suministros LPS®

SARTORIUS

Mass Metrology –
Professional Equipment for Absolute Precision

turning science into solutions

From the Prototype Kilogram to Mass Standards

International trade requires the worldwide standardization of measurements. Mass plays an important role because the majority of commerce throughout the world is defined by the mass of substances. To make sure the same masses are used around the world, each country has a National Metrology Institute (NMI) that governs units of measurement.

Sartorius develops innovative mass comparators to the highest standards for NMIs and other metrological institutions.

The last few years alone have seen the following developments with customer cooperation:

- 1 kg prototype mass comparator with an incredibly high resolution of 0.0000001 g,
- Various automatic balances,
- Fully automatic systems for determining the volumes of weights,
- Many more products at the forefront of technology.

At this point, we would like to especially thank all our partners for their outstanding cooperation in helping to make our developments exceptionally successful:

- The Bureau International des Poids et Mesures (BIPM),
- The German Physikalisch-Technische Bundesanstalt (PTB),
- The Technical University of Ilmenau (TUI), Germany.


Mass Comparator

Products for the Determination of Mass

Cubis® MCM Manual Mass Comparators

Manual High-capacity Mass Comparators

Automatic Mass Comparators and Robots

Metrological Equipment and Accessories

Technical Specifications

Summary and Product Recommendations

Cubis® MCM Manual Mass Comparators

The New Cubis® MCM Manual Mass Comparators

Your Full-range Mass Standards Laboratory

The new manual Cubis® MCM mass comparators are the first devices on the market that unite metrological weighing competence with an integrated control of workflows in line with the recommendations of the International Organization of Legal Metrology (OIML). In its international recommendations R111-1, the OIML defines metrological and technical requirements. Its primary aim is the global harmonization of mass determination. Especially the pharmaceutical industry demands that greater accuracies based on global regulations be transferred to production. As an alternative, the Cubis® MCM produces results that are all naturally also ASTM-compliant.

Integrated Workflow Control
The integrated workflow control of the manual Cubis® MC mass comparators minimizes the error rate during operation: During the measurement process, the device gives the user instructions about the step to perform next. This markedly keeps the factor "human" from compounding the accuracy of mass determination and makes the results more reliable. At the same time, the workflow is ergonomically optimized and gives the user a more relaxed working atmosphere.

Integrated Climate Sensors
The sensors integrated in the mass comparator automatically log climate data like temperature, air pressure and humidity for calculating the air buoyancy correction at the site of the measurement. The climate data can be documented via a PC. That way, it is possible at any time to check that the limits on temperature, air pressure and humidity of the respective calibration levels (E1, E2, F1 or F2) are in compliance.

Fastest Methodology
Compared to conventional devices, Cubis® mass comparators deliver fast-run method cycles (ABA, ABBA or AB1...BnA) for determining the conventional value of mass (also referred to as conventional mass and its combined standard uncertainty.

The manual mass comparators can seamlessly be integrated in the infrastructure of mass standards laboratory. Based on the Cubis® Q-Com communication concepts, they can be integrated in existing networks and every type of data desired can be transferred to other devices.

The Cubis® MCM mass comparators are specified under both ideal and real laboratory conditions. This ensures that they always provide you their full and reliable performance during on-site use.

With all their integrated functions and technical possibilities, the Cubis® mass comparators work like "small metrological laboratories" – but integrated in the mass comparator.

Cubis® MCM

Manual Mass Comparators with the Full Performance Spectrum of a Cubis® Balance

- All MCM mass comparators feature a Cubis® MSA display and control unit with color touchscreen for fast and simple configuration of parameters and workflows.
- Thanks to the continuous weighing value display, every weight value between 0 g and maximum capacity can be indicated.
- The climate sensors integrated into the draft shield log temperature, humidity and air pressure (models without a draft shield contain an external climate module with the corresponding sensors in the equipment supplied).
- Steps for calibrating performed in accordance with the methods ABA, ABBA, AB1…BnA enable error-free, efficient work.
- The reference weight data and the guidance through the measurement procedure are automatically accounted for.
- The measurement uncertainty is determined in full accordance with OIML and ASTM recommendations. No external software or a climate measuring station is required for recording ambient parameters.
- Filters can be optimally adapted to the ambient conditions.
- The electronics and the power supply for display and evaluation are separate from the weighing system, in order to prevent heat from affecting the results.

- All Cubis® MCM mass comparators are equipped with off-center load compensation in order to significantly reduce measurement errors when the load is off-center. Therefore, no automatic centering is usually necessary and the loading is much easier.
- Application programs for weighing, unit conversion, individual identifiers, density determination, statistics are integrated as standard on Cubis® MCM mass comparators.
- MCM mass comparators automatically detect when the balance is skewed and provide graphic support during leveling. On the models MCM2004, MCM5004 and MCM5003, motorized leveling is also possible.
- The Cubis® MCM balances know no limits in terms of connectivity and communication. Diverse data interfaces like USB, RS-232C and Ethernet enable nearly all forms of bidirectional communication. Integration in networks or communication with external software via standardized communication protocols, SICS or Webservices is also possible.
- It is easy to store all data on an SD card and transfer them to PCs or other MCM mass comparators.
- The modern Q-App programming featured by MCM mass determination software allows you to configure the system specifically for individual customers' demands for mass determination or integration into their system. Please contact our product specialists.
- Additional draft shields are available for all models. They reduce air movement caused by air conditioning systems. Even under unfavorable ambient conditions, they keep standard deviations at a minimum.

Model 1

Model 2

Model 3

Models up to 1 kg

Model 1	**MCM6.7**
Maximum capacity and electrical weighing range	6.1 g
Readability	0.1 µg
Repeatability s under optimal conditions [1)]	0.15 µg

Model 2	**MCM36**	**MCM66**	**MCM106**
Maximum capacity and electrical weighing range	31 g	61 g	111 g | 61 g
Readability	1 µg	1 µg	1 µg
Repeatability s under optimal conditions [1)]	1 µg	1 µg	1 µg

Model 3	**MCM605**	**MCM1005**	**MCM1004**
Maximum capacity and electrical weighing range	610 g	1,110 g | 610 g	1,110 g | 610 g
Readability	10 µg	10 µg	100 µg
Repeatability s under optimal conditions [1)]	10 µg	15 µg	50 µg

Models up to 10 kg

Model 4	**MCM2004**	**MCM5004**	**MCM5003**
Maximum capacity and electrical weighing range	2.5 kg	5.1 kg	5.1 kg
Readability	0.1 mg	0.1 mg	1 mg
Repeatability s under optimal conditions [1)]	0.05 mg	0.3 mg	0.5 mg

Model 5	**MCM10K3**
Maximum capacity and electrical weighing range	11 kg
Readability	1 mg
Repeatability s under optimal conditions [1)]	0.8 mg

Models up to 60 kg

Model 6	MCM40K3	MCM60K3	MCM60K2
Maximum capacity	41 kg	64 kg	64 kg
Readability	1 mg	2 mg	10 mg
Repeatability s under optimal conditions [1)]	2 mg	4 mg	6 mg

Repeatability is the standard deviation "s"; it is calculated from 5 ABA cycles, after eliminating drift
[1)] Optimal conditions: automatic measurement without operator influence measured in a laboratory under E1 conditions, on a decoupled weighing stone, no drafts from above.

Model 4

Model 5

Model 6

Accessories for Cubis® MCM for Recording Temperature, Air Pressure and Humidity

Accessories and Service	Order Number
Climate module, uncalibrated, for all MCM models	YCM20MC
Calibration of a climate module YCM20MC with DAkkS calibration certificate	YCM20DAkkS
Climate module with DAkkS calibration certificate for all MCM models	YCM20MC-DAkkS
Hook for below-balance weighing for models MCM40K3, MCM60K3, MCM60K2, MCM40K3-DAkkS, MCM60K3-DAWKS and MCM60K2-DAkkS	69EA0040
Tower for climate module, for mounting YCM20MC, can be ported to following models MCM10K3, MCM40K3, MCM60K3, MCM60K2, MCM10K3-DAkkS, MCM40K3-DAkkS, MCM60K3-DAkkS and MCM60K2-DAkkS incl. connection cable	YCM20MC Tower

Automatic Buoyancy Correction

When comparing mass under atmospheric conditions, the weights are subject to buoyancy as a function of their volume and the air density; this buoyancy runs in the opposite direction of the weight force. If the material density of the object to be tested deviates from the reference weight, a buoyancy correction as well as a standardization to air density 1.2 kg/m^{-3} which must be performed to determine the conventional mass.

All models in the Cubis® MCM manual mass comparator family are standard equipped with a module for recording air temperature, air pressure and humidity to determine air density. On comparators equipped with a draft shield, this module is located within the weighing chamber in order to record the ambient conditions that actually prevail. On devices without a draft shield, the climate module is attached to an external tower in order to record ambient conditions relevant to the mass comparison in this case as well.

