help you to determine  
the optimal instrument configuration  
for your testing needs.  
Contact us today!

All instruments are also available  
with various automation options:  
► Page 22



## STATIC AND DYNAMIC TESTING

MDR 3000 Professional	D-MDR 3000	D-RPA 3000
Entry model instrument in the Rubber Process Analyzer (RPA) technology. The MDR 3000 Prof. can be operated either in static testing mode (MDR) or also in dynamic testing mode (RPA).	Top model for advanced dynamic testing of all kinds of rubber, rubber-like, curing or crosslinking materials. This includes TPE, TPV, LSR, Composite materials, Polyolefins, ...	High-end instrument for demanding static and dynamic testing in QC and R&D with a huge set of customizing options. This enables testing capabilities that have not been possible to measure in a Rheometer before, such as die gap regulation, High-speed data acquisition, FT-Rheology, low-temperature cooling, ...
ISO 13145, ISO 6502, ASTM D 5289, ASTM D 6204, ASTM D 6601, ASTM D 6048, ASTM D 7050, ASTM D 7605, ASTM D 8059, DIN 53529	ISO 13145, ISO 6502, ASTM D 5289, ASTM D 6204, ASTM D 6601, ASTM D 6048, ASTM D 7050, ASTM D 7605, ASTM D 8059, DIN 53529	ISO 13145, ISO 6502, ASTM D 5289, ASTM D 6204, ASTM D 6601, ASTM D 6048, ASTM D 7050, ASTM D 7605, ASTM D 8059, DIN 53529
Biconical, closed die system, sealed	Biconical, closed die system, sealed	Biconical, closed die system, sealed
Direct, wearless servo drive system with ceramic bearings	Direct, wearless servo drive system with ceramic bearings	Advanced wearless servo drive system with ceramic bearings
0.001 Hz to 33 Hz (0.001 Hz to 50 Hz optional)	0.001 Hz to 100 Hz	0.001 Hz to 100 Hz
+/- 0.01° to 20° (+/- 0.01° to 90° optional)	+/- 0.001° to 180°	+/- 0.0001° to 360°
Ambient to 232 °C	Ambient to 232 °C	Ambient to 232 °C
Torque, temperature, frequency, strain Optional: Normal force	Torque, temperature, frequency, strain Optional: Normal force	Torque, temperature, frequency, strain Optional: Normal force, die gap, die pressure
$S'$ , $S''$ , $S'$ , $G'$ , $G''$ , $G''$ , $\tan \delta$ , $\eta'$ , $\eta''$ and $\eta^*$	$S'$ , $S''$ , $S'$ , $G'$ , $G''$ , $G''$ , $\tan \delta$ , $\eta'$ , $\eta''$ and $\eta^*$	$S'$ , $S''$ , $S'$ , $G'$ , $G''$ , $G''$ , $\tan \delta$ , $\eta'$ , $\eta''$ and $\eta^*$

# MonTech MDR 3000 Basic

## Entry level Moving Die Rheometer



### The MDR 3000 Basic

is the easiest to operate and most cost-effective way to determine viscoelastic properties of polymers and rubber compounds before, during and after cure.

The acquired data gives exact information about processability, cure characteristics, cure speed and the behavior of the compound after-cure, as well as optional pressure measurement for sponge rubber compounds.

The MDR 3000 Basic comes as a complete and ready-to-test set consisting of the Rheometer itself, an external Personal Computer with the latest Windows Operating System, TFT screen, keyboard and mouse, as well as a printer.

Like every MonTech Rheometer, the MDR 3000 Basic also features an Ethernet Interface and can therefore be directly integrated in any customer's factory network, guaranteeing the most stable data transfer and communication in any laboratory or factory environment, allowing data access at the instrument and from remote and office workstations, creating a digital process chain and integrated workflow based on a digital data repository, eliminating the need of result printing after each test series.

Designed as a table top instrument utilizing only minimal benchspace, the MonTech MDR 3000 Basic is synonymous with a reliable but easy and efficient testing operation. The instrument is equipped with the latest PLC-based control and data acquisition electronics, ensuring the highest data acquisition precision and reliability, along with superior temperature control - improving overall data significance and laboratory efficiency. The instrument comes with the MonControl Analysis software for test configuration management, data recording, automated Pass/Fail testing, processing of historical data as well as online statistical process control (SPC), having more than 3500 different datapoints available for selection. With an optional 5" instrument touch-control panel, the instrument can even be conveniently operated in stand-alone mode by directly displaying and printing the most essential datapoints - including the possibility to save and archive test data on a USB flashdrive.

### Completely closed, rotor-less, sealed, biconical test chamber system

entirely made from stainless steel, precision machined, hardened and ground to utmost precision for highest durability and testing accuracy. The lower die is directly connected to the central shaft and drive system. All these parts and components are also made from solid stainless steel, making the MDR 3000 Basic a cost-efficient, long-lasting and safe investment. The upper die is attached to the reaction torque measurement for immediate recording of the material feedback at the highest precision.

The MDR 3000 Basic features an extremely stiff, ultra-rugged loadframe paired with a unique, column-guide-free, accessible testing area along with the most simple single-button operation and integrated multi-color status bar making this instrument truly the most reliable testing system for quality control purposes not only in the laboratory, but also directly in the production area.

Of course various different automation options for increasing testing productivity are available and can be fitted to the instrument at any time.

