



ThermoFisher
SCIENTIFIC

Introducing the **NEW** HAAKE MARS iQ series

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HAAKE MARS iQ series

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Applications and Measurements

- Viscosity measurements
- Yield stress / thixotropy
- Oscillatory tests
- Axial tests

- Viscosity measurements
- Yield stress / thixotropy
- Tribology

- Viscosity measurements
- Yield stress / thixotropy
- Oscillatory tests

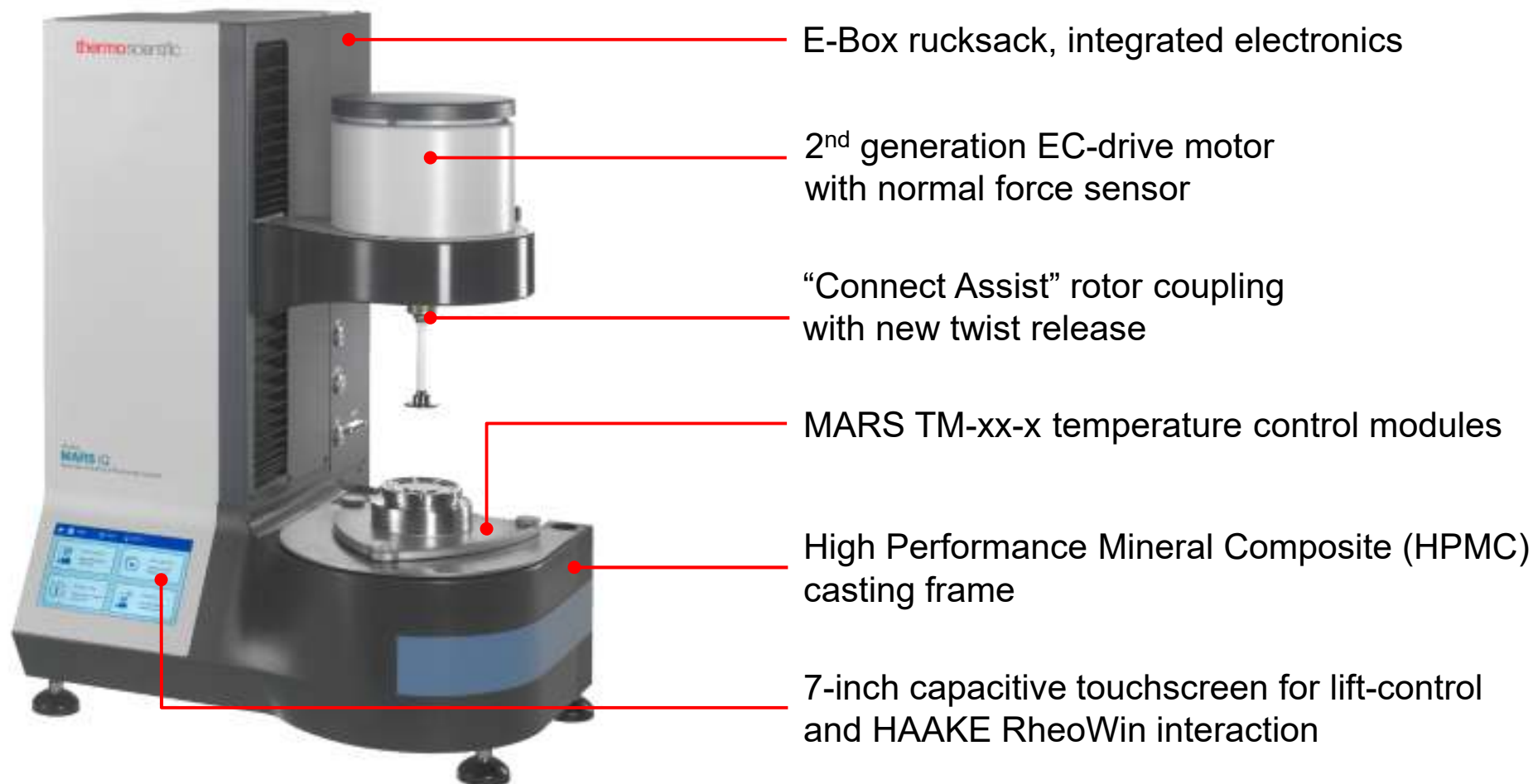


- Oscillatory tests

- Viscosity measurements
- Yield stress / thixotropy

- Viscosity measurements
- Yield stress / thixotropy
- Oscillatory tests

MARS iQ technology – highlights at a glance



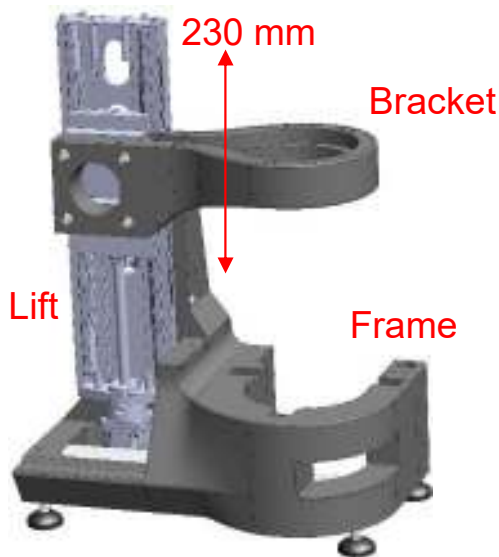
A choice between two models:

- MARS iQ with a ball-bearing EC drive motor
- MARS iQ Air with an air-bearing EC drive motor covers much wider torque range

MARS iQ technology

The Frame

- Completely new, very **spacious**, folded H-frame design with **high stiffness** and **large lift travel**
- Instrument frame and bracket for drive motor made from **High Performance Mineral Composite (HPMC)** casting material
- HPMC frame with **unmatched stiffness, vibration damping and temperature stability**
- Completely integrated electronics (no additional box)
- Frame with **278 degree access** to sample area (ideal for sample loading and trimming)



MARS iQ technology

HPMC casting material

- **High Performance Mineral Composite** (HPMC) casting material used for MARS iQ series frame and drive motor bracket is specially formulated mineral composite casting **optimized for use in a rheometer**

A high tech material

- Mineral composite casting is not only widely used in (large) machine beds/frames but also in smaller device in medical sector, as well as for solar technology, electronics and packaging industries
- Because of **outstanding vibration damping, chemical resistance and thermal properties**, it is often used as alternative to steel, grey cast iron, iron castings or aluminum

An eco friendly material

- Amount of energy need to create composite mineral casted parts is significantly lower of that needed for creating similar parts from cast iron, steel or aluminum
- Composite mineral casted parts can be shredded and handled like common (stone/concrete) building rubble

MARS iQ technology

The Lift

- Direct drive lift with highly accurate **linear optical encoder**
- Gap setting accuracy $< 1 \mu\text{m}$ for **precise gap setting** of parallel plate and cone & plate geometries
- **Lift speed** from $0,05 \mu\text{m/s}$ to 20 mm/s
- **Large lift travel 230 mm** for convenient mounting of larger measuring setups and accessories such as:

Building material cell



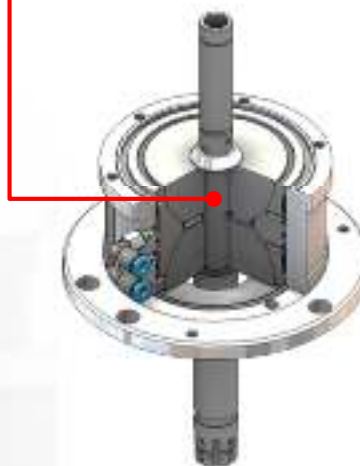
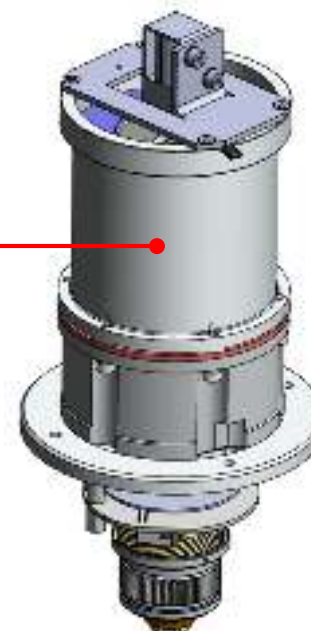
Pressure cells