Climate module connected within the draft shield

Since the climate module can be plugged into the mass comparator, it is simply removed for calibration. The calibration data and related characteristic correction curves are stored in the internal memory of the climate module. That means that synchronous and metrologically traceable climate data and their measurement uncertainties are available for mass comparisons. The following standard uncertainties are specified for a calibrated climate module:

Temperature:

u_t = 0.15 K in the range 18 °C to 24 °C

Pressure:

u_p = 1 hPa in the range 800 hPa to 1,100 hPa

Humidity:

u_r = 1 % in the range 30% to 70%

The mass comparator calculates the air density from the measured ambient conditions and their uncertainty. When density of the test weight and reference weight and their uncertainties are known, the integrated application software "Mass Calibration" calculates the air buoyancy correction including the related uncertainty.

The mass comparison results indicate the conventional mass of the calibration weight with the corresponding uncertainties.

External climate module with YCM20MC Tower

Manual High-capacity Mass Comparators

Manual High-capacity Mass Comparators

up to 3,000 kg

All Sartorius high-capacity mass comparators are constructed of high-grade stainless steel. This design eliminates the possibility of reactions from magnetic weights having an effect on comparison weighing.

The unique sandwich construction with integrated, strain-free weigh cells guarantees excellent repeatabilities even when weights are loaded in a “heavy-handed” way.

Models of the CCS range are equipped with four high-resolution strain-test medium type load cells which are aligned with one other. Draft shields are supplied as standard for all high-capacity mass comparators.

The innovative sturdy three-point frame of the CCT models with three high-resolution strain-test medium type load cells guarantee a stable and distortion-free setup. Potential off-center loading errors are minimized due to the large distances between the weigh cells and a very high repeatability is enabled.

CCT Range

	CCT1000K	CCT2000K
Maximum capacity	1,200 kg	2,100 kg
Readability	1 g	1 g
Repeatability (optimal) s*	2 g	5 g

CCS Range

	CCS600K	CCS1000K	CCS3000K
Maximum capacity	605 kg	1,510 kg	3,010 kg
Readability	1 g	5 g	10 g
Repeatability (optimal) s*	2 g	5 g	10 g

CCI Range

	CCI100K2	CCI300K
Maximum capacity	151 kg	303 kg
Readability	50 mg	1 g
Repeatability (typical) s*	200 mg	0,5 g

s* Repeatability is the standard deviation "s"; it is calculated from 5 ABA cycles, after eliminating drift. Prerequisites for accurate calculation of the standard deviation are good ambient conditions in accordance with OIML R111 for an M1 mass standards laboratory.

CCT range

CCS range

Manual high-capacity mass comparator of the CCS range

Automatic
Mass Comparators and Robots


3
4
2
5

Mass Comparator CCL1007 for National Prototype Kilogram

for Mass Comparisons of Silicon Spheres and Weight Artefacts

Sartorius has mastered the core disciplines of weighing like no other company. It is also setting benchmarks in mass metrology. In cooperation with the Bureau International des Poids et Mesures and the Institute for Process Measurement and Sensor Technology of the Technical University of Ilmenau, Sartorius has developed a mass comparator – the CCL1007 – that is capable of determining differences in mass to an accuracy of 0.1 µg for weights of 1 kg – even under high-vacuum conditions.

The CCL1007 comparator is optimally protected from environmental effects by a pressure-stable vacuum chamber made of aluminum with a housing of polymethyl methacrylate (PMMA). Measurements can be performed under normal pressure conditions as well as at high vacuum up to a pressure of 10^-6 hPa. Unlike conventional stainless steel vacuum bell jars, the aluminum chamber does not cause any magnetic reactions that would affect the weighing system and weights.

The system is equipped with a fully automatic load alternator which can take up to eight weights simultaneously. Since the weights are stored on a unique three-point frame, it is possible to use cylindrical as well as spherical weight. Thus, the device fulfills the essential prerequisites for highly accurate metrological tests for the new definition of the kilogram based on the Avogadro constant using silicon spheres.

Thanks to its automatic loading device, the weight sets can be positioned on the load alternator without having to open the entire vacuum chamber.

During loading, the center of mass of the weight is determined. A special procedure automatically corrects any decentering of the weight which is then placed in the center of the load alternator. For contamination-free loading, the mass comparator CCL1007 can additionally be equipped with a vacuum transfer channel (YVTS01C).

The actual weigh cell is located in the upper section of the vacuum chamber. In case the reference standards on the load alternator deviate from one kilogram, the weighing pan for the substitution weights can be accessed via the upper loading hatch. Moreover, it is also possible to remove the internal one-gram calibration weight and perform calibrations separately.

All components inside the vacuum chamber are completely resistant to high vacuum. This prevents any contamination of the weights. All materials used in the vacuum chamber are solid materials with a low vapor pressure. They are free of oil and grease.

The driving forces necessary for rotating the load alternator and lifting and lowering the weights are transferred into the interior of the vacuum chamber by rotary axes and vacuum couplings. The load alternator is driven by a pulley hoist system and positioned exactly. The more than 20 vacuum flanges enable additional sensors to be introduced into the vacuum chamber.

The motors that drive the load alternator and the related control device are located outside the vacuum chamber in a control unit. Ceramic axles and spatial separation prevent any energy input from these components onto the vacuum chamber. This minimizes temporal and spatial temperature gradients in the interior of the vacuum chamber.

The system is controlled via a user-friendly operating software, which can be extended with ScalesNet-M. ScalesNet-M (YSN03C, see page 36) is a management software program designed to cover all requirements and to network equipment in mass standards laboratories.

The CCL1007 places special environmental and mechanical demands on rooms, installations and operations. Specially trained personnel are also required. For that reason, our specialists are there to assist you in equipping your laboratory through setup to startup and help you troubleshoot any problems.

CCL1007 with vacuum transfer system VTS

Areas of Application

- As a 1 kg prototype weighing system for the subdivision of the mass of the primary reference standards of National Metrology Institutes (NMIs) with national mass reference standards (kilogram prototype)
- Dissemination of the mass scale of NMIs in the range of 1 kg to 1 mg; adapter plates are required for groups of weights and weights < 200 g
- Determination of mass for international comparison measurements (key comparisons) and calibrations for national institutes, calibration laboratories and industry in accordance with the attainable measurement uncertainties specified in the CMC tables published by the BIPM
- Experimental determination of air density by comparison weighing of special buoyancy artifacts in air and under vacuum
- Determination of the mass of 1 kg silicon spheres (also suitable within the scope of the Avogadro project for more accurate definition of the Avogadro constants and for new definition of the kilogram mass unit)
- Experimental research on the impact of cleaning procedures as well as on the effects that sorption and convection could have on mass and on the long-term stability of mass standards

Vacuum Transfer System VTS

The globally unique vacuum transfer system (VTS) not only allows air-to-air loading on the standard model, but air-to-vacuum and air-to-protective gas. That way the measurement conditions inside the vacuum chamber remain constant while loading the load alternator with weights. Moreover, the vacuum transfer channel can be connected with special transport containers.

These containers enable weights to be stored in the lab under protective gas or a vacuum. This makes it possible to open containers inside the vacuum transfer channel under protective gas or in a vacuum and to load the load alternator automatically. That means that the weights are only ever exposed to the ambient conditions desired. The transport containers thus also enable loading of vacuum to vacuum and of protective gas to protective gas.

Technical Specifications

	CCL1007
Maximum capacity	1,031 g
Readability	0.1 µg
Repeatability s*	s ≤ 0.2 µg
Repeatability in vacuum, s*	s ≤ 0.1 µg
Repeatability (typical), s*	s ≤ 0.1 µg
Linearity	≤ 1 µg
Electronic weighing range	2 g
Pressure range	10^{-6} – 1,000 mbar
Application Ranges	
OIML R111 Classes	≤ E1 1 kg
with adapter plates for groups of weights	≤ E1 1 mg ...1 kg
Silicon sphere	∅ 95 mm

s* Repeatability is the standard deviation "s"; it is calculated from 6 ABBA cycles, after eliminating drift. Prerequisites for accurate calculation of the standard deviation are good ambient conditions in accordance with OIML R111 for an E1 mass standards laboratory.