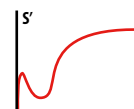




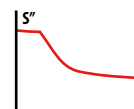
### Technical specification

<b>International standards</b>	ISO 6502, ASTM D 5289, DIN 53529, ...
<b>Die configuration</b>	Biconical, closed System, sealed
<b>Die gap</b>	0.45 mm nominal
<b>Sample volume</b>	approx. 4.5 cm <sup>3</sup>
<b>Drive system</b>	Mechanical, brushless DC eccentric drive
<b>Closing system</b>	Pneumatic with soft-close to prevent foil rips
<b>Oscillation frequency</b>	1.667 Hz (100 cpm)
<b>Oscillation strain</b>	+/- 0.1°, 0.2°, 0.5° (Std), 1°, 3°, 7.17°, Mechanically adjustable (+/- 1.4%, 2.8%, 7% (Std), 14%, 42%, 100%)
<b>Torque range</b>	0.01 to 250 dNm
<b>Normal force / Pressure (opt.)</b>	0 to 10.000 kPa (1.450 lbin), Auto tare
<b>Temperature control system</b>	Ambient to 232 °C, precision +/- 0.03 °C, Max. heating rate: 85°C/min digital, microprocessor PID controlled
<b>Temperature check system</b>	Recordings of the temperature gradient on the screen, microprocessor monitored
<b>Measured Data</b>	Torque (dNm, lbf.in, kgf.cm), Temperature (°C, °F), Pressure (bar, kg per cm <sup>2</sup> ), Time (min - min / min - sec / sec), Shear rate (1/s, rad/s), Cure rate (1/min, 1/sec)
<b>Calculated Data</b>	$S'$ , $S''$ , $S^*$ , $\tan \delta$ , phase angle, cure rate, ...
<b>Data Interface</b>	Ethernet (10/100 MBit), USB (int.), CF card (int.), RS232 (opt.)
<b>Data points</b>	Over 3500 data points available for each test <i>Including: <math>S'</math> Min, <math>S'</math> Max, TS 1, TS 2, TC 10, TC 30, TC 50, TC 90</i>
<b>Pneumatics</b>	min. 4.5 Bar / 60 psi
<b>Electrical</b>	100-120 V, 8 Amps or 200-240 V, 5 Amps, 47-63 Hz, Single phase
<b>Instrument options</b>	<ul style="list-style-type: none"> <li>- Instrument control panel with 5" touchscreen display and printer</li> <li>- Selectable oscillation frequency 1,67 / 0,83 Hz (100 / 50 cpm)</li> <li>- Adapted transducers for high or low-viscosity torque range</li> <li>- Normal force / Pressure measurement</li> <li>- Single channel forced air cooling system</li> <li>- Autoloader 5 or 10 sample linear</li> <li>- Autoloader with 24 or 48 sample tray</li> <li>- R-VS 3000 constant volume sample cutter</li> <li>- Label Printer</li> <li>- Signal tower</li> <li>...</li> </ul>

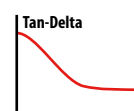
### Calculated results



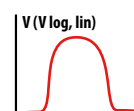
Elastic Modulus



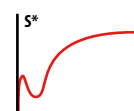
Viscous Modulus



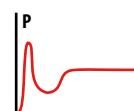
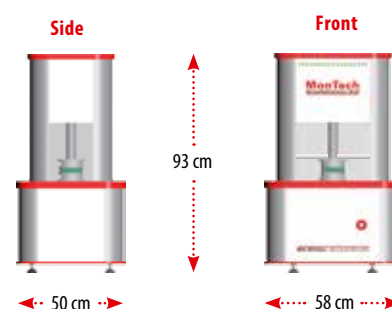
Tan - Delta



Vulcanization speed



Complex Modulus

Normal force / Pressure  
(optionally available)

# MonTech MDR 3000

## Advanced Moving Die Rheometer



### The MDR 3000

is the industry standard for measuring the viscoelastic properties of polymers and elastomeric compounds before, during and after cure.

The acquired data gives advanced information about processability, cure characteristics, cure rate as well as the behavior of the compound after-cure at fixed, user selectable strain rates.

The instrument comes in the unique MonTech Series 3000 loadframe - industrial proof, fanless and ultra-rugged even for toughest production environments.

The reaction torque is measured by a high resolution, digital strain gauge assembly with integrated temperature compensation, making the MDR 3000 the most accurate and precise Moving Die Rheometer for static testing.

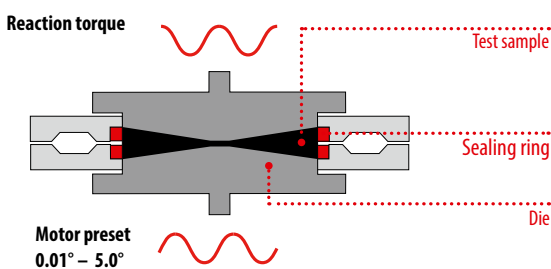
Optionally, the instrument can be equipped with a combined torque / normal force sensor to assess blowing or sponging reactions of the tested material. For increased productivity and throughput, various types of highly reliable automation systems are also available.

Of course the MDR 3000 can be easily upgraded at a later stage to an MDR 3000 Professional to not only be able to run static but also dynamic test sequences.

### Unique direct drive system

The instrument utilizes a direct, high-precision, gearless torque drive system mounted directly to the lower die assembly. Therefore, the oscillation angle can be directly changed in the MonControl software, making the instrument capable of always measuring materials in the optimal strain range. This feature significantly reduces signal noise, improving the accuracy of testing results. With this fully digital drive system, no mechanical strain adjustments are needed and the motor positioning is monitored and recorded throughout the test.

For less demanding applications the MDR 3000 is also available in a economy "M" version equipped with a mechanical stainless steel drive system with BLDC motor.

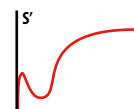


The heart of the instrument is the directly heated and precisely regulated biconical die assembly. The lower die oscillates with a predefined angle and frequency whereas the reaction torque is recorded on the upper die.

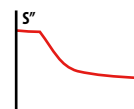
### Technical specification

<b>International standards</b>	ISO 6502, ASTM D 5289, DIN 53529, ...
<b>Die configuration</b>	Biconical, closed die system, sealed
<b>Die gap</b>	0.45 mm nominal
<b>Sample volume</b>	approx. 4.5 cm <sup>3</sup>
<b>Drive system</b>	Direct, wearless servo drive system
<b>Closing system</b>	Soft closing to prevent foil rips and damage of test sample
<b>Oscillation frequency</b>	1.667 Hz (100 cpm)
<b>Oscillation strain</b>	+/- 0.01° to 5° (+/- 0.14% to 70%), Programmable via Software Optional "M" version with mechanically fixed oscillation angle
<b>Torque range</b>	0.01 to 250 dNm
<b>Normal force / Pressure (opt.)</b>	0 to 10.000 kPa (1.450 lbin), Auto tare
<b>Temperature control system</b>	Ambient to 232 °C, precision +/- 0.03 °C, Max. heating rate: 85°C/min digital, microprocessor controlled
<b>Temperature check system</b>	Recordings of the temperature gradient on the screen, microprocessor monitored
<b>Measured Data</b>	Torque (dNm, lbf.in, kgf.cm), Temperature (°C, °F), Pressure (bar, kg per cm <sup>2</sup> ), Time (min - min / min - sec / sec), Shear rate (1/s, rad/s), Cure rate (1/min, 1/sec)
<b>Calculated Data</b>	S', S'', S''', tan δ, phase angle, cure rate, ...
<b>Data Interface</b>	Ethernet (10/100 MBit), USB (int.), CF card (int.), RS232 (opt.)
<b>Data points</b>	Over 3500 data points available for each test Including: S' Min, S' Max, TS 1, TS 2, TC 10, TC 30, TC 50, TC 90
<b>Pneumatics</b>	min. 4.5 Bar / 60 psi
<b>Electrical</b>	200-240 V, 6 Amps, 47-63 Hz, Single phase
<b>Instrument options</b>	- "M" version with mechanical drive system - Instrument control panel with 5" touchscreen display and printer - Adapted transducers for high or low-viscosity torque range - Normal force / Pressure measurement - Double channel forced air cooling system - Autoloader 5 or 10 sample linear - Autoloader with 24, 48 or 100 sample tray or tray changers - R-VS 3000 constant volume sample cutter - Label Printer - Signal tower ...