MARS iQ technology

Drive motor and air-bearing

- 2nd generation **EC drive motor** with CR-mode, CD-mode and CS-Mode for both rotational and oscillatory rheometry
- New hybrid (digital/analog) motor control
- Lowest torque < 1 μNm (MARS iQ Air)
- 2nd generation **double spherical air-bearing** with increased stiffness, lower air-consumption (≈ 1.0 l/min)



Available measuring modes & rheological tests

Ball bearing



Air bearing



	VTIQ	MARS iQ	VTIQ Air	MARS Air	MARS 40/60
Flow/viscosity curve	✓	✓	✓	✓	✓
Controlled stress tests	✓	✓	✓	✓	✓
Creep and recovery	✗	✗	✗	✓	✓
Oscillatory tests	(✓)	✓	✓	✓	✓
Temperature ramp	✓*	✓	✓*	✓	✓
Axial tests/ NF measurements	✗	(✓)	✗	✓	✓

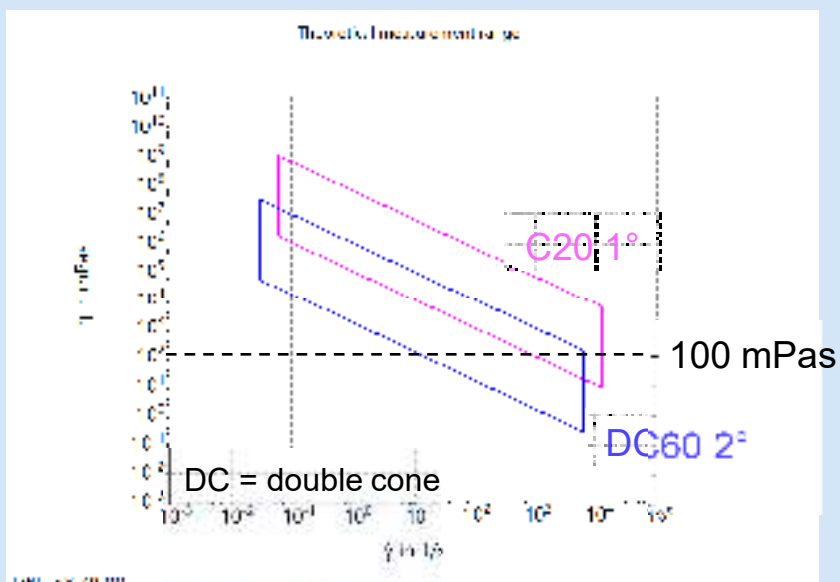
(✓) optional

* only with coaxial cylinders according to DIN 53019 / ISO 3219

Measuring ranges in Controlled Rate mode

MARS iQ

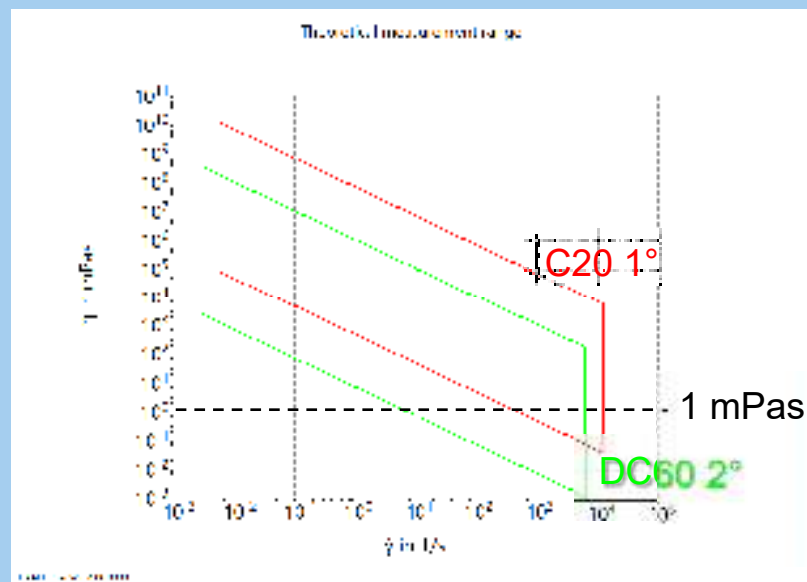
- Medium viscous fluids up to stiff pastes
- Limited measuring range for viscosities below ~ 100 mPas



- Coaxial cylinders, large cone & plate, parallel plate and double cone geometries for medium viscous fluids

MARS iQ Air

- Low viscous fluids up to stiff pastes



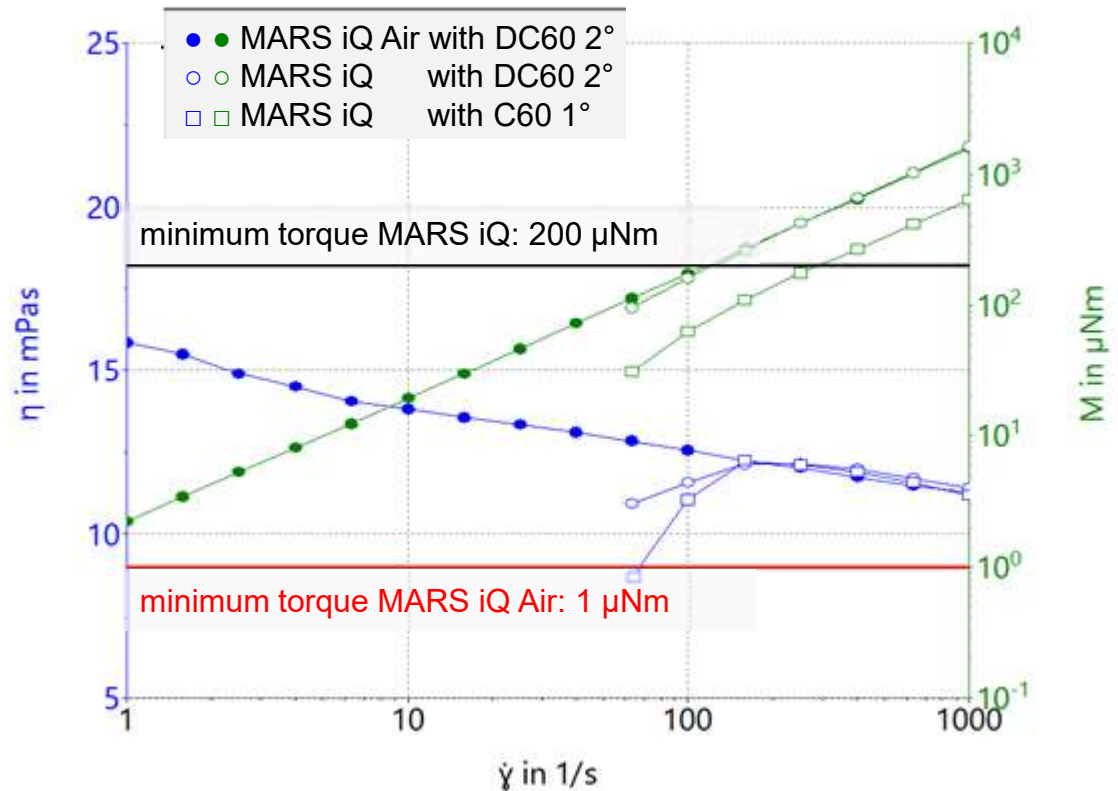
- Coaxial cylinders, large cone & plate, parallel plate and double cone geometries for low viscous fluids