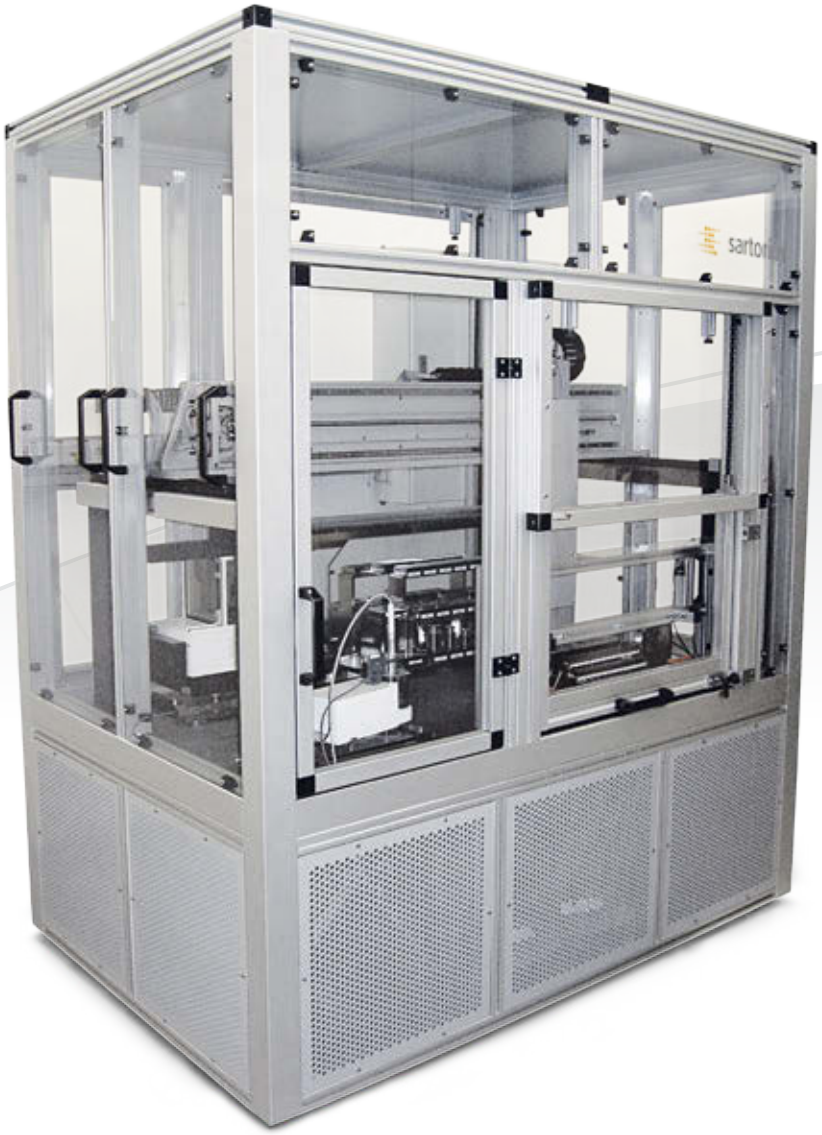
Robot for Fully Automated Determination of Mass

from 1 mg to 1 kg

Robot systems with the latest weighing technology guarantee highest accuracy for the determination of mass. The fully automated mass comparison simplifies work in the mass laboratory. This enables complete sets of weights to be measured efficiently within the shortest time possible.

The robot systems are supplied with a user-friendly control software. Thereby, the system of every PC in the local laboratory network can be controlled and monitored. An additional PC workplace is thus not needed. A climate station is also part of the basic configuration. So all climate parameter relevant for a mass comparison are available.

Thanks to the modular design of the robot system, the device can be adapted to customer requirements accordingly. The range of functions can also be extended at any time: The application range covers weights from 1 mg up to 10 g (CCR10) or 10 g up to 1 kg (CCR1000) and from 1 mg up to 1 kg in the maximum level of expansion (CCR10-1000). The number of magazine positions is specified by the customer: Up to 164 magazine positions can be provided for the range of 1 mg to 1 kg. Because you can already position your weights on the turning magazines for the next measurements while running a measurement, you no longer have to sit through protracted waiting periods to acclimatize your weights.



Robot systems, CCR10-1000, for determining the mass of weights (1 mg – 1 kg)

Once the user has positioned the weights on the magazine positions and entered the weighing mode via the operating software, all mass comparisons can be performed automatically (direct comparison of weights or comparison of weight combinations). The corresponding measurement records, listing weighing and climate values, are generated and available for evaluation in a broad variety of programs. Naturally, all Sartorius robot systems can also be controlled directly by ScalesNet M. ScalesNet-M (YSN03C, see page 36) is a management software program designed to cover all requirements and to network equipment in mass standards laboratories.

To allow the robot system to work quickly, the test weight and reference weight are placed on separate comb-type weight grabbers. These weight grabbers can accommodate a group of up to four weights. So that all weights of a weight group are placed on the load pan at the same time.

The mass comparison for E1 weights is continuously possible from 1 kg to 1 mg in one device (CCR10-1000). There is no need for time-consuming transfer of weights from device to device.

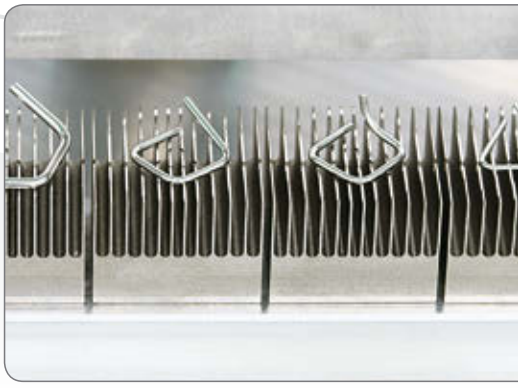
The magazine positions and comb-type weight grabbers are designed so that any desired types of weight – wire or leaf weights or knob, cylindrical or disk weights – can be handled efficiently.

Typical users are:

- National metrological institutes for presenting a mass scale from 1 kg to 1 mg
- Manufacturers of weights with maximum throughput of direct mass comparisons
- Calibration laboratories for increasing the throughput through mass comparisons even during night hours and on the weekends

Comb-type weight grabber with 4 weights

Magazine of the CCR10-1000 (10 g – 1 kg)



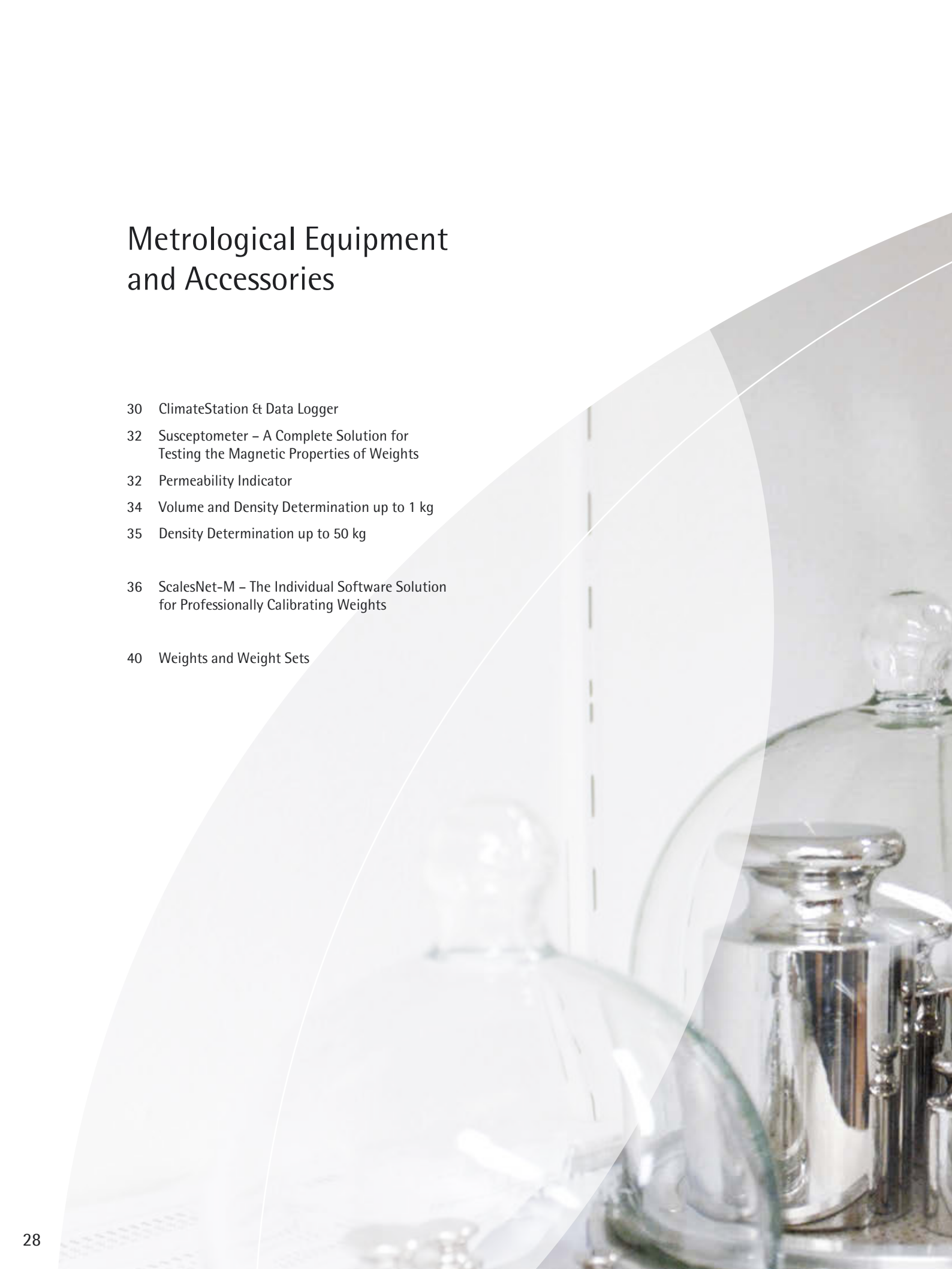
Detail of the magazine on CCR10-1000 (1 mg – 10 g)

Technical Specifications

	CCR10	CCR1000	CCR10-1000
	1 mg – 10 g	10 g – 1 kg	1 mg – 1 kg
Maximum capacity	10.5 g	1,021 g	10.5 g | 1,021 g
Readability	0.1 µg	1 µg	0.1 µg | 1 µg
Repeatability (typical), s*	< 0.2 µg	< 2 µg	< 0.2 µg | < 2 µg
Linearity	1 µg	20 µg	1 µg | 20 µg
Electronic weighing range	3.5 g	21 g	3.5 g | 21 g
Magazine positions	39	23	39 | 23
Optional magazine positions	26 – 65	2 – 37	2 – 102

s* Repeatability is the standard deviation "s"; it is calculated from 6 ABBA cycles, after eliminating drift. Prerequisites for accurate calculation of the standard deviation are good ambient conditions in accordance with OIML R111 for an E1 mass standards laboratory.