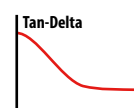
### Calculated results



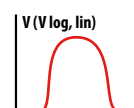
Elastic Modulus



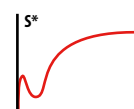
Viscous Modulus



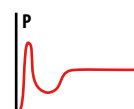
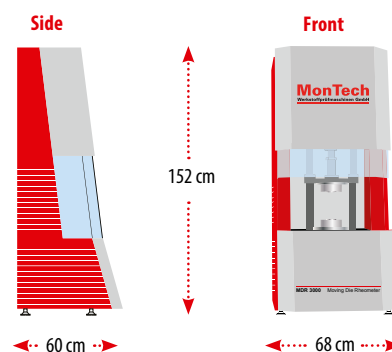
Tan - Delta



Vulcanization speed



Complex Modulus

Normal force / Pressure  
(optional available)

# MonTech MDR 3000 Professional Performance Moving Die Rheometer



## The MDR 3000 Professional

is designed for measuring the viscoelastic properties of polymers and elastomeric compounds before, during and after cure.

The acquired data gives exact information about advanced material properties, processability, cure characteristics, cure rate and the behavior of the compound at the after-cure as well as final compound dynamic mechanical properties.

The MDR 3000 Professional is a unique hybrid testing system; it can be operated in static testing (MDR) mode and with a single click in the MonControl Software, be switched over into dynamic testing (RPA) operation mode.

This provides the highest possible flexibility to the user as the MDR 3000 Professional can cover everyday routine QC tasks by working like a normal static Moving Die Rheometer at highest accuracy, repeatability and reproducibility while offering full Rubber Process Analyzer testing capabilities for even complex R&D testing, allowing the user to program, execute and evaluate arbitrary test sequences with the included MonControl Software.

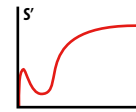
The instrument is equipped with MonTech's unique, patented direct precision drive system, offering variable oscillation amplitude and frequency along with precision temperature control, enabling testing according to almost every DIN / ISO and ASTM test standard in reference to Moving Die Rheometers and Rubber Process Analyzers.

Due to the rugged and flexible construction and various options such as cooling and automation, this device can be used for extended quality control and production monitoring purposes not only in the laboratory, but also directly on the shopfloor.

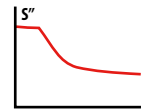
**Technical specification**

<b>International standards</b>	ISO 13145, ISO 6502, ASTM D 5289, ASTM D 6204, ASTM D 6601, ASTM D 6048, ASTM D 7050, ASTM D 7605, ASTM D 8059, DIN 53529, ...
<b>Die configuration</b>	Biconical, closed die system, sealed
<b>Die gap</b>	0.45 mm nominal
<b>Sample volume</b>	approx. 4.5 cm <sup>3</sup>
<b>Drive system</b>	Direct, wearless servo drive system with ceramic bearings
<b>Closing system</b>	Soft closing to prevent foil rips and damage of test sample
<b>Oscillation frequency</b>	0.001 Hz to 33 Hz (0.001 Hz to 50 Hz optional) (0.05 to 2000 cpm (0.05 to 3000 cpm))
<b>Oscillation strain</b>	+/- 0.01° to 20° (+/- 0.01° to 90° optional) (+/- 0.14% to 280% (0.14% to 1260%))
<b>Torque range</b>	0.001 to 250 dNm
<b>Normal force / Pressure (opt.)</b>	0 to 10.000 kPa (1.450 lbin), Auto tare
<b>Temperature control system</b>	Ambient to 232 °C, precision +/- 0.03 °C, Max. heating and cooling rate: 85°C/min, digital, microprocessor controlled (Pneumatic double channel cooling system optional)
<b>Temperature check system</b>	Recordings of the temperature gradient on the screen, microprocessor monitored
<b>Measured Data</b>	Torque (dNm, lbf.in, kgf.cm), Shear modulus (Pa, dynes/cm <sup>2</sup> , psi), Dynamic viscosity (Pa s), Temperature (°C, °F), Pressure (bar, kg per cm <sup>2</sup> ), Time (min - min / min - sec / sec), Frequency (Hz, cpm), Shear rate (1/s, rad/s), Strain (deg, %), Cure rate (1/min, 1/sec)
<b>Subroutines</b>	Isothermal, Non-Isothermal, Timed, Temperature Sweep, Strain Sweep, Frequency Sweep, Shear rate Sweep, Relaxation, Retardation, Hysteresis, Tension tests, LAOS, ...
<b>Calculated Data</b>	S', S'', S*, G', G'', G*, tan δ, phase angle, cure rate, η', η'', η*, ...
<b>Data Interface</b>	Ethernet (10/100 MBit), USB (int.), CF card (int.), RS232 (opt.)
<b>Data points</b>	Over 3500 data points available for each static subtest <i>Including:</i> S' Min, S' Max, TS 1, TS 2, TC 10, TC 30, TC 50, TC 90 Integrated, automatic reporting features for dynamic tests
<b>Pneumatics</b>	min. 4.5 Bar / 60 psi
<b>Electrical</b>	200-240 V, 6 Amps, 47-63 Hz, Single phase
<b>Instrument options</b>	- Instrument control panel with 5" touchscreen display and printer - Adapted transducers for high or low-viscosity torque range - Normal force / Pressure measurement - Double channel forced air cooling system - Low-temperature cooling system MCool 10 / MCool -40 - Autoloader 5 or 10 sample linear - Autoloader with 24, 48 or 100 sample tray or tray changers - R-VS 3000 constant volume sample cutter

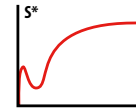
**Calculated results**



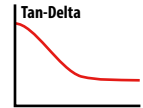
Elastic Torque



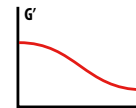
Viscous Torque



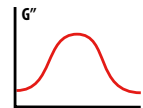
Complex Torque



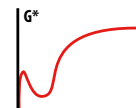
Tan-Delta



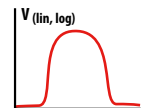
Storage Shear Modulus



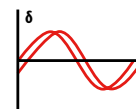
Loss Shear Modulus



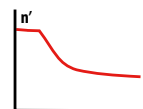
Complex Shear Modulus



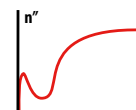
Vulcanization speed



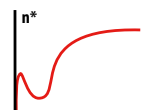
Loss Angle



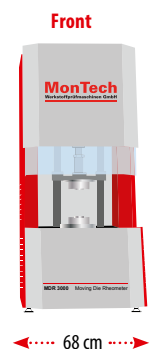
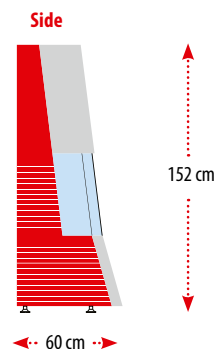
Real Dynamic Viscosity



Imaginary Dynamic Viscosity



Dynamic Complex Viscosity





# MonTech D-MDR 3000 Advanced Dynamic Moving Die Rheometer

## The D-MDR 3000

is designed for measuring the viscoelastic properties of polymers and elastomeric compounds before, during and after cure. The acquired data gives exact information about advanced material properties, processability, cure characteristics, cure rate, behavior of the compound at the after-cure and final compound dynamic mechanical properties, with an unlimited amount of testing steps and subroutines.