- Small diameter cone & plate geometries with small cone angles for stiffer pastes
- Parallel plates with small measuring gaps for high shear rates

Viscosity measurements - low viscous fluids

Viscosity curve of coffee creamer

- MARS iQ provides accurate viscosity data at shear rates from around 100 s^{-1} on
- MARS iQ Air provides accurate viscosity data at shear rates from around 1 s^{-1} on



MARS iQ Air works for low viscous fluids:

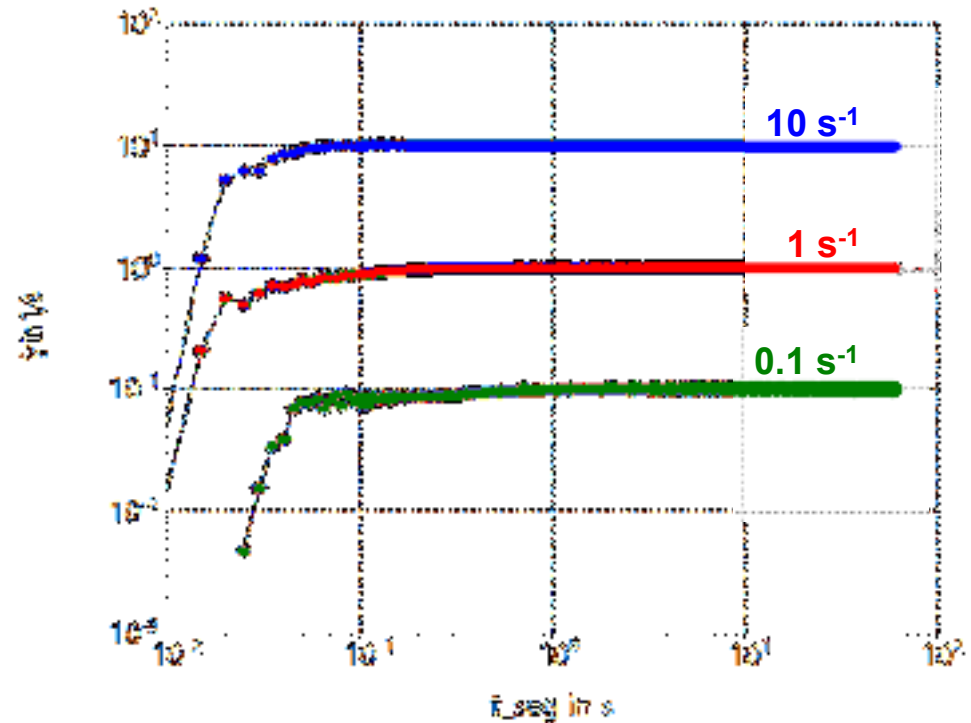
Fruit juice, milk, cream, inks, low viscous solutions and dispersions

Viscosity measurements – step times

Strain rate step tests with hair styling gel

- Strain rate step test with viscoelastic hair styling product
- EC Motor of the MARS iQ is highly dynamic in adjusting a constant shear rate
- 95 % of set value is reached after:

Shear rate set value	t (95% of set value)
0.1 s^{-1}	0.5 s
1 s^{-1}	0.1 s
10 s^{-1}	0.06 s

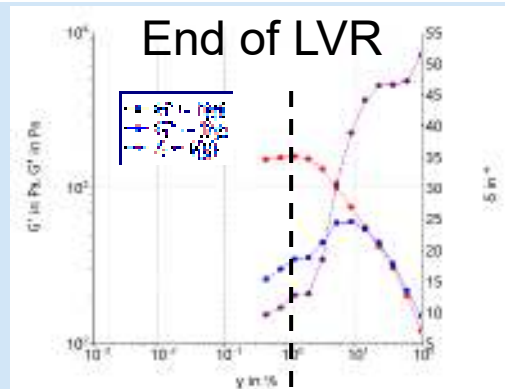


Oscillatory tests – comparison of measuring ranges

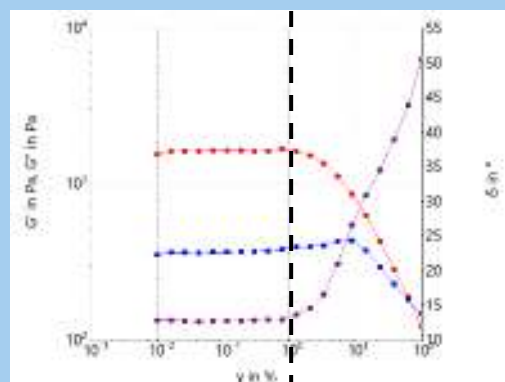
Amplitude sweep cosmetic cream

- 60 mm parallel plates, 1mm gap
- Linear viscoelastic range limit can be reached with MARS iQ
- MARS iQ Air and MARS 60 can measure more than one decade below LVR limit
- MARS iQ can be used in oscillation mode for stiffer creams and pastes such as
 - Moisturizing creams, ointments (no lotions, shower gels etc.!))
 - Food spreads (mayonnaise, mustard..)
 - Printing pastes

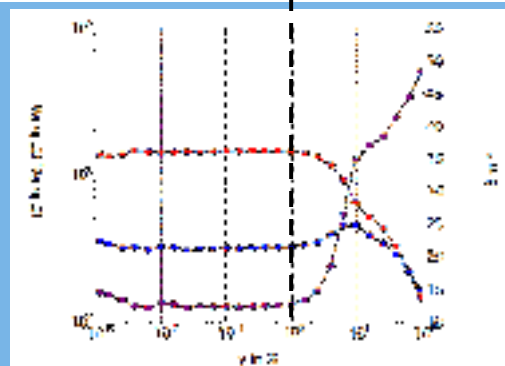
MARS iQ
 $M_{d,min} = 200 \mu\text{Nm}$



MARS iQ Air
 $M_{d,min} = 1 \mu\text{Nm}$



MARS 60
 $M_{d,min} = 0.002 \mu\text{Nm}$



MARS iQ technology

The Normal force sensor

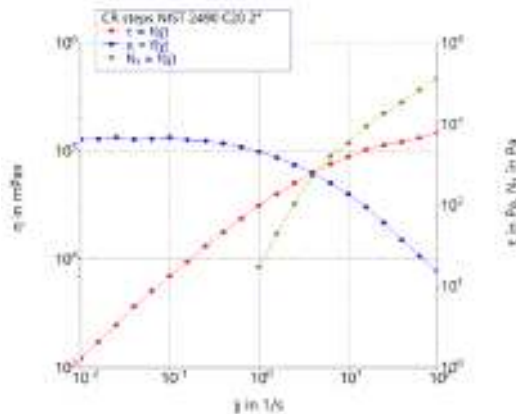
- Completely new high resolution normal force sensor with very good temperature stability for axial rheometry
- The normal force sensor is standard for the MARS iQ Air and optional for the MARS iQ
- **The HAAKE MARS iQ is the only ball bearing rheometer with normal force sensor**
- This allows for various testing options:



Measuring normal forces during tests	Controlling axial force during gap setting	Maintaining a constant gap using Autotension function	Performing axial ramp tests
1 st normal stress difference in steady state rotational step tests	For testing rubber or gel like materials	Temperature with shrinking/expanding samples	Penetration, squeezing, bending tests, tackiness (rheometer as texture analyzer)