Metrological Equipment and Accessories



Climate Station & Data Logger

With the YCM16C, Sartorius has developed a highly precise, unique climate station for continually recording ambient temperature data.

Suitable for All Metrological Laboratories

The climate station YCM16C is the perfect solution for determining air density and can be used to monitor the room climate in all metrological laboratories.

Room Monitoring

As is required for calibration laboratories, the YCM16C provides room monitoring for all of the accuracy classes given in accordance with OIML R111-1 up to class E1. The room climate data is constantly monitored and shown on the display.

Air Buoyancy Correction

The climate station can be combined with ScalesNet-M software to make air buoyancy corrections in order to achieve an extremely high degree of accuracy when determining mass.

Easy to Use

It can be operated directly using the push knob or from your desk using network-based remote control. The supplied software automatically synchronizes the ambient climate data on your PC. If there is a power failure, the integrated UPS enables the climate station to keep recording reliable climate data even without a PC.

Special Features

- Up to 16 analog and 99 digital sensors
- PC software for synchronization
- 8 MB data logger for up to 30 days of data recording
- Monitors the accuracy class in accordance with OIML R111
- Dew point calculation
- Air density calculation
- 1 integrated air pressure sensor
- 1 external humidity | temperature sensor
- WEB and FTP server
- UPS for power outages
- 4-line LCD display, 20 characters per line
- Can be operated directly using the push knob or remotely via USB | LAN | RS-232
- Firmware update via SD card
- LAN | USB | RS-485 | RS-232 interfaces
- SD card interface (FAT16)
- 12 V | 7 Ah battery operation

Calibrated air humidity | temperature sensor
YCM16H | YCM16T

Calibrated air pressure sensor YCM16P

Technical Specifications

	YCM16C
Temperature measuring range	-30 – +60 °C
Temperature readability	0.001 °C
Humidity measuring range	0 – 100 %
Humidity readability	0.01 %
Pressure measuring range	300 – 1100 hPa
Pressure readability	0.001 hPa

Air temperature sensor YCM20T

Optional Accessories

	Order number
Software for mass determination	YPR02C
Air temperature sensor 1/3 DIN	YCM16T
Air temperature sensor 1/10 DIN	YCM20T
Air humidity|temperature sensor	YCM16H
Air pressure sensor	YCM16P
ScalesNet-M software	YSN03C PC

Susceptometer & Permeability Indicator

A Complete Solution for Testing the Magnetic Properties of Weights

Susceptometer

It is recommended to test the magnetic properties of weights using the OIML R111-1. In fact, evidence supports the demand that both the susceptibility and magnetization of weights be accounted for.

Susceptometer Method

There are several methods for defining the magnetic properties of weights. The susceptometer method is stipulated in OIML R111-1 for testing weights of classes E1, E2, F1, and F2. The Sartorius YSZ01C | YSZ02C susceptometers let you easily and conveniently determine the susceptibility and magnetization of weights in compliance with OIML R111-1.

This method measures the interaction between a permanent magnet and the weight to be tested using a high-resolution balance by weight force. The desired magnetic properties of the weight can be calculated on the basis of the known properties of the test magnet, the distance of the weight from the test magnet and the weight's geometry.

The Sartorius susceptometer stands out against other well-known instruments by virtue of its highly compact design and integrated components.

Susceptometer YSZ01C | YSZ02C

Technical Specifications

Susceptometer	**YSZ01C**	**YSZ02C**
Readability	10 µg	1 µg
Application range in accordance with OIML R111	E2 | F1 | F2	E1 | E2 | F1 | F2
Maximum capacity	50 kg	50 kg
Z_0, distance from center of magnet to the bottom of weight in mm | field strengths Z_0, (A/m)	**Adjustable in fixed steps:** Z1 = 18 | 2,700 Z2 = 20 | 2,000 Z3 = 27 | 800	 Z4 = 35 | 360 Z5 = 43 | 200
Turning mechanism for magnet	Easy to operate by external rotary knob, marking for N-S orientation of the magnet	
Software	Convenient application software; standard settings and easy, user-defined configuration possible; quick check function; printing of reports, exporting of results	
Data transfer protocol	HTML mode and data transfer to user-specific metrology software via CSV file format	

Optional Accessories

Susceptometer	**Order number**
3 Reference magnets in a wooden case for Sartorius susceptometers YSZ01C and YSZ02C	YSZ01RMC
Susceptibility standard, as reference, in a wooden case for Sartorius susceptometers YSZ01C and YSZ02C, with PTB susceptibility certificate	YSZ01RSC

An innovative turning mechanism for adjusting the position of the test magnet and simple adjustment of the height of the loading platform also make working with the susceptometer simple and effective. This design significantly improves the repeatability of measurements.
The susceptometer is available in two resolution levels. The YSZ01C features a 10-µg resolution; the YSZ02C has a 1-µg resolution.

Application Software

The convenient software that comes standard with the susceptometer enables data to be automatically transferred from the unit. It moreover supports the user through all required handing steps and provides assistance with settings before and during a measurement. Menu prompts request all relevant data and guide the user through the steps necessary for performing a measurement. The results of the test are recorded and can be exported to higher-level databases.

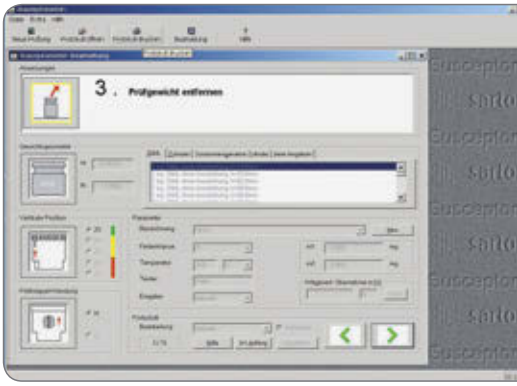
Permeability Indicator

The Sartorius permeability indicator is easy to operate and is used to determine the relative permeability value of materials with small magnetic properties. The indicator operates according to the susceptometer method described in detail in OIML R111:2004 (Part 1, B.6.5).

The magnetic susceptibility "χ" is the result of the relationship between the relative magnetic permeability and the magnetic susceptibility (µr = 1 + χ).

χ = magnetic susceptibility
µr = relative magnetic permeability

The measuring principle of the indicator is based on the reciprocal attraction of a permanent magnet with a reference material of a known size along with an unknown material to be tested. This makes it possible to determine the relative permeability figure of the material to be tested by substituting the reference material as a limit value.



Application software for susceptometers

YSZ01RMC

YSZ01RSC

YAW61 with optional knob weight

Technical Specifications

Permeability Indicator	**YAW61**
Balance beams with a permanent magnet in the housing, including permeability reference standards [µr]	1.01 | 1.02 | 1.03 | 1.05 | 1.06 | 1.08 1.15 | 1.20 | 1.30 | 1.60 | 1.80 | 1.90 | 5.0

Volume & Density Determination

Up to 1 kg & up to 50 kg

Volume & Density Determination up to 1 kg

The most accurate method for determining density of solid bodies in accordance with OIML R111-1 is hydrostatic technique comparing the mass in a liquid.

Sartorius has integrated this method in its fully automatic volume comparator: With the VD1005, Sartorius supplies a system for density determination for weights in the range from 1 g up to 1 kg.

The volume comparator is equipped with two nine-position load alternators: One in a liquid bath and one in the air.

The two load alternators operate synchronously in that one position in liquid is assigned to each second position in air. By using substitution weights, this innovative dual-weight alternator design makes it possible to directly compare the mass of a single-volume reference (e.g., silicon sphere) with a variety of weights in liquid.

The load alternators and weighing pans are designed as comb-type weight grabbers so that weights and groups of weights from 1 g to 1 kg can be transferred directly from the load alternator to the suspended weighing pan. Adapter plates are not required. This has a positive effect on the accuracy of the overall measurement system.

Volume comparator VD1005

Sartorius pycnometer YP50K

After the data has been entered, an integrated PC with user-friendly software takes over fully automatic control of the volume comparator and evaluation of density measurement.

Application

Density determination of weights in accordance with OIML R111, class E1: 1 g...1 kg

Volume & Density Determination up to 50 kg

In combination with mass comparator MCM60K3 and a PC, the pycnometer is an outstandingly reliable solution for volume determination.