The D-MDR 3000 is the universal dynamic Moving Die Rheometer, providing the highest testing flexibility for static as well as dynamic testing applications for all kinds of rubber, rubber-like, curing or crosslinking materials.

This includes, of course, all kinds of rubber materials filled with carbon black, silica or any other type of organic or inorganic filler, as well as TPE, TPV, LSR, and Composite Materials such as Prepregs, Polyolefins, Glues, Gelatine, ....

Utilizing a unique, patented, wearless direct drive design with digital drive and control technology, the D-MDR 3000 can cover almost every possible test condition in any combination, with shear rates up to 500 sec<sup>-1</sup>.

Temperature in the dies is precisely controlled and the unique direct double channel forced air cooling system not only enables rapid cooling to the setpoint but also allows non-isothermal testing and integrated friction heat compensation essential to high-strain testing.

High precision torque and force measurements, in conjunction with the high resolution motor feedback, guarantee the most precise and accurate torque readings to derive elastic modulus, measured as in-phase stress ( $S'$ ), and viscosity, measured as out-of-phase stress ( $S''$ ), as well as loss angle and tan-delta.

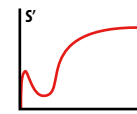
Based on this fundamental measurement data, modulus (G), dynamic viscosity ( $\eta$ ), Compliance (J), Tensile Modulus (E), Compliance under extension/compression (D), Spring rate (K) and Damping coefficient (C) are calculated.



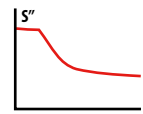
## Technical specification

<b>International standards</b>	ISO 13145, ISO 6502, ASTM D 5289, ASTM D 6204, ASTM D 6601, ASTM D 6048, ASTM D 7050, ASTM D 7605, ASTM D 8059, DIN 53529, ...
<b>Die configuration</b>	Biconical, closed die system, sealed
<b>Die gap</b>	0.45 mm nominal, variable die gap and closing force optional
<b>Sample volume</b>	approx. 4.5 cm <sup>3</sup>
<b>Drive system</b>	Direct, wearless servo drive system with ceramic bearings
<b>Closing system</b>	Soft closing to prevent foil rips and damage of test sample
<b>Oscillation frequency</b>	0.001 Hz to 100 Hz (0.05 to 6000 cpm)
<b>Oscillation strain</b>	+/- 0.001° to 180° (+/- 0.014% to 2516%)
<b>Torque range</b>	0.001 to 250 dNm
<b>Normal force / Pressure (opt.)</b>	0 to 10.000 kPa (1.450 lbin), Auto tare
<b>Temperature control system</b>	Ambient to 232 °C, precision +/- 0.03 °C, Max. heating and cooling rate: 85°C/min, digital microprocessor controlled (Pneumatic double channel cooling system standard, low-temperature cooling systems (+10 / -40°C) optional)
<b>Temperature check system</b>	Recordings of the temperature gradient on the screen, microprocessor monitored
<b>Measured Data</b>	Torque (dNm, lbf.in, kgf.cm), Shear modulus (Pa, dynes/cm <sup>2</sup> , psi), Dynamic viscosity (Pa s), Temperature (°C, °F), Pressure (bar, kg per cm <sup>2</sup> ), Time (min - min / min - sec / sec), Frequency (Hz, cpm), Shear rate (1/s, rad/s), Strain (deg, %), Cure rate (1/min, 1/sec)
<b>Subroutines</b>	Isothermal, Non-Isothermal, Timed, Temperature Sweep, Strain Sweep, Frequency Sweep, Shear rate Sweep, Relaxation, Retardation, Hysteresis, Tension tests, LAOS, ...
<b>Calculated Data</b>	$S'$ , $S''$ , $S^*$ , $G'$ , $G''$ , $G^*$ , $\tan \delta$ , phase angle, cure rate, $\eta'$ , $\eta''$ , $\eta^*$ , ...
<b>Data Interface</b>	Ethernet (10/100 MBit), USB (int.), CF card (int.), RS232 (opt.)
<b>Data points</b>	Over 3500 data points available for each static subtest Including: $S'$ Min, $S'$ Max, TS 1, TS 2, TC 10, TC 30, TC 50, TC 90 Integrated, automatic reporting features for dynamic tests
<b>Pneumatics</b>	min. 4.5 Bar / 60 psi
<b>Electrical</b>	200-240 V, 6 Amps, 47-63 Hz, Single phase
<b>Instrument options</b>	<ul style="list-style-type: none"> <li>- Instrument control panel with 5" touchscreen display and printer</li> <li>- Adapted transducers for high or low-viscosity torque range</li> <li>- Normal force / Pressure measurement</li> <li>- Cavity pressure control system</li> <li>- High speed data acquisition</li> <li>- Low-temperature cooling system MCool 10 / MCool -40</li> <li>- Autoloader 5 or 10 sample linear</li> <li>- Autoloader with 24, 48 or 100 sample tray or tray changers</li> <li>- R-VS 3000 constant volume sample cutter</li> </ul>

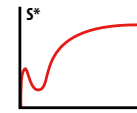
## Calculated results



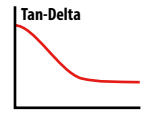
Elastic Torque



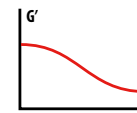
Viscous Torque



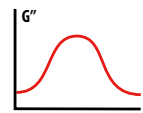
Complex Torque



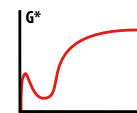
Tan-Delta



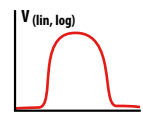
Storage Shear Modulus



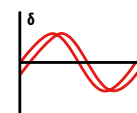
Loss Shear Modulus



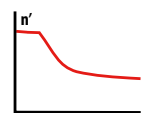
Complex Shear Modulus



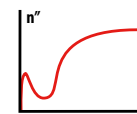
Vulcanization speed



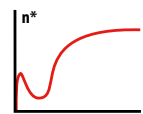
Loss Angle



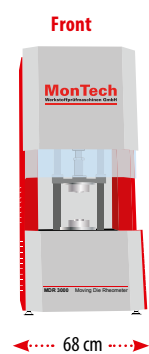
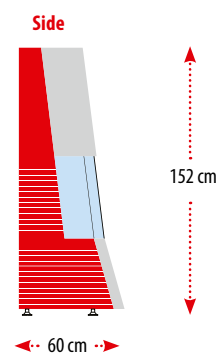
Real Dynamic Viscosity