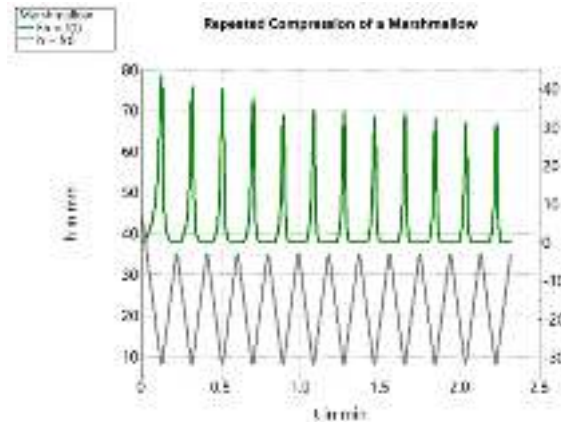
MARS iQ technology - Normal force capabilities

Measuring normal forces during tests



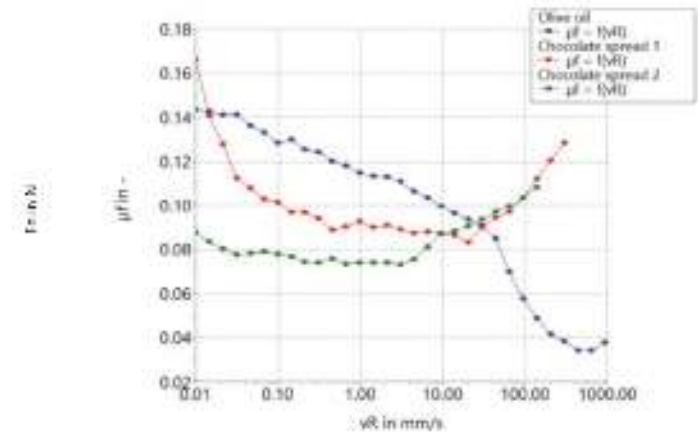
- MARS iQ Air with C20 2°
- Viscoelastic standard 2490 from NIST (not available anymore)

Performing axial ramp tests



- Repeated compression and relaxation of marshmallow
- Simulation of several “chewing cycles”

Performing tribological measurements



- Stribeck curves (friction coefficient μ_f as function of sliding speed vR) of different food products
- Geometry based on ball on three plates principle



MARS iQ technology - „Assist“ functionalities

Connect Assist

- **Quick coupling** of measuring geometries and temperature module with **automatic recognition** for fast and safe exchange between configurations
- **New: twist coupling sleeve** to release rotor



Color Assist

- **Color-coded connector plugs** and sockets for the correct connection of the cooling liquid



Protect Assist

- Optional **transparent door with safety interlock** switch for additional protection of the operator from touching moving or hot parts, high voltage (Electro Rheology) etc.



“Assist“ functionalities: Make work more convenient and avoid errors

MARS iQ technology - „Assist“ functionalities

Measuring geometries with "Connect Assist"

- "Connect Assist" technology for a fast and convenient rotor mounting/dismounting
- Rotors are exchangeable between all rheometer models (Viscotester iQ, MARS 40 & 60, MARS iQ)

Tag on shaft contains all information (geometry factors, inertia etc.)



Data is read once rotor is attached to rheometer

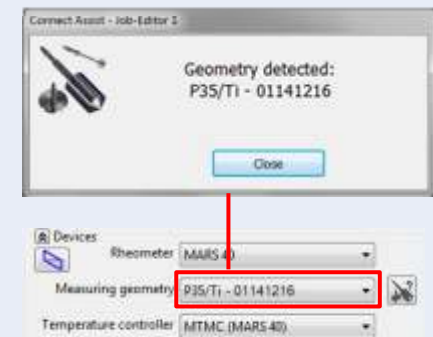


Mounted rotor is automatically recognized and shown

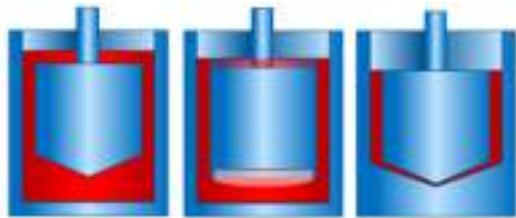
On MARS iQ touchscreen status bar



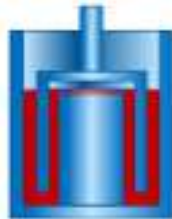
In RheoWin JobEditor



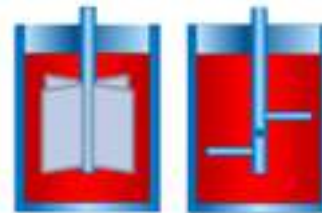
Measuring geometries for measurements on water up to solids



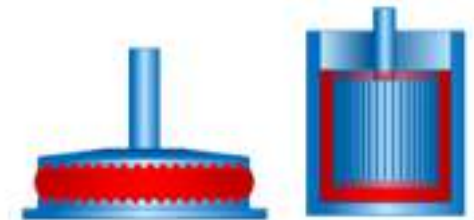
Coaxial cylinders



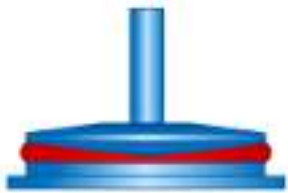
Double gap



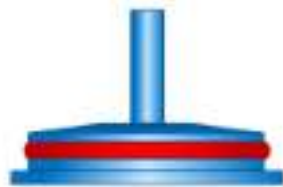
Vane and pin rotors



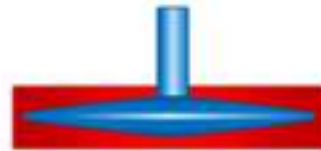
Profiled surfaces



Cone and plate



Parallel plates



Double cone



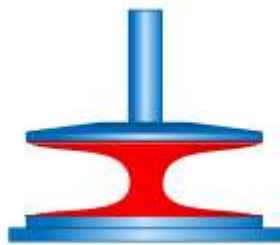
Ring rotor



ISO 2555



Tribology



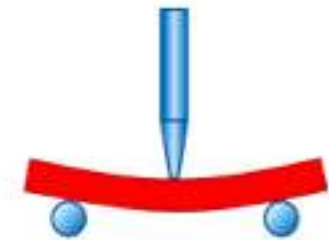
Tack / Texture



Pressure



High shear



Bending / breaking

MARS iQ technology - temperature control from -60 °C to +400 °C

"Assist" technologies to simplify operation

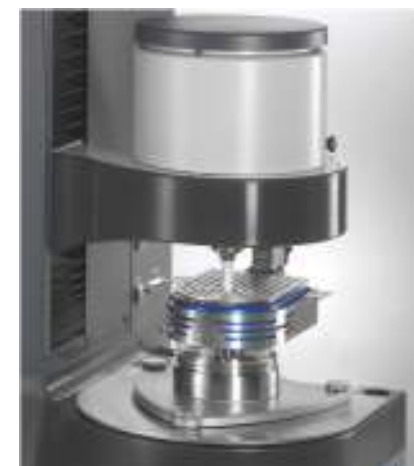
- "Connect Assist" quick fit coupling and automatic recognition
- "Color Assist" color-coded connector plugs and sockets

Automatic temperature calibration tool ensures correct sample temperature

- Lower temperature modules TM-XX-X from HAAKE MARS I/III/40/60
- Upper temperature modules TM-EL-H and TM-IN-H redesigned for new holder at rear of drive motor bracket

Temperature Control Module	Temperature Range
Peltier Plate TM-PE-P	- 60 °C – 200 °C
Peltier Cylinder TM-PE-C32	- 40 °C – 200 °C
Liquid Plate TM-LI-P	- 40 °C – 200 °C
Liquid Cylinder: TM-LI-C32 / TM-LI-C48	- 40 °C – 180 °C
Electrical Plate TM-EL-P (+H)	- 40 °C – 400 °C
Electrical Cylinder TM-EL-C48	- 20 °C – 200 (300) °C*