All required accessories, including a sturdy storage and shipping case, are included as standard equipment. A PC, mass comparator and reference weights are not included in the standard equipment supplied.

Software supports the user in volume determination.

1 kg silicon sphere YDR1000SIC

E1 set of weights YCS31-612-09, stackable

Thermostat YVT01C

Technical Specifications

	VD1005
Density uncertainty*	1 kg/m^3
Volume uncertainty*	0.00015 cm^3
Weight diameter	6...100 mm
Maximum sphere diameter	95 mm
Comparator Technical Specifications	
Maximum capacity	1,010 g
Readability	10 µg
Repeatability s*	< 40 µg
Repeatability (typical), s*	< 20 µg
Weighing range, electronic	1,010 g

* Partial uncertainty of the volume comparator (without references and test weights)

s* Repeatability is the standard deviation "s"; it is calculated from 6 ABBA cycles, after eliminating drift. Prerequisites for accurate calculation of the standard deviation are good ambient conditions in accordance with OIML R111 for an E1 mass standards laboratory.

Optional Accessories for Density Determination

	Order number
Thermostat	YVT01C
1 kg silicon sphere with PTB density certificate	YDR1000SIC
E1 set of 1 g to 1 kg weights with PTB density certificate (stackable) as a density reference and as a substitution weight set for volume comparators	YCS31-612-09

ScalesNet-M

The Individual Software Solution for Professionally Calibrating Weights

With ScalesNet-M, Sartorius offers a customized solution for equipping a simple measurement laboratory through to the complete equipping of a national institute. Years of experience as a leading manufacturer of weights are incorporated in the development and have made ScalesNet-M into professional software for effective mass calibration.

Individual

The modular concept of ScalesNet-M can be adapted to the highly diversified needs of our customers and supplemented at any time.

Mass Calibration

With ScalesNet-M, mass calibration is traceable, secure and transparent at all levels. ScalesNet-M monitors and records all steps from the order arriving to the creation of calibration certificates, helping the customer reach their objective efficiently. ScalesNet-M is suitable for connection to all comparators from any manufacturer and flexible in incorporating existing climate measurement stations. At the same time, Sartorius provides a global service including initial installation, training, equipment connection and (remote) servicing and updating of ScalesNet-M.

Automatic Monitoring

All means of testing, such as reference weights, comparators and climate sensors are automatically monitored by ScalesNet-M. Reminders are issued for all necessary calibrations and adjustments, which are then executed and documented by ScalesNet-M.

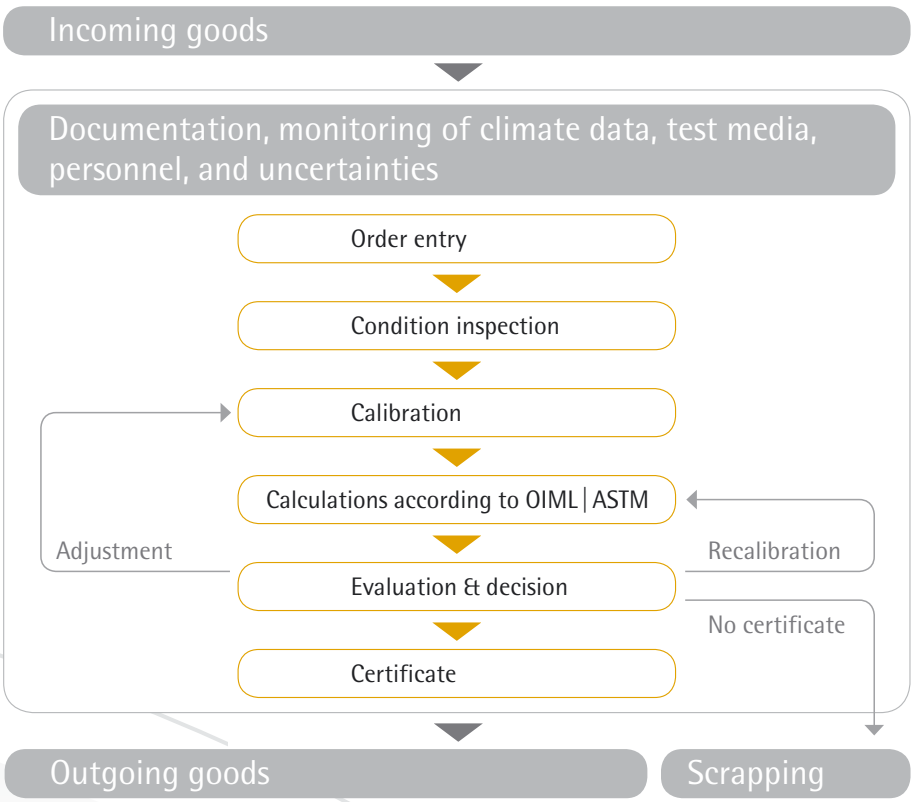
Advantages

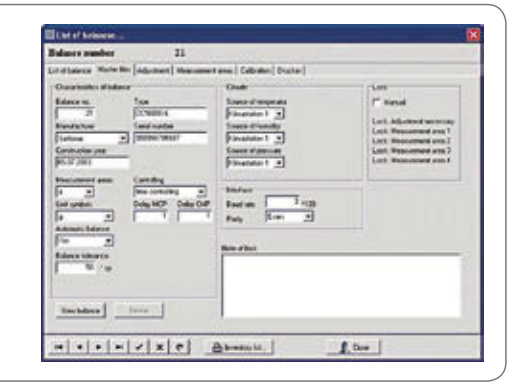
- Safe weight calibration
- Efficient measurement laboratory management
- Calculation and evaluation according to international guidelines such as OIML | ASTM
- Basis for an accredited measurement laboratory according to DIN EN ISO | IEC 17025
- Transparent documentation and archiving of all process-relevant data
- Automatic monitoring of test medium in laboratory
- Display of the customer and reference weight calibration history
- Incorporation of existing customer and calibration data into the ScalesNet-M database
- Individual software module compiling
- Connecting of comparators and climate measurement stations from any manufacturer
- Flawless, time-saving and automatic creation of multilingual, linguistically accurate calibration certificates
- Verifiable software
- Customizable service package

Features

- Calibration of any class and value of weights
- Suitable for all weighing cycles in accordance with international guidelines (OIML | ASTM)
- Subdivision mass comparison for calibrating E1 weights
- Automatic evaluation of calibration results
- Rapid comparison of weights without logging
- Export function of weight values as a CSV file
- Monitoring, recording and visual presentation of climate data
- Order preparation
- Examples integrated for weighing schemes
- Presentable history of all processes
- Cycles with and without additional weights and sensitivity weights
- All weight classes are already integrated in accordance with OIML and ASTM
- Inputting of own weight classes
- Automatic uncertainty calculation
- Continual test medium monitoring
- Automatic syntactically correct printout of calibration certificates
- DAkkS certificates and test log templates
- SQL database structure for customer, weight and calibration data
- Administration of user rights
- Automatic generation of inventory lists
- Plausibility test when standard set and comparator are selected
- Manual input of weighing data for comparators without RS-232 connection

Monitoring and Controlling the Calibration Process Using ScalesNet-M





Software ScalesNet-M

Equipment Supplied

The YSN03C basic package contains one CD and one dongle with the following licenses:

- 1× ScalesServer, SQL database
- 1× ScalesMass, laboratory calibration
  1× ScalesDesk, administration and user management
- 1× ScalesPrinter, printer control
  1× ScalesPlan, data backup
- 1× License for 5× mass comparators
  1× License for OIML R111 M1, M2, M3,
- ASTM 5, 6, 7, NIST Handbooks F, AMCMpt, Maint

System Requirements

- PC or laptop with a resolution of at least 1024 × 768, with Windows® XP or Windows® 7 and internet access for remote maintenance
- Local administrator rights for the PC
- PC connection cable for comparators

Reports

- DAkkS calibration certificates
- Calibration report
- Inventory lists
- Device lists
- Six comparison log
- Dissemination log

Languages

The software is available in German, English and Russian. Please contact us if another language is required.

User Management

- User groups (read | write rights, administrator)
- Individual user accounts

ScalesNet-M Module

YSN03C – Basic module
Sartorius basic software module for highly accurate mass determination.

ScalesNet-M, YSN03C Basic module

Modules for supplementing the ScalesNet-M software

YSN03NC – Network module
PC license for connecting to local networks.

YSN03LC – ScalesMass module
User license for simultaneous mass calibration on an additional PC. Only in conjunction with YSN03NC.

YSN03PC – ScalesDesk module
Administrator license for the simultaneous use of an additional administrator on an additional PC. Only in conjunction with YSN03NC.

YSN03DC – ScalesPrinter module
PC license for connecting an additional printer.

YSN03EC – Class E module
PC license for calibrating weights in accordance with OIML R111 classes E and F as well as classes 0 to 4 in accordance with ASTM E617.

YSN03FC – Class F module
PC license for calibrating weights in accordance with OIML R111 classes F1 and F2 as well as classes 2 to 4 in accordance with ASTM E617.