Imaginary Dynamic Viscosity



Dynamic Complex Viscosity



# MonTech D-RPA 3000 Flagship Dynamic Rubber Process Analyzer

## The D-RPA 3000

is designed for measuring the viscoelastic properties of polymers and elastomeric compounds before, during and after cure. The acquired data gives exact information about the processability, cure characteristics, cure rate and behavior of the compound at the after-cure.

The D-RPA 3000 fulfills the complete range of all test requirements; Polymers, raw materials, basic, finished and cured compounds can all be characterized. Besides the cure properties, cure characteristics and processability can all be determined and evaluated.

The D-RPA 3000 is the state-of-the-art machine for dynamic testing purposes. The machine can be fitted with several unique options such as variable die gap, low-temperature cooling, and high speed data acquisition - providing the highest frequency-strain combination available on the market.

The high flexibility of the D-RPA 3000 allows the user to program and execute arbitrary test sequences with the MonControl Analyses Software. Each dynamic test sequence can include an unlimited number of the following substeps: timed tests, isothermal tests, non-isothermal tests, amplitude sweeps, frequency sweeps, temperature sweeps, shear rate sweeps, relaxations, retardations, hysteresis and tension tests. Of course, any combination of these sub-tests are possible - with or without an initial strain, as well as strain or stress controlled.

Equipped with single test - multi subtest test procedure programming with up to 1000 sub-programs as well as an unbeaten shear rate range of up to  $1000 \text{ sec}^{-1}$  - the D-RPA 3000 is truly the most flexible and dynamic multi function Rheometer in the market.



## Completely closed, directly heated, biconical test chamber system

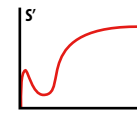
entirely made of high-strength stainless steel, precision ground and hardened, significantly reducing sample slippage for highest dynamic test ranges and most accurate torque, modulus and viscosity readings.



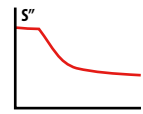
## Technical specification

<b>International standards</b>	ISO 13145, ISO 6502, ASTM D 5289, ASTM D 6204, ASTM D 6601, ASTM D 6048, ASTM D 7050, ASTM D 7605, ASTM D 8059, DIN 53529, ...
<b>Die configuration</b>	Biconical, closed die system, sealed
<b>Die gap</b>	0.45 mm nominal, variable die gap and closing force optional
<b>Sample volume</b>	approx. 4.5 cm <sup>3</sup>
<b>Drive system</b>	Advanced wearless servo drive system with ceramic bearings
<b>Closing system</b>	Soft closing to prevent foil rips and damage of test samples, optionally variable closing force and die gap
<b>Oscillation frequency</b>	0.001 Hz to 100 Hz (0.05 to 6000 cpm)
<b>Oscillation strain</b>	+/- 0.0001° to 360° (+/- 0.0014% to 5032%)
<b>Torque range</b>	0.0001 to 250 dNm
<b>Normal force / Pressure (opt.)</b>	0 to 10.000 kPa (1.450 lbin), Auto tare
<b>Temperature control system</b>	Ambient to 232 °C, precision +/- 0.03 °C, Max. heating and cooling rate: 85°C/min, digital, microprocessor controlled (Pneumatic double channel cooling system standard, low-temperature cooling systems (+10 / -40°C) optional)
<b>Temperature check system</b>	Recordings of the temperature gradient on the screen, microprocessor monitored
<b>Measured Data</b>	Torque (dNm, lbf.in, kgf.cm), Shear modulus (Pa, dynes/cm <sup>2</sup> , psi), Dynamic viscosity (Pa s), Temperature (°C, °F), Pressure (bar, kg per cm <sup>2</sup> ), Time (min - min / min - sec / sec), Frequency (Hz, cpm), Shear rate (1/s, rad/s), Strain (deg, %), Cure rate (1/min, 1/sec)
<b>Subroutines</b>	Isothermal, Non-Isothermal, Timed, Temperature Sweep, Strain Sweep, Frequency Sweep, Shear rate Sweep, Relaxation, Retardation, Hysteresis, Tension tests, LAOS, ...
<b>Calculated Data</b>	$S'$ , $S''$ , $S^*$ , $G'$ , $G''$ , $G^*$ , $\tan \delta$ , phase angle, cure rate, $\eta'$ , $\eta''$ , $\eta^*$ , ...
<b>Data Interface</b>	Ethernet (10/100 MBit), USB (int.), CF card (int.), RS232 (opt.)
<b>Data points</b>	Over 3500 data points available for each static subtest <i>Including:</i> $S'$ Min, $S'$ Max, TS 1, TS 2, TC 10, TC 30, TC 50, TC 90 Integrated, automatic reporting features for dynamic tests
<b>Pneumatics</b>	min. 4.5 Bar / 60 psi
<b>Electrical</b>	200-240 V, 6 Amps, 47-63 Hz, Single phase
<b>Instrument options</b>	<ul style="list-style-type: none"> <li>- Instrument control panel with 5" touchscreen display and printer</li> <li>- Adapted transducers for high or low-viscosity torque range</li> <li>- Normal force / Pressure measurement</li> <li>- Cavity pressure control system</li> <li>- High speed data acquisition</li> <li>- Low-temperature cooling system MCool 10 / MCool -40</li> <li>- Autoloader 5 or 10 sample linear</li> <li>- Autoloader with 24, 48 or 100 sample tray or tray changers</li> <li>- R-VS 3000 constant volume sample cutter</li> </ul>