* For dedicated measuring geometries, e.g. pressure cells



MARS iQ technology - Passive and active sample hoods

- Minimize equilibration time, maximize heat transfer
- Gas inlet to create special environmental conditions (e.g. N₂)
- With integrated inner and outer solvent trap
- New holder for redesigned upper TM-xx-x



PEEK hood

- Robust
- Least expensive



NEW Glass hood

- For sample observation during test
- With or without lift support



NEW Insulated hood
TM-IN-H

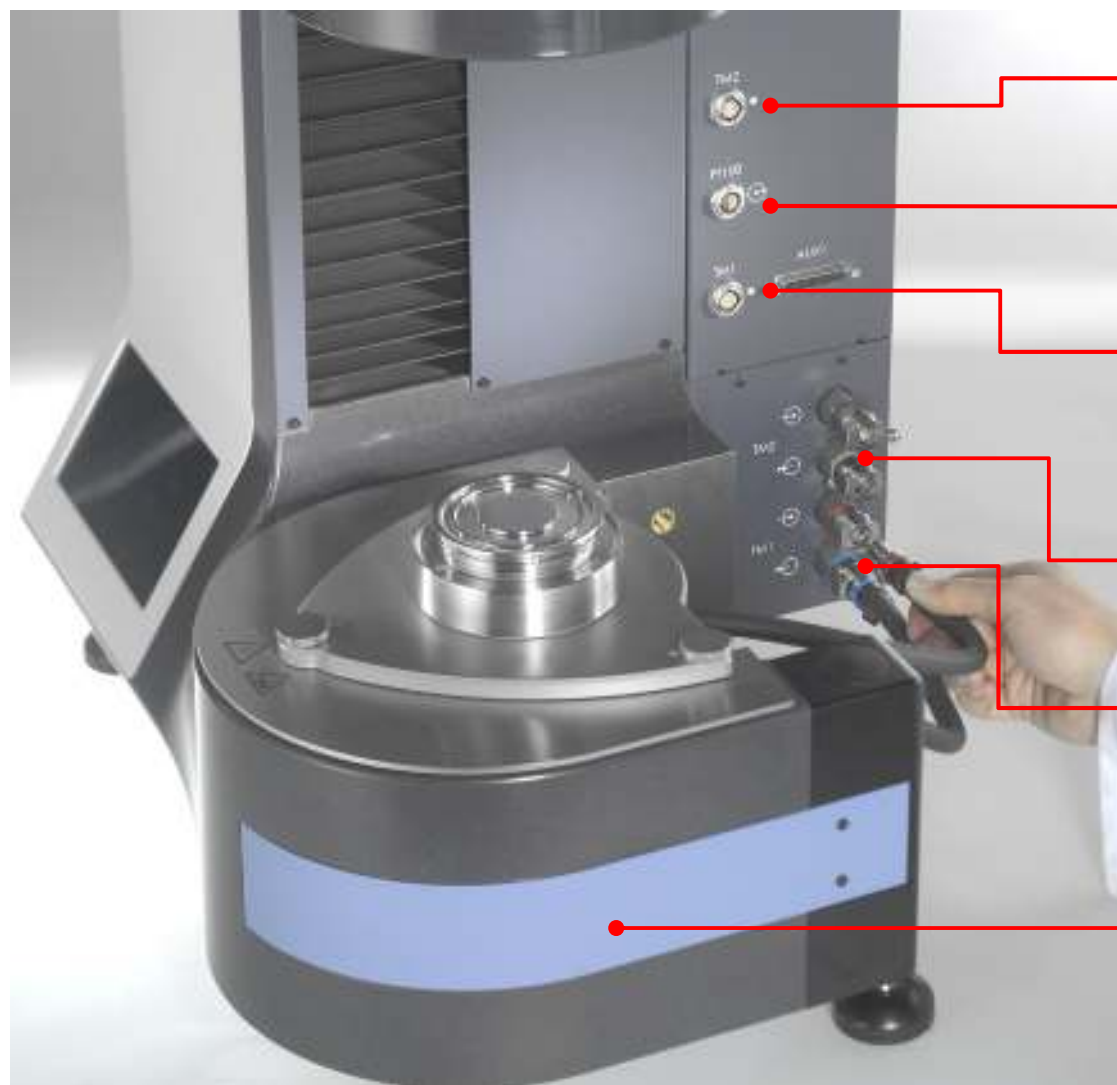
- Distributes heat around sample
- Improved insulation
- Convenient lift support



NEW Active hood
TM-EL-H

- Optimal temperature control up to 400 °C
- Convenient lift support
- Cooling with liquid or with compressed air
- Transparent glass ring

MARS iQ technology - Connections (accessible from the front)



Socket for upper TM-xx-x
(electrical connection)

Socket for Pt100 sensor

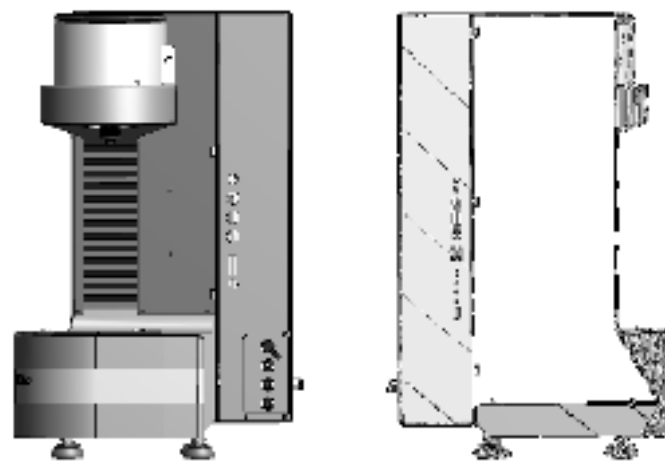
Socket for lower TM-xx-x
(electrical connection)

Couplings for upper TM-xx-x
(for liquid or compressed air)

Couplings for lower TM-xx-x
(for liquid or compressed air)

Removable panel
(access to space below TM-xx-x)