YSN03CC – Module for a climate measuring station
PC license for connecting an additional climate measuring station.

YSN03BC – Module for manual comparators
PC license for connecting up to five additional scales or manual mass comparators for simultaneous use.

YSN03AC – Module for automatic mass comparators
PC license for connecting automatic mass comparators with load alternator equipment.

YSN03MC – Module for the mass comparison
PC license for mass comparison for E1 weight classes and for calibrating weights of all accuracy classes in accordance with OIML R111 and ASTM E617.

YSN03RC – Robot module
PC license for connecting a robot, a vacuum mass comparator (such as the CCL 1007) or a load alternator that uses the a_control controlling software. Only in conjunction with YSN03NC.

Weights and Weight Sets

Regular inspection and testing of weighing instruments are a must to ensure reliable weighing results. Sartorius offers highly accurate metrological weights and weight sets with nominal mass values from 1 mg to 1,000 kg, special and test weights, as well as the accessories required for correct handling and storage of weights.

Unambiguousness | Traceability

For unique classification, Sartorius weights are laser marked with a three-digit marking in accordance with the international OIML R111 recommendations. Sartorius weights are therefore uniquely identifiable.

Sartorius reference weights and sets of reference weights are the first choice for primary mass standards. They feature a first-class finish with a high gloss polished, corrosion stable surface. The quality of the reference weights exceeds the requirements of the international OIML R111 recommendation.

Sartorius test weights and sets of test weights are top-class working standards for everyday use. These weights are made of high-quality material with a polished or finely turned surface and also meet the international OIML R111 recommendation for shape, material, and markings.

They are therefore suitable for legal and general metrological applications in research and industry.

DAkkS certificate

Sartorius reference, test, special, and custom weights are available with or without DAkkS certification.

Sartorius weights meet the requirements for traceability to the national kilogram prototype in conformance with ISO 9001:2000. They help support your quality management and quality assurance systems, and meet GLP and GMP requirements.

Details about our weights and other accessories can be found in the separate brochure or please visit our website at www.sartorius.com.

Set of reference weights

Glass bell jar with lower base

Excerpt from Our Weight and Accessories Range

Weight sets	Order number DAkkS calibrated E1	Order number DAkkS calibrated E2
1 mg – 5 g	YCS011-351-02*	YCS011-352-02*
1 mg – 100 g	YCS011-511-02*	YCS011-512-02*
1 mg – 200 g	YCS011-521-02*	YCS011-522-02*
1 mg – 1 kg	YCS011-611-02*	YCS011-612-02*
1 mg – 5 kg	YCS011-651-02*	YCS011-652-02*
1 g – 1 kg	YCS31-611-02*	YCS31-612-02*
1 g – 5 kg	YCS31-651-02*	YCS31-652-02*
1 g – 10 kg	YCS31-711-02*	YCS31-712-02*

Glass bell jar with lower base	Order number
for 1 mg – 5 g	YAW00
for 1 mg – 200 g	YAW01
for 100 g – 1 kg	YAW02
for 2 kg – 5 kg	YAW03
for 10 kg	YAW04
for 20 kg	YAW05
for 50 kg	YAW06

* Weights with DAkkS certificate in Sartorius's name for classes E2, F1, F2 up to 50 kg

1 kg silicon sphere YDR1000SIC

Accessories

Handles for lifting weights	Nominal value	Order number
Comb-type weight grabber	for 500 g	YAW41
Comb-type weight grabber	for 1 kg	YAW42
Comb-type weight grabber	for 2 kg	YAW43
Comb-type weight grabber	for 5 kg	YAW50
Lifting device	for 10 kg	YAW51
Lifting device	for 20 kg	YAW52
Lifting device	for 50 kg	YAW53
Crane with chain hoist		YLD01C
Gripper for weights with handle		YLD02C

Weighing tables	Order number
Weighing table made from synthetic stone (L × W × H) 900 × 600 × 760 mm	YWT03

Special weighing pans	Order number
Weighing pan with set of weighing plates for weighing mass combinations for CC1000S-L	YWP04C
Centering pan for MCM40K3 | MCM60K3 | MCM60K2	YWP03C

Weighing table with optional accessories

Draft shield

Draft shield	Order number
for MCM67	YDS20C
for MCM1004 | MCM2004 | MCM5004 | MCM5003 | MCM36 | MCM66 | MCM106 | MCM605 | MCM1005 | MCM10K3	YDS24C
for MCM10000S-L | MCM10000U-L | MCM20000S-L	YDS01C
for MCM40K3 | MCM60K3 | MCM60K2	YDS05C
for CCI60K2	YDS62C
for CCI100K2 | CCI300K	YDS64C

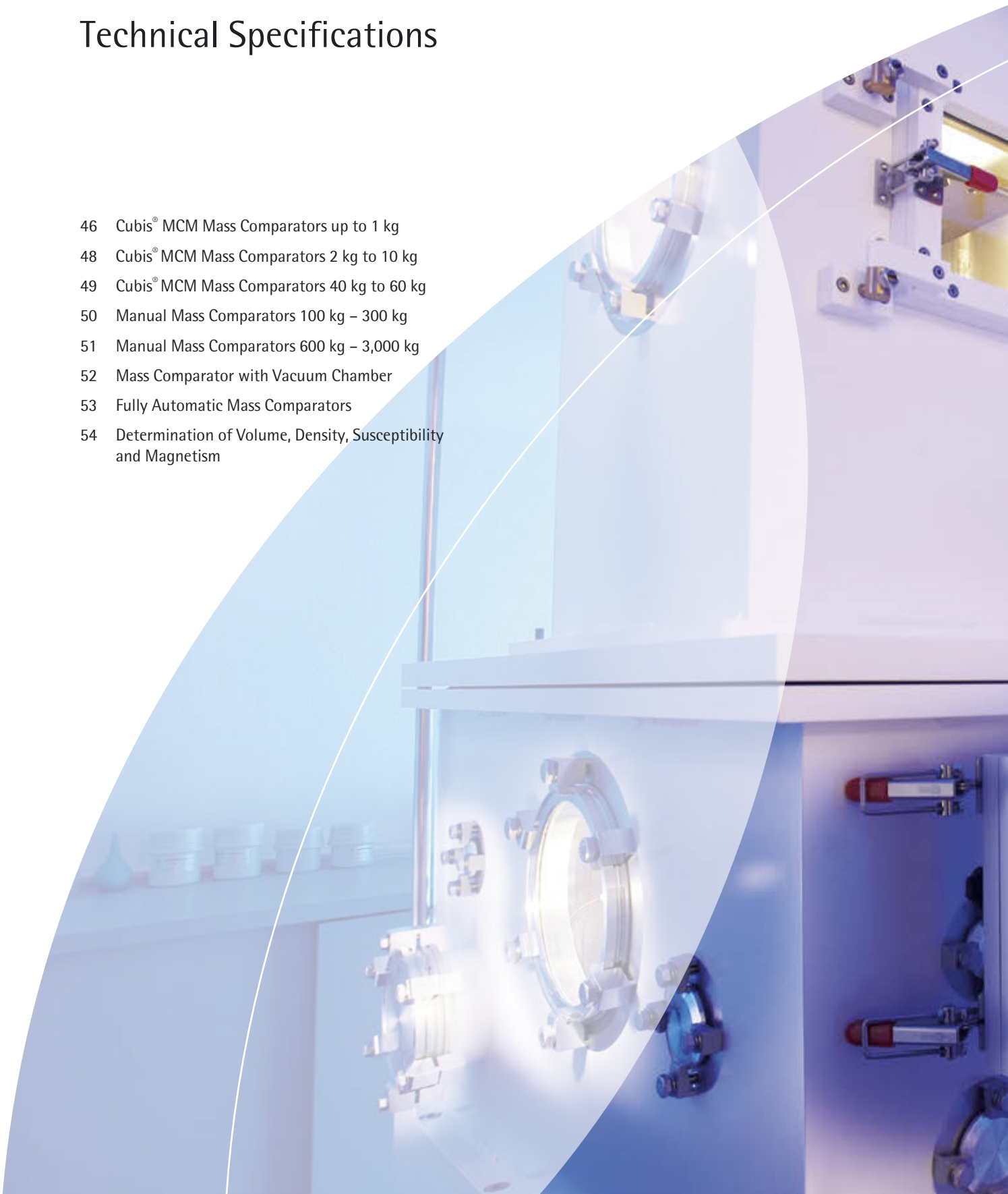
Density references	Order number
1,000 g silicon sphere	YDR1000SIC
500 g silicon sphere	YDR500SIC
200 g silicon sphere	YDR200SIC
1,000 g Zerodur sphere	YDR1000C
500 g Zerodur sphere	YDR500C
200 g Zerodur sphere	YDR200C
E1 set of 1 g to 1 kg weights with PTB density certificate (stackable) as a density reference and as a substitution weight set for volume comparators	YCS31-612-09

Printer	Order number
Data printer, with real-time clock for printing out date and time, and for statistical evaluation of weight values	YDP20-OCE

Switch	Order number
Foot switch with T-connector	YFS01
Hand switch with T-connector	YHS02