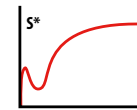
## Calculated results



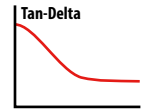
Elastic Torque



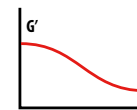
Viscous Torque



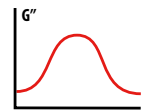
Complex Torque



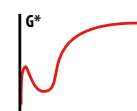
Tan-Delta



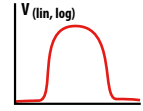
Storage Shear Modulus



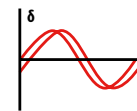
Loss Shear Modulus



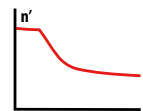
Complex Shear Modulus



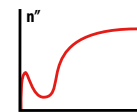
Vulcanization speed



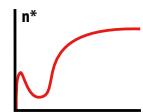
Loss Angle



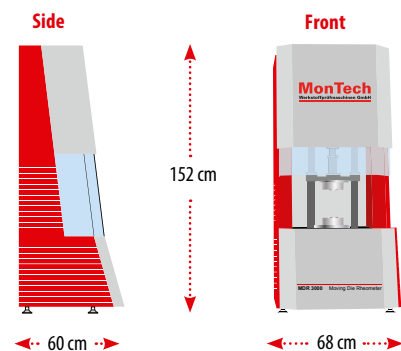
Real Dynamic Viscosity



Imaginary Dynamic Viscosity



Dynamic Complex Viscosity





# MonTech Moving Die Rheometer

## Automation options

**All MonTech Moving Die Rheometers as well as Rubber Process Analyzers can be easily automated, allowing customers to increase productivity and release operators for other important tasks.**

MonTech offers the worlds largest Rheometer Automation portfolio designed for our customers to rely on - in the lab or on the shopfloor, in multiple shifts, 365 days, every year.

Depending on the selected type of automation system, samples are loaded and unloaded automatically from linear or rotary trays, film is fed and tested samples are removed automatically.

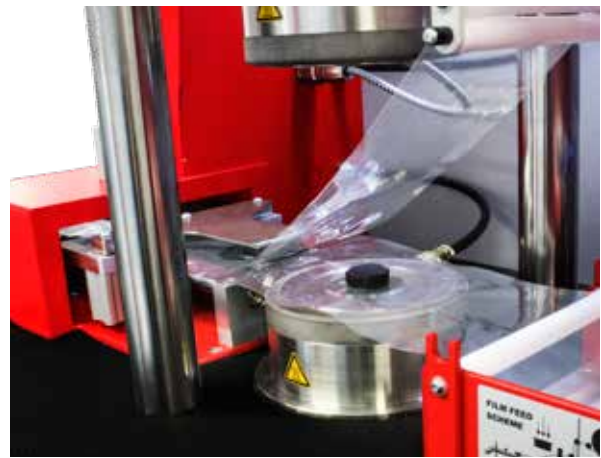
Of course, every automated machine can - within a single click - also be switched into manual operation mode.

### Semi Automation

#### Testing made easy:

The semi-automated loader consists of an automatic film feeding system, eliminating the need to manually handle testing film.

This semi-automatic system is especially popular for online testing requirements where workers are cutting warm samples directly from the mill and feeding them into the Rheometer. This means that no delay for queuing or handling the sample can be accepted. However, handling testing film is not easy for workers wearing protective gloves, and can cause variations in test results if film is not placed correctly, or if more than one layer of testing film is used on either the lower or upper die. Therefore, the semi automation automatically provides film transportation and removal of the tested sample so that the operator just has to place the test sample and hit the start button.



### Linear Automation

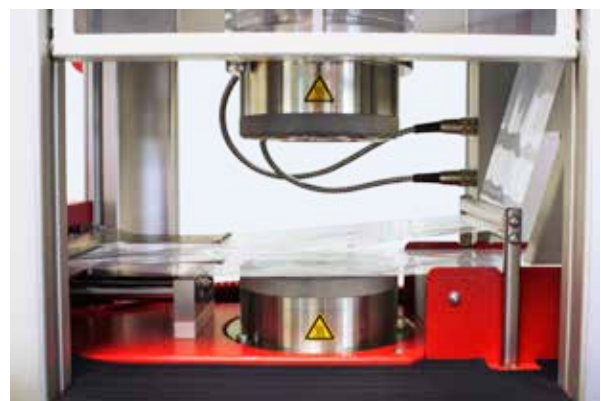
#### Easily increasing productivity:

Linear Automation systems are mainly used for online testing, utilizing a fast and reliable direct conveyor feeder with the lower film as transportation carrier.

**5 Samples:** This system features automated sample loading and unloading with a linear queue of 5 test samples. This is ideally suitable for online testing purposes.

**10 Samples:** This system is equipped with the same features as, the 5 Sample linear loader but can queue up to 10 test samples, making this system ideally suitable for online testing purposes and for laboratory testing.

Linear automation systems are always the preferred choice for very sticky materials such as silicones or glue that sample loading arm systems might not be able to handle.





## Tray Automation

### Maximum efficiency:

Tray automation systems allow users to queue larger amounts of samples and leave the testing system running totally unattended over long periods. With MonTech's patented direct sample handling system, sample placement accuracy and test result repeatability is significantly increased. Samples are handled and monitored by a high-volume vacuum system, ensuring perfect sample pickup, transportation and drop-off - even for less than ideal test samples.

### 24, 48 or 100 samples tray

This system features automated sample loading and unloading with a direct tray-to-chamber handling system. A interlocking rotary tray with a capacity of 24, 48 or 100 samples is integrated into the right side of the instrument, minimizing the overall footprint of the testing system.

Test samples are queued in the software with their individual identification and test specifications, picked up from the tray and directly placed into the test chamber. Of course, the test queue can be altered at any time, samples can be skipped, planned stops can be inserted and immediate tests can be performed. Film is fed and monitored automatically and tested samples are immediately removed once tests are finished.

Tray automation systems are especially suitable for operator-less testing over long testing times, significantly increasing instrument and lab productivity.



Automation option		MDR 3000 Basic	MDR 3000	MDR 3000 Prof.	D-MDR 3000	D-RPA 3000
	Semi	-	x	x	x	x
Linear	5 Samples linear	x	x	x	x	x
	10 Samples linear	x	x	x	x	x
Tray	24 Samples tray	x	x	x	x	x
	48 Samples tray	x	x	x	x	x
	100 Samples tray	-	x	x	x	x
Tray changer	10x24 tray changer	-	x	x	x	x
	10x48 tray changer	-	x	x	x	x

x = available - = not possible

## Tray change Automation

Tray change systems feature similar sample handling like the tray automation but additionally offer an automated 10-slot tray changer system. This results in a 10 times higher sample queuing capacity, allowing the machine to run continuously for multiple days or even weeks.

### 10 x 24 and 10 x 48 samples tray changer

The fully enclosed tray change system features automated sample loading and unloading with a direct tray-to-chamber handling system and a separate tray handling mechanism.

Up to 10 rotary tables with a stock of 24 or 48 samples each can be stored at the instrument and automatically processed. Trays are automatically moved into loading and unloading positions, where the samples are picked from the trays and directly placed into the test chamber.

For all automation systems various options such as film-out sensors, alignment systems, ... are available.