MARS iQ technology - Dimensions



Weight: 57 kg

MARS iQ technology – Touchscreen

Touchscreen

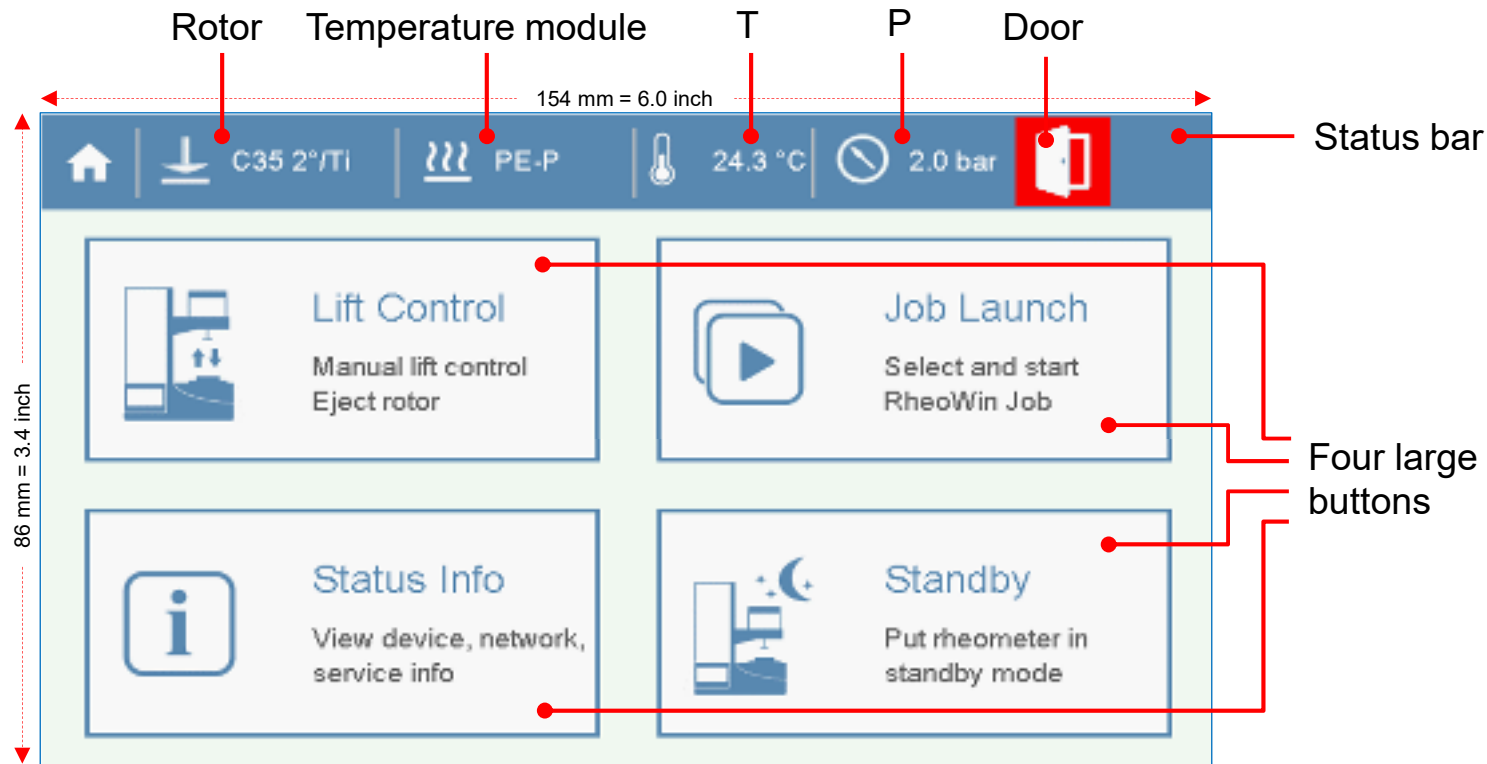
- The manual control of instrument is completely performed using a 7” color touchscreen.
- The modern **capacitive** (like in a smart phone) touchscreen can be conveniently operated while wearing standard (nitrile) lab gloves.



Dimensions of a 7” touch screen
Width = 15.4 cm = 6.0 inch
Height = 8.6 cm = 3.4 inch

MARS iQ technology - User interface - Main Screen

- The touchscreen main screen has four large buttons for accessing the four individual screens for: **Lift Control**, **Job Launch**, **Status Info** and **Standby**.
- The Status bar displays the name of the currently mounted rotor and TM-xx-x temperature module, the current temperature T and the air-bearing air pressure P (MARS iQ Air only) as well the status of the optional "Protect Assist" door.



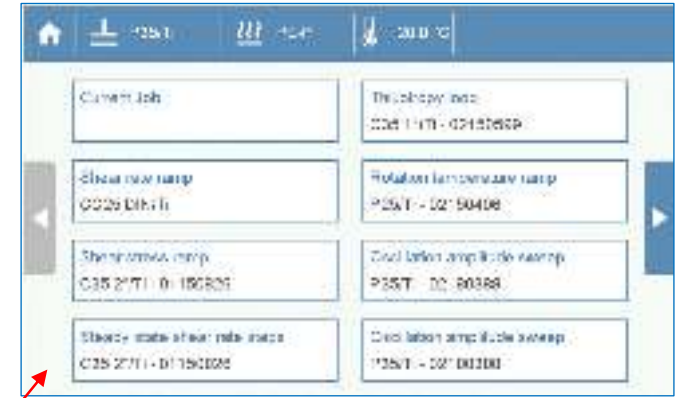
(This is the real physical size of the screen when printing this PowerPoint page on a A4 paper size in Landscape mode.)

MARS iQ technology – The User Interface Structure

The Lift screen



The Job Launch screen



The Main screen



The Status Info screen



The Standby screen



MARS iQ technology – The Lift Control screen

The screenshot shows the MARS iQ Lift Control interface. The top status bar includes a home icon, a leveling icon, 'P35/Ti', a wavy line icon, 'PE-P', a temperature icon, and '20.0 °C'. The main display area is divided into several sections:

- Current gap value:** A large display showing '50.000' mm.
- Current normal force value:** A display showing '0.00' N, with a 'Reset' button to its right.
- Buttons:** A grid of control buttons including:
 - '+0.050 mm' (trim up)
 - '50.000 mm' (trim set)
 - 'LOCK' (lock motor shaft)
 - 'STOP' (stop lift)
 - '+1.000 mm' (fast up)
 - '0' (zero point)
 - 'Lift upward fast/slow' (upward arrows)
 - 'Lift downward fast/slow' (downward arrows)

Annotations with red lines point to these elements. An inset dialog titled 'edit trim position value' is shown on the right, featuring a numeric keypad with the value '000.050 mm' entered. Below the keypad are '✓' and '✗' buttons. Text on the right explains that the trim, gap, and fast upward button values are editable and that a long tap (3+ seconds) opens this dialog.

MARS iQ technology – The Job Launch screen

- From the Job Launch screen, pre-selected RheoWin Jobs can be launched (started) directly from the MARS iQ touchscreen by tapping on a Job name. Here the touchscreen is used as a sort of “remote control” for RheoWin which runs on the PC the MARS iQ is connected to.
- The list of Jobs is created/edited in RheoWin and then transferred to the touchscreen.
- Any Job name in the list, is the name of a *.rwj Job file name which can be stored in any directory on the PC or any network drive that can be accessed by RheoWin.



MARS iQ technology – The Status Info screen

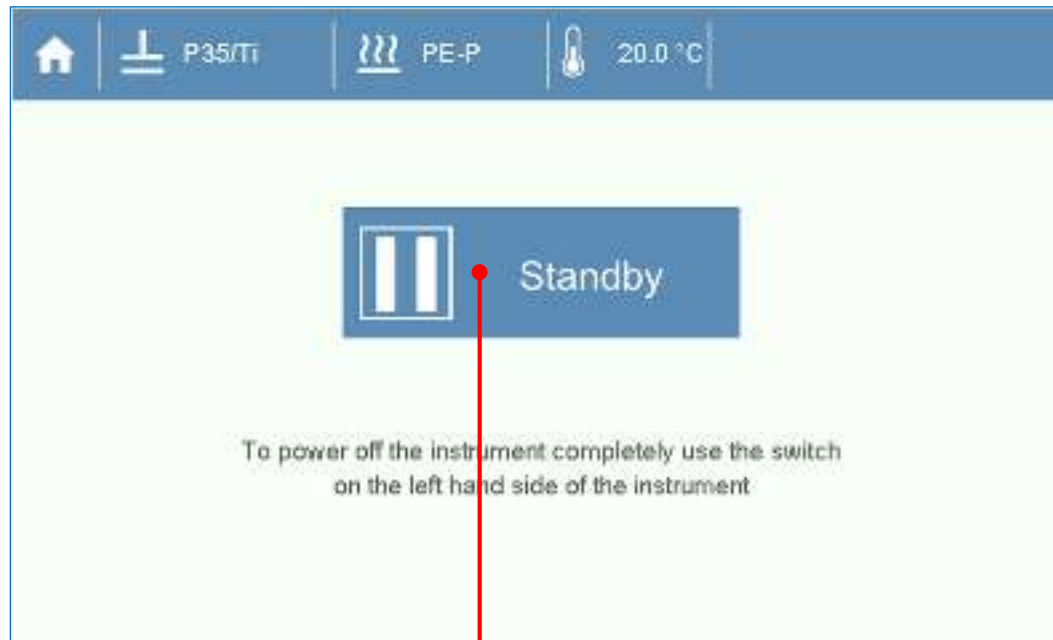
- The Status Info screen consists of three sub-screens, one for the **Rheometer**, one for the **Temperature control** and one for the **Rotor** (or measuring geometry).
- The **Rheometer** Status Info screen displays the instrument serial number, the firmware version numbers and the instrument TCP/IP network address
- The **Temperature control** Status Info screen displays the name of the TM-xx-x temperature module mounted on the rheometer, the current sample temperature and certain “internal” temperature values.
- The **Geometry** status info screen displays the name, type and serial number of the geometry mounted to the rheometer drive motor shaft and certain property values.