Density determination	Order number
Below-balance weighing equipment for CC30002 | CC50002 | MCM40K3 | MCM60K3 | MCM60K2	69EA0040
Density kit for MCM36 | MCM66 | MCM106 | MCM605 | MCM1005	YDK01LP

Technical Specifications




sartorius

Cubis® MCM Manual
Mass Comparators

Up to 1 kg




Order number with uncalibrated climate sensors	**MCM6.7**	**MCM36**	**MCM66**	**MCM106**
Order number with calibrated climate sensors with DAkkS certificate	**MCM6.7-DAkkS**	**MCM36-DAkkS**	**MCM66-DAkkS**	**MCM106-DAkkS**
Design	1	2	2	2
Maximum capacity	6.1 g	31 g	61 g	111 g
Readability	0.1 µg	1 µg	1 µg	1 µg
Application range	0 – 6 g	0 – 30 g	0 – 60 g	0 – 111 g
Repeatability s				
Under optimal conditions [1]	0.15 µg	1 µg	1 µg	1 µg
Under standard conditions E [2]	0.3 µg	1.5 µg	2 µg	2 µg
at 1/3 load [2]	0.2 µg			
at 1/10 load [2]		0.7 µg	0.7 µg	0.7 µg
Under standard conditions F [3]	0.6 µg	4 µg	5 µg	5 µg
Electronic weighing | taring range	6.1 g	31 g	61 g	61 g
Substitution weights				50 g
Linearity	1 µg	6 µg	8 µg	8 µg
Eccentric load deviation	0.25 µg/mm	1 µg/mm	1 µg/mm	1 µg/mm
Stabilization time	10 s	3 s	3 s	5 s
Cycle time (ABA)	90 s	90 s	90 s	90 s
Standard Accessories				
Data interfaces	RS-232C, USB, Ethernet, SD card (optional RS-232C, PS2, Bluetooth®)			
Draft shield	•	•	•	•
Additional application programs	Weighing, unit conversion, individual identifiers, density determination, statistics			
Below-balance weighing equipment	•	•	•	•
Climate sensors	Integrated into draft shield			
Optional accessories				
Calibration weight	5 g | E2 YCW352-00	20 g | E2 YCW422-00	50 g | E2 YCW452-00	50 g | E2 YCW452-00
Climate module	YMC20MC	YMC20MC	YMC20MC	YMC20MC
Calibrated climate module	YMC20MC-DAkkS	YMC20MC-DAkkS	YMC20MC-DAkkS	YMC20MC-DAkkS
2nd Draft shield	YDS20C	YDS24C	YDS24C	YDS24C
Weighing table	YWT03	YWT03	YWT03	YWT03
Dimensions				
Weighing pan size	∅ 16 mm	∅ 30 mm	∅ 30 mm	∅ 50 mm
Maximum object size (D × H)	16 × 70 mm	30 × 120 mm	30 × 120 mm	50 × 120 mm
Weigh cell (W × D × H)	122 × 343 × 141 mm	222 × 431 × 301 mm	222 × 431 × 301 mm	222 × 431 × 301 mm
Electronics unit (W × D × H)	239 × 320 × 56 mm	239 × 320 × 56 mm	239 × 320 × 56 mm	239 × 320 × 56 mm

Repeatability is the standard deviation "s"; it is calculated from 5 ABA cycles, after eliminating drift

[1] Optimal conditions: automatic measurement without operator influence measured in a laboratory under E1 conditions, on a decoupled weighing stone, no drafts from above

[2] Standard conditions E: measured by hand in a laboratory under E1 conditions, on a decoupled weighing stone, no drafts from above

[3] Standard conditions F: measured by hand in a laboratory under at least F1 conditions, on a non-decoupled weighing stone, air conditioning and minimal drafts from above



Order number with uncalibrated climate sensors	**MCM605**	**MCM1005**	**MCM1004**
Order number with calibrated climate sensors with DAkkS certificate	**MCM605-DAkkS**	**MCM1005-DAkkS**	**MCM1004-DAkkS**
Design	3	3	3
Maximum capacity	610 g	1,110 g	1,110 g
Readability	0.01 mg	0.01 mg	0.1 mg
Application range	0 – 610 g	0 – 1,110 g	0 – 1,110 g
Repeatability s			
Under optimal conditions [1]	10 µg	15 µg	0.05 mg
Under standard conditions E [2]	20 µg	20 µg	0.07 mg
at 1/3 load [2]	15 µg		
at 1/10 load [2]	10 µg	15 µg	0.05 mg
Under standard conditions F [3]	30 µg	50 µg	0.2 mg
Electronic weighing | taring range	610 g	610 g	610 g
Substitution weights		500 g	500 g
Linearity	100 µg	100 µg | 600 g	0.1 mg | 600 g
Corner load error	10 µg/mm	15 µg/mm	30 µg/mm
Stabilization time	5 s	5 s	3 s
Cycle time (ABA)	90 s	90 s	90 s
Standard Accessories			
Data interfaces	RS-232C, USB, Ethernet, SD card (optional RS-232C, PS2, Bluetooth®)		
Draft shield	•	•	•
Additional application programs	Weighing, unit conversion, individual identifiers, density determination, statistics		
Below-balance weighing equipment	•	•	•
Climate sensors	Integrated into draft shield		
Optional Accessories			
Calibration weight	500 g | E2 YCW552-00	500 g | E2 YCW552-00	500 g | E2 YCW552-00
Climate module	YMC20MC	YMC20MC	YMC20MC
Calibrated climate module	YMC20MC-DAkkS	YMC20MC-DAkkS	YMC20MC-DAkkS
2nd Draft shield	YDS24C	YDS24C	YDS24C
Weighing table	YWT03	YWT03	YWT03
Dimensions			
Weighing pan size	∅ 90 mm	∅ 90 mm	∅ 90 mm
Maximum object size (D × H)	135 × 140 mm	135 × 140 mm	135 × 140 mm
Weigh cell (W × D × H)	222 × 431 × 301 mm	222 × 431 × 301 mm	222 × 431 × 301 mm
Electronics unit (W × D × H)	239 × 320 × 56 mm	239 × 320 × 56 mm	239 × 320 × 56 mm

Repeatability is the standard deviation "s"; it is calculated from 5 ABA cycles, after eliminating drift

[1] Optimal conditions: automatic measurement without operator influence measured in a laboratory under E1 conditions, on a decoupled weighing stone, no drafts from above

[2] Standard conditions E: measured by hand in a laboratory under E1 conditions, on a decoupled weighing stone, no drafts from above

[3] Standard conditions F: measured by hand in a laboratory under at least F1 conditions, on a non-decoupled weighing stone, air conditioning and minimal drafts from above

Cubis® MCM Manual
Mass Comparators

2 kg – 10 kg




Order number with uncalibrated climate sensors	**MCM2004**	**MCM5004**	**MCM5003**	**MCM10K3**
Order number with calibrated climate sensors with DAkkS certificate	**MCM2004-DAkkS**	**MCM5004-DAkkS**	**MCM5003-DAkkS**	**MCM10K3-DAkkS**
Design	4	4	4	5
Maximum capacity	2,500 g	5,100 g	5,100 g	11 kg
Readability	0.1 mg	0.1 mg	1 mg	1 mg
Application range	0 – 2,500 g	0 – 5,100 g	0 – 5,100 g	0 – 11 kg
Repeatability s				
Under optimal conditions [1]	0.05 mg	0.3 mg	0.5 mg	0.8 mg
Under standard conditions E [2]	0.1 mg	0.5 mg	0.8 mg	1 mg
at 1/3 load [2]				
at 1/10 load [2]	0.07 mg	0.3 mg	0.5 mg	0.8 mg
Under standard conditions F [3]	0.3 mg	0.8 mg	1.5 mg	3 mg
Electronic weighing | taring range	2,500 g	5,100 g	5,100 g	11 kg
Substitution weights		50 g		
Linearity	1 mg	2 mg	3 mg	6 mg
Corner load error	30 µg / mm	151 µg / mm	300 µg / mm	0.5 mg / mm
Stabilization time	3 s	3 s	3 s	3 s
Cycle time (ABA)	90 s	90 s	90 s	90 s
Standard Accessories				
Data interfaces	RS-232C, USB, Ethernet, SD card (optional RS-232C, PS2, Bluetooth®)			
Draft shield	•	•	•	
Additional application programs	Weighing, unit conversion, individual identifiers, density determination, statistics			
Below-balance weighing equipment	•	•	•	•
Climate sensors	Integrated into draft shield			Can be connected to external PCs
Optional Accessories				
Calibration weight	2 kg | E2 YCW622-00	5 kg | E2 YCW652-00	5 kg | E2 YCW652-00	10 kg | E2 YCW712-00
Climate module	YMC20MC	YMC20MC	YMC20MC	YMC20MC
Calibrated climate module	YMC20MC-DAkkS	YMC20MC-DAkkS	YMC20MC-DAkkS	YMC20MC-DAkkS
2nd Draft shield	YDS24C	YDS24C	YDS24C	YDS24C
Weighing table	YWT03	YWT03	YWT03	YWT03
Lifting device for 10 kg				YAW51
Lifting device for 20 kg				
Dimensions				
Weighing pan size (W × D)	136 × 136 mm	136 × 136 mm	136 × 136 mm	200 × 200 mm
Maximum object size (D × H)	130 × 200 mm	130 × 200 mm	130 × 200 mm	
Weigh cell (W × D × H)	240 × 276 × 373 mm	240 × 276 × 373 mm	240 × 276 × 373 mm	240 × 276 × 102 mm
Electronics unit (W × D × H)	239 × 320 × 56 mm	239 × 320 × 56 mm	239 × 320 × 56 mm	239 × 320 × 56 mm