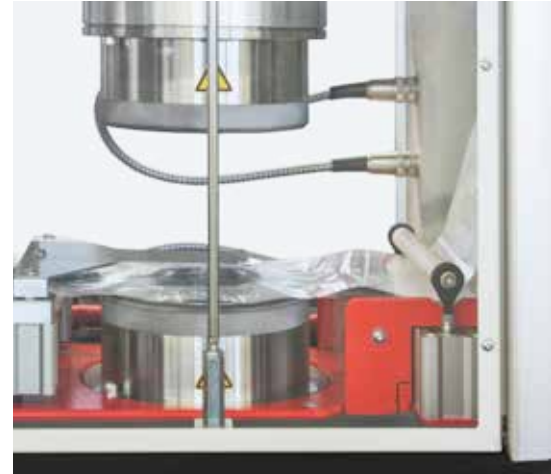
# MonTech Automation options in detail



Sample queueing and sample detection sensors for fully monitored sample handling.



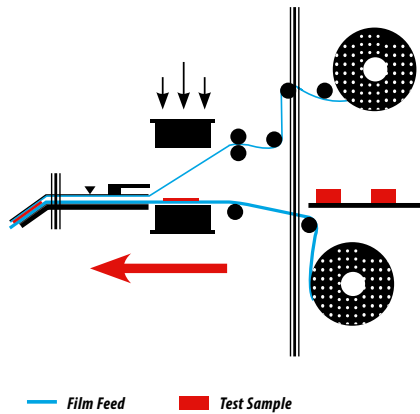
Every step in the sample handling process is closely monitored to have full sample traceability.



Integrated sample scrapers and film guides prevent film breakage and ensure proper sample removal.



High volume vacuum handling of samples guarantee proper sample handling and placement.



Reliable feeding and transportation of testing films from 2 or optionally 4 rolls.



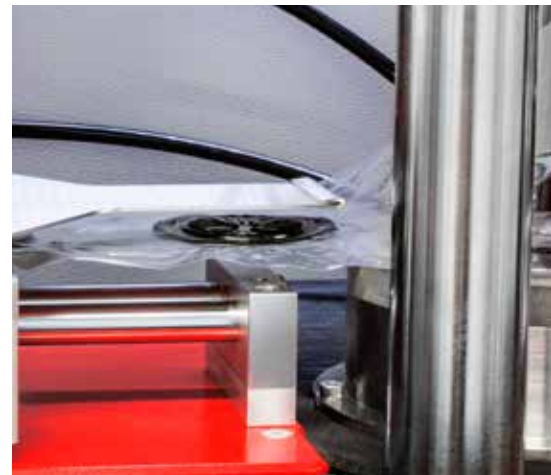
Precise film guiding to avoid any crinkles or folding of the testing film.



With direct tray-to-chamber handling, the sample arm picks samples from the tray. The testing area of 3000 Series is completely protected by a supervised safety door.



Monitored sample placement directly into the center of the die.



Haul-off mechanism: Sample removal, film guide and feeding



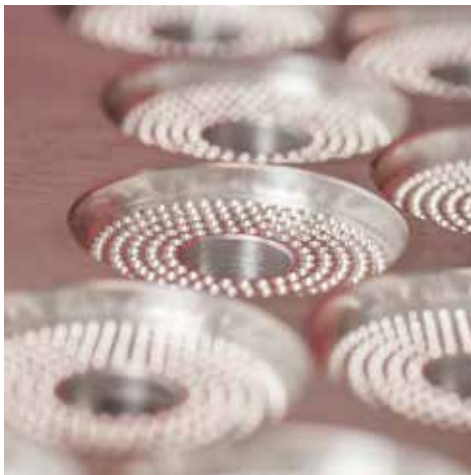
All sample movements are closely monitored by special proximity sensors, light barriers, vacuum or camera. This standard feature on all linear and tray systems ensures full sample traceability and prevents any loss of samples. Optionally, barcode or RFID readers can be directly integrated into the instrument or sample tray.



Samples can be grouped together for easy operator recognition, with room for running immediate tests between scheduled sequences.



Safe, reliable and automated sample removal and film advancement.



Special anti-tack machined sample tray provides high reliability for sample detection, pick-up and handling.

# MonTech

## Advanced instrument options for MDRs and RPAs

### Cooling systems

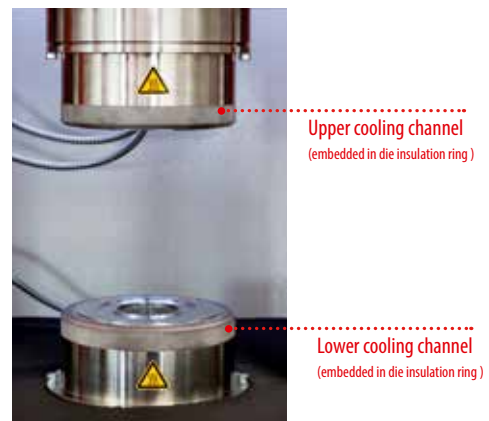
#### Pneumatic cooling system

Both chambers are cooled separately by a PID-controlled forced air cooling system.

In MDR mode this system can be used to rapidly cool the instrument from a higher to any lower testing temperature and therefore significantly reduce non-productive time of the instrument as well as shorten stabilization and operator waiting times.

Forced air cooling systems enable cooling at any point during test sequences in non-Isothermal and RPA operation modes, allowing test definitions to follow precise cooling ramps and steps. Cooling can also be used to conduct heat from the sample when friction heat is a concern, such as testing with high shear rates.

#### Forced air cooling operation principle:



	MDR 3000 Basic	MDR 3000	MDR 3000 Professional	D-MDR 3000	D-RPA 3000
<b>Pneumatic</b>	0	0	0	S	S
<b>MCool 10</b>	-	-	0	0	0
<b>MCool -40</b>	-	-	-	-	0

- = not available    S = Standard    0 = Option

#### MCool 10

Integrated cartridge cooling system that separates the provided air streams into cold (-45°C) and hot (+110°C) fractions to enhance the performance of the machine compared to the standard pneumatic cooling system.

This system is especially suitable for testing at or below room temperature in order to provide the most accurate test results as well as correlations with final product application environments.

This system is highly recommended for dynamic testing on very soft rubbers, polymers and silicones.

The operation principle of the MCool 10 cooling system is very simple:

Air is accelerated and separated in cartridge centrifuges.

Afterwards the cold fraction of the air is used for separate cooling of both test dies down to +8°C.

Only a forced air supply with at least 4 Bars is required - there are no additional chillers or cooling liquids needed.

(Performance of the cooling systems depends on supplied air).

This technology is worldwide patented by MonTech.

#### MCool -40

The advanced MCool -40 cooling system features a liquid cooling system with external chiller system.