Buttons: Tap to go to previous/next status info screen

MARS iQ technology – The Standby screen

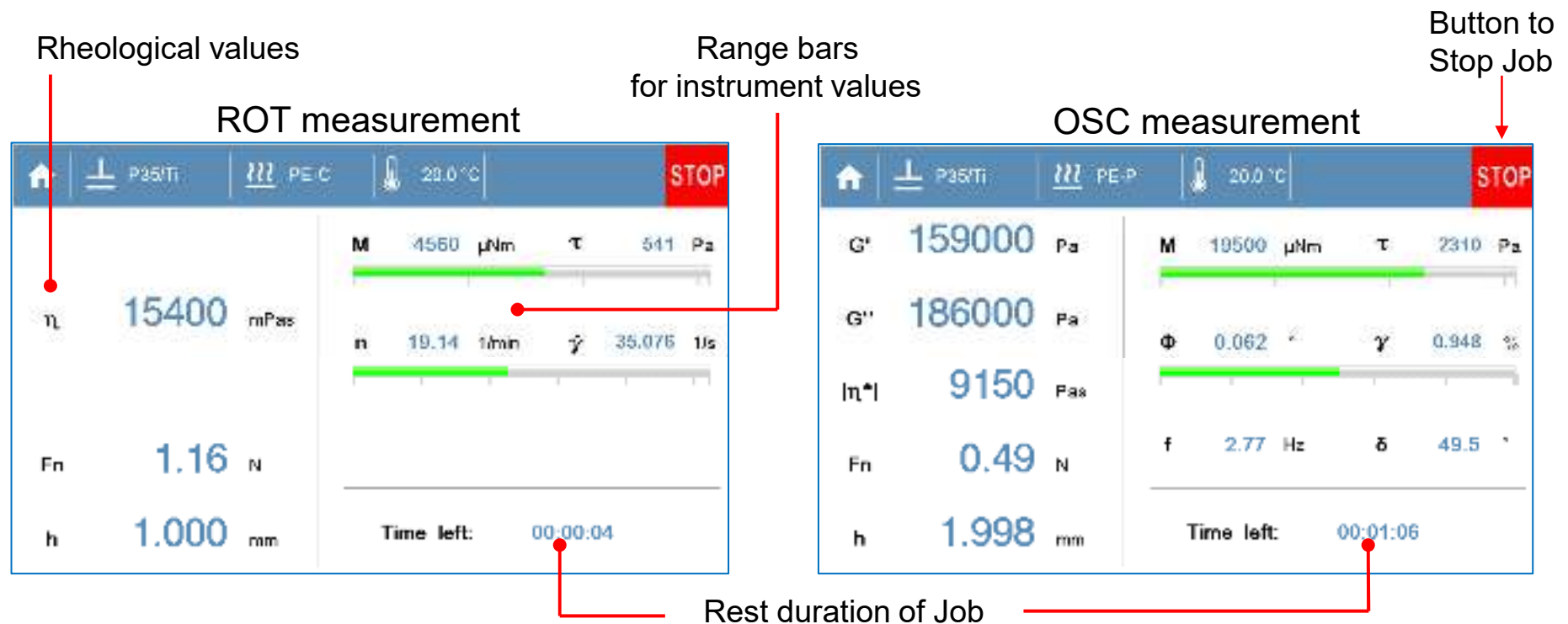
- From the Standby screen the instrument can be put in a power saving standby mode by tapping the Standby button.
- When the instrument is in standby mode the touchscreen is black
- By tapping the (black) touchscreen the instrument is put into normal operating mode.



Button: Tap to put instrument in standby mode

MARS iQ technology – The Online Data screen

- When a RheoWin Job is running the basic instrument values (torque, angle and angular velocity) are displayed in range bars along with the stress, strain and strain-rate. During an OSC measurement the frequency f and phase angle δ are also displayed
- Depending on the mode of operation (ROT or OSC) some basic rheological (η , $|\eta^*|$, G' and G'') values are displayed
- The values of the current gap h and the normal force F_n , as well as the **rest duration of the Job** (Time left) are always displayed



MARS iQ technology - Interaction with RheoWin

- Any job can be started from
 - the Job Launch screen on the MARS iQ touchscreen (RheoWin must be running)
 - or
 - from within the RheoWin software running on the PC
 - or
 - from the Windows desktop (using the RheoWin jobrun.exe program)
- Any job will/can display **action messages** on the MARS iQ touchscreen when the lift is moving up or down or into measurement or trim position, etc.
- When active **user action** is required to continue the Job, for example after the sample was loaded, a Continue button is available on the MARS iQ touchscreen and in RheoWin at the same time.
The operator can tap/click the button on the touchscreen or in RheoWin.
- The RheoWin Message Element can be used to display any text, in any language and including (numeric) **data evaluation results**, in RheoWin and on the MARS iQ touchscreen.

MARS iQ technology - User interface / Interaction with RheoWin

Job as defined in RheoWin

1 ID 5: lift Zero point; Lift apart [Message] [Image]; Tripping position = Gap + 0.050 mm [Image]

2 ID 9: Disc Frq Sweep CD 35, 1,000 % F10,00 Hz - 0,5000 Hz; log 1 --- #0 T10,00 °C

3 ID 10: Crossover

4 ID 12: Message The crossover values are: $G' = G'' = R_{ID10_POS}$ later $= R_{ID10_POS}$ $f = R_{ID10_POS}$

5 ID 11: lift Lift apart [Message] [Image]

End of job

Launch (start) Job from touchscreen or from RheoWin

Action message

Button: Tap to continue Job

The sequence of screenshots shows the following steps:

- Initial state: Force = -0.00 H, Height = 131.72 mm. Instruction: "Place the disc".
- Disc placement: Force = 0.08 H, Height = 1.998 mm. Instruction: "The disc has been placed. Press the disc down to the reference position." "Continue" button is visible.
- Measurement start: Force = -43.81 H, Height = 2.996 mm. Instruction: "Start".
- Measurement progress: Force = -0.01 H, Height = 151.65 mm. Instruction: "Proceed with the test." "Continue" button is visible.
- Measurement data summary:

U	159000	Pa	M	118800	Pa	T	10.01	Pa
G'	186000	Pa	G''	2.062	Pa	Y	0.740	Pa
(G')	9150	Pa	f	2.07	Hz	S	42.5	Pa
F ₁	0.49	H						
h	1.998	mm	Time: 00:00	Unit: 00				
- Measurement end: Force = -0.03 H, Height = 151.65 mm. Instruction: "Stop the measuring geometry." "Continue" button is visible.