Both dies are separately chilled and cooled by an external cooling unit that is connected with the instrument.

The cooling system works as an addition to the pneumatic cooling system - only if lower temperatures are required the chiller will be started to cool down the dies as low as -40° Celsius.

This makes the instrument equipped with this cooling system the ideal Dynamic Mechanical Rheological Testing System:

The machine is able to run anything from sample curing down to glass transition testing.

The total heating system of the dies remains unchanged so that instruments equipped with this device are absolutely comparable with any other Moving Die Rheometer or Rubber Process Analyzer. This technology is worldwide patented by MonTech.



## Advanced technology options

### Axial force transducer system for normal force measurement

Features a combined torque / force transducer to measure torque as well as die cavity pressure (derived from the normal force) directly in the test chamber. Before each test, the transducer and amplifier is balanced automatically.

The system also includes a second channel amplifier system for realtime simultaneous measurements of torque and normal force with a data acquisition rate of 10 kHz.

### Cavity pressure controller system

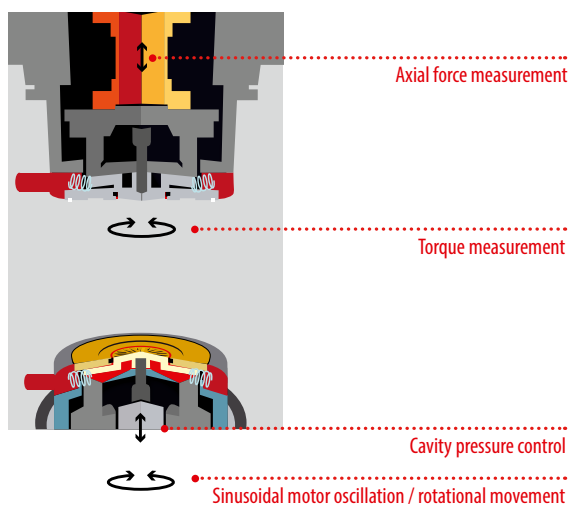
With this option, cavity pressure can also be controlled either to a pre-programmed or to an online calculated pressure level.

The closing force and die gap are designed as a variable, independent axis, so that the cavity pressure can be precisely controlled.

This system is especially suitable for test sequences that include curing as well as a cool-down of the sample for a dynamical

mechanical analysis, and can be utilized to compensate for material shrinkage as well as to avoid any slippage in the test chamber.

This technology is worldwide patented by MonTech.



### High speed data acquisition system

The high speed DAQ option offers unique result stream resolution as well as an ultimate level of precision for the torque signal and motor position.

Both channels are sampled and processed simultaneously with 24-bit resolution at a data rate of 180 kHz.

All data streams are provided on the PC and calculated online in a realtime kernel.

It is also possible to save the raw data streams to the PC's memory.

This makes the system especially suitable for FT-Rheology purposes as well as applications that require precise analysis of

material responses in any harmonic such as the characterisation of long-chain branching. The high speed data acquisition system is especially suitable for analyzing the non-linear material response by LAOS (Large Amplitude Oscillatory Shear) measurements.

The scope of supply includes the MonLAOS software system (see page 112 for details) with full FT - Rheology capability to analyze the frequency spectrum of the materials response, higher harmonics, for calculating Chebyshev coefficients and the Long Chain Branching Index (LCBI)



# MonTech Rheometer

## Data and productivity options

Increase productivity and efficiency of your testing system with MonTech's unique data and productivity options:

### Data / IT options

#### Integrated Industrial computer

From harsh mixing plants to cleanrooms, special environments demand special encapsulation and protection of the computer system for controlling and managing the instrument.

MonTech therefore offers machine integrated and machine mounted computer systems in various protection ratings, guaranteeing the highest reliability under even the toughest environmental conditions.

#### Instrument Control Panel

Allows the machine to be operated from a remote computer or completely standalone for simple quality control and printing results.

#### RS 232 Logic Interface

Compatibility to older host or software systems as well as interfacing with proprietary third party software systems is no problem for MonTech testing instruments.

Every machine can be equipped with a serial RS232 bi-directional interface to program the instrument as well as retrieve test data and results by a simple, standardized ASCII protocol.

#### Result and Label Printer

All test results can be directly printed from the instrument through an optional printer. Of course reports for single test results, test series reports and even Pass/Fail labels with or without barcodes are available for printing.

#### Additional Instrument Outputs

Additional, programmable output signals for switching auxiliary units and devices attached to the instrument or its environment such as: chillers, Ventilation systems, ...

#### Signal tower

For direct Pass / Fail operator feedback

### Productivity options

#### Enhanced instrument protection

Explosive, corrosive, cleanroom or other critical environments are no problem for MonTech rubber testing machinery.

All instruments can be tailored to meet any International Protection Rating that our customer's environment requires.

#### Instrument table or cart

For flexible instrument setup and utilization, MonTech offers movable instrument carts, fixed workbench carts and movable closed-instrument carts.

Please contact us to discuss your individual instrument setup and space requirements to identify your ideal workplace scenario.

#### Forced air aspiration system

For a safe workplace free from smells and fumes, even when testing aggressive or hazardous materials, a forced ventilation and aspiration system can be fitted to every MonTech Rheometer.

Optionally activated carbon filtration systems can directly be integrated into the instrument.



5" Color Touchscreen Instrument control panel

## Traceable Calibration Torque Standards

MonTech offers a full range of high precision, internationally traceable reference calibration standards for instrument calibration and verification purposes.

### Torque calibration standard

MonTech's advanced, fully elastic torsion torque standards have been specially developed for the highest calibration precision of Moving Die Rheometers. Compression as well as clamping types are available. Torque standards allow users, in combination with the MonTech easy calibration system, to verify as well as calibrate the instrument directly, significantly increasing data confidence and instrument uptime.

All MonTech torque standards are fully traceable to national and international standards with overall uncertainties of less than 0.35%.

Torsion springs and torque standards can be calibrated under static and dynamic conditions at single or multiple deflection angles providing additional information on linearity as well as continuous stress-strain profiles by linear regression calculations.

MonTech calibrates torque standards and offers preventive maintenance programs that include accredited calibration.



Compression Torque Standard



Clamping Torque Standard

## Reference Materials

Besides reference standards, MonTech offers reference materials for instrument verification purposes.



### Reference compound for Rheometer

SBR or EPDM reference compound for Rheometer cure and dynamic testing, allowing customer to easily verify and perform consistency checks on MDRs and RPAs. Material is supplied as slabs or pre-cut samples with film. Each lot comes with a test certificate and round-robin / interlab validation. Compound stability is typically good for up to 3 months. Various standard and customer specific delivery plans are available.

## *Moving Die Rheometer*



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