Thank you for your attention

For further information
please visit

www.thermofisher.com/MARSiQ



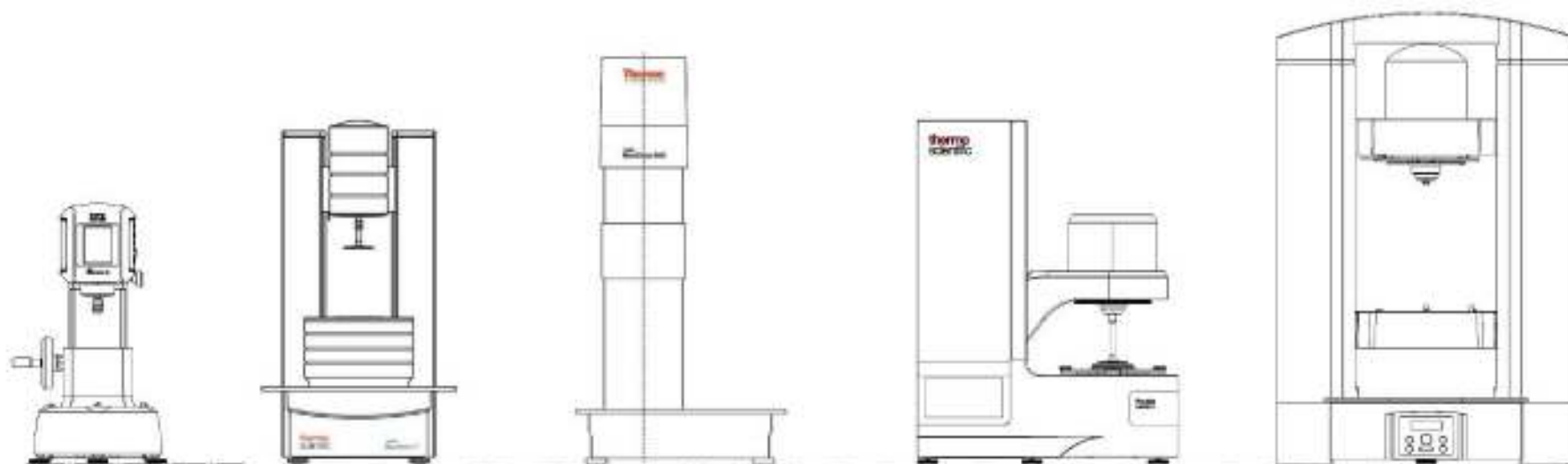
MARS iQ technology: HPMC casting

- Frame and lift of a rheometer provide necessary accuracy for radial and axial gap of any measuring geometry and therefore for measuring results
- As a consequence the rheometer frame must be stiff, must not change its dimensions when the ambient and/or frame temperature changes. A rheometer frame must also dampen external vibrations.
- Therefore material properties like the Young's modulus (stiffness), heat conduction coefficient, the thermal expansion coefficient and the damping of the material the frame is made of, are very important.
- The table below shows that the properties of the HPMC casting used for the MARS iQ frame are far superior to those of aluminum and iron casting (used in other rheometers).

Property	Unit	HPMC casting	Aluminium	Cast iron
Heat conduction coefficient	W/(m.K)	1.3 – 2.0	170	48.5
Thermal expansion coefficient	K ⁻¹	12.5 10 ⁻⁶	22 10 ⁻⁶	10 10 ⁻⁶
Density	kg/m ³	1600	2660	7200
Young's modulus	GPa	18	74	103
Damping (log decrement)	-	0.025	0.007	0.0045

- Due to its low density value, the lower Young's modulus can be easily compensated for by increasing the wall thickness of parts.

MARS iQ compared with other "HAAKE" instruments



Viscotester iQ Series

RotoVisco 1
RheoStress 1

RheoStress 6000

MARS iQ Series

MARS 40 / 60

Instrument	Width in mm	Height in mm	Depth in mm	Weight in kg	Control box yes/no	Control box WxHxD in mm	Control box Weight in Kg
MARS iQ	515	700	390	57	no	n.a.	n.a.
VT iQ (w. HX iQ)	270	500	500	18	no	n.a.	n.a.
MARS 40/60 (w. glassplate)	580	890	430	61	yes	230x200x360	9
RV1/RS1 (w. Glassplate)	385	660	395	46	no	n.a.	n.a.
RS6000 (w. glassplate)	400	770	400		yes	n.a.	n.a.

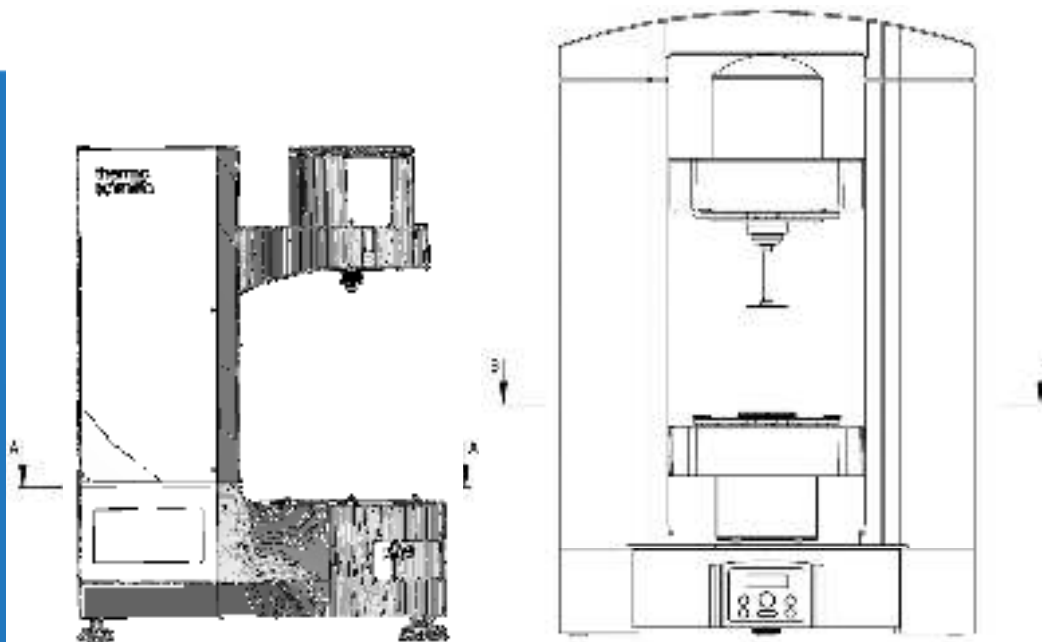
Dimensions and accessibility compared with MARS 40/60

Dimensions

	MARS iQ ¹⁾	MARS 40/60 ²⁾
Height	700 mm	890 mm
Width	515 mm	580 mm
Depth	430 mm	440 mm
Weight	57 kg	61 kg

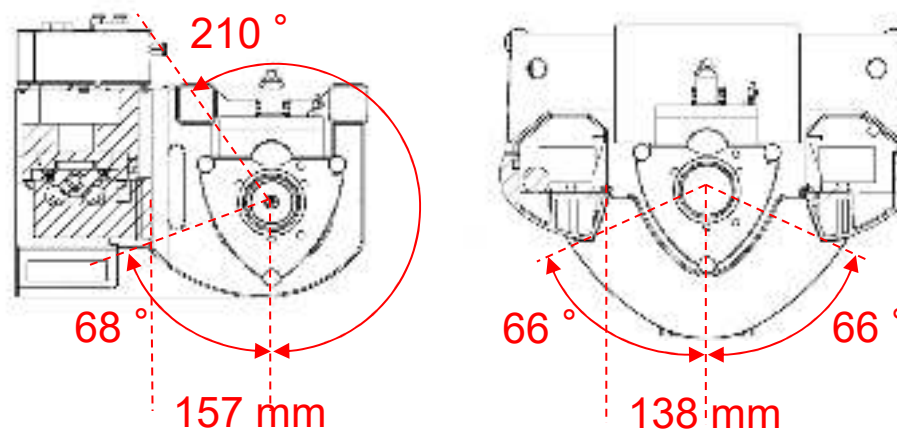
- 1) Complete instrument
- 2) Without control box

MARS iQ is clearly smaller.
Needs 36 % less total lab bench width!



Accessibility

The accessibility to the sample area is clearly better on the MARS iQ.
(also for left-handed operators)



MARS iQ Connections – left side and rear