Repeatability is the standard deviation "s"; it is calculated from 5 ABA cycles, after eliminating drift

[1] Optimal conditions: automatic measurement without operator influence measured in a laboratory under E1 conditions, on a decoupled weighing stone, no drafts from above

[2] Standard conditions E: measured by hand in a laboratory under E1 conditions, on a decoupled weighing stone, no drafts from above

[3] Standard conditions F: measured by hand in a laboratory under at least F1 conditions, on a non-decoupled weighing stone, air conditioning and minimal drafts from above

Cubis® MCM Manual Mass Comparators

40 kg – 60 kg



Order number with uncalibrated climate sensors	**MCM40K3**	**MCM60K3**	**MCM60K2**
Order number with calibrated climate sensors with DAkkS certificate	**MCM40K3-DAkkS**	**MCM60K3-DAkkS**	**MCM60K2-DAkkS**
Design	6	6	6
Maximum capacity	41 kg	64 kg	64 kg
Readability	1 mg	2 mg	10 mg
Application range	0 – 41 kg	0 – 64 kg	0 – 64 kg
Repeatability s			
Under optimal conditions [1]	2 mg	4 mg	6 mg
Under standard conditions E [2]	3 mg	6 mg	10 mg
at 1/3 load [2]			
at 1/10 load [2]	2 mg	4 mg	
Under standard conditions F [3]	6 mg	10 mg	25 mg
Electronic weighing | taring range	41 kg	64 kg	64 kg
Linearity	20 mg	40 mg	50 mg
Corner load error	3.5 mg / mm	3.5 mg / mm	3.5 mg / mm
Stabilization time	5 s	5 s	5 s
Cycle time (ABA)	120 s	120 s	120 s
Standard Accessories			
Data interfaces	RS-232C, USB, Ethernet, SD card (optional RS-232C, PS2, Bluetooth®)		
Additional application programs	Weighing, unit conversion, individual identifiers, density determination, statistics		
Below-balance weighing equipment	with opt. accessories 69EA0040	with opt. accessories 69EA0040	with opt. accessories 69EA0040
Climate sensors	Can be connected to external PCs		
Optional Accessories			
Calibration weight	20 kg | E2 YCW722-00	50 kg | E2 YCW752-00	50 kg | E2 YCW752-00
Climate module	YMC20MC	YMC20MC	YMC20MC
Calibrated climate module	YMC20MC-DAkkS	YMC20MC-DAkkS	YMC20MC-DAkkS
2nd Draft shield	YDS05C | YDS03C	YDS05C | YDS03C	YDS05C | YDS03C
Lifting device for 10 kg	YAW51	YAW51	YAW51
Lifting device for 20 kg	YAW52	YAW52	YAW52
Lifting device for 50 kg		YAW53	YAW53
Crane with chain hoist		YLD01C	YLD01C
Gripper for weights with handle		YLD02C	YLD02C
Floor-mounted column, stainless steel			
Dimensions			
Weighing pan size (W × D)	400 × 300 mm	400 × 300 mm	400 × 300 mm
Weigh cell (W × D × H)	400 × 326 × 126 mm	400 × 326 × 126 mm	400 × 326 × 126 mm
Electronics unit (W × D × H)	239 × 320 × 56 mm	239 × 320 × 56 mm	239 × 320 × 56 mm

Repeatability is the standard deviation "s"; it is calculated from 5 ABA cycles, after eliminating drift

[1] Optimal conditions: automatic measurement without operator influence measured in a laboratory under E1 conditions, on a decoupled weighing stone, no drafts from above

[2] Standard conditions E: measured by hand in a laboratory under E1 conditions, on a decoupled weighing stone, no drafts from above

[3] Standard conditions F: measured by hand in a laboratory under at least F1 conditions, on a non-decoupled weighing stone, air conditioning and minimal drafts from above

Manual High-capacity Mass Comparators

100 kg – 300 kg

	CCI100K2	CCI300K
Maximum capacity	151 kg	303 kg
Readability	0.05 g	1 g
Application range	0 – 151 kg	0 – 303 kg
Repeatability s*	0.3 g	1 g
Repeatability at 1/10 load		
Repeatability (typical), s*	0.2 g	0.5 g
Electronic weighing | taring range	151 kg	303 kg
Linearity	2 g	10 g
Corner load error	25 mg/mm	50 mg/mm
Stabilization time	10 s	10 s
Standard Accessories		
Interfaces	2× RS-232C	2× RS-232C
Draft shield	•	
Application programs		
Below-balance weighing equipment		
PC connection cable	•	•
Optional Accessories		
Calibration weight	50 kg | F1 YCW753-00	100 kg | F1 YCW813-02
PC software ScalesNet-M	YSN03C	YSN03C
Climate station for E1	YCM16C	YCM16C
2nd Draft shield		YDS64C
Lifting device for 10 kg	YAW51	YAW51
Lifting device for 20 kg	YAW52	YAW52
Lifting device for 50 kg	YAW53	YAW53
Crane with chain hoist	YLD01C	YLD01C
Gripper for weights with handle	YLD02C	YLD02C
Floor-mounted column, stainless steel	YDH03CIS	YDH03CIS
Dimensions		
Weighing pan dimensions (W × D)	800 × 600 × 135 mm	800 × 600 × 135 mm
Weigh cell (W × D × H)		
Electronics unit (W × D × H)	303 × 195 × 90 mm	303 × 195 × 90 mm

s* Repeatability is the standard deviation "s"; it is calculated from 5 ABA cycles, after eliminating drift.
Prerequisites for accurate calculation of the standard deviation are good ambient conditions in accordance with OIML R111 for an E1 mass standards laboratory.

Manual High-capacity Mass Comparators

600 kg – 3,000 kg





	CCS600K	CCT1000K	CCS1000K	CCT2000K	CCS3000K
Maximum capacity	605 kg	1,200 kg	1,510 kg	2,100 kg	3,010 kg
Readability	1 g	1 g	5 g	1 g	10 g
Application range	0 – 605 kg	0 – 1,200 kg	0 – 1,510 kg	0 – 2,100 kg	0 – 3,010 kg
Repeatability s*	2.5 g	3 g	6 g	8 g	12 g
Repeatability (typical), s*	2 g	2 g	5 g	5 g	10 g
Electronic weighing | taring range	605 kg	1,200 kg	1,510 kg	2,100 kg	3,010 kg
Linearity	30 g	25 g	200 g	30 g	500 g
Corner load error	0.2 g/mm	0.3 g/mm	0.6 g/mm	0.7 g/mm	1 g/mm
Stabilization time	20 s	30 s	20 s	30 s	20 s
Standard Accessories					
Interfaces	2× RS-232C	2× RS-232C	2× RS-232C	2× RS-232C	2× RS-232C
Draft shield	•	•	•	•	•
PC connection cable	•	•	•	•	•
Optional Accessories					
Calibration weight	500 kg | F1 YCW853-02	1000 kg | F2 YCW914-02	1000 kg | F2 YCW914-02	1000 kg | F2 YCW914-02	1000 kg | F2 YCW914-02
PC software ScalesNet-M	YSN03C	YSN03C	YSN03C	YSN03C	YSN03C
Climate station for E1	YCM16C	YCM16C	YCM16C	YCM16C	YCM16C
Floor-mounted column, stainless steel	YDH03CIS	YDH03CIS	YDH03CIS	YDH03CIS	YDH03CIS
Base for installing floor-mounted column, stainless steel	YBP03CIS	YBP03CIS	YBP03CIS	YBP03CIS	YBP03CIS
PC software for mass determination	YPR02C	YPR02C	YPR02C	YPR02C	YPR02C
PC Software SartoCollect	YSC02	YSC02	YSC02	YSC02	YSC02
Dimensions					
Weighing pan dimensions (W × D)	830 × 1,030 × 250 mm	1,510 × 1,370 × 240 mm	830 × 1,030 × 250 mm	1,920 × 1,710 × 230 mm	1,000 × 1,250 × 300 mm
Electronics unit (W × D × H)	303 × 195 × 90 mm	303 × 195 × 90 mm	303 × 195 × 90 mm	303 × 195 × 90 mm	303 × 195 × 90 mm
Net weight	150 kg	225 kg	150 kg	400 kg	300 kg
Gross weight	250 kg	338 kg	250 kg	536 kg	470 kg
Pallet	1.5 × 1.1 × 0.6 m	1.8 × 1.8 × 0.6 m	1.5 × 1.1 × 0.6 m	2.1 × 2.2 × 0.6 m	1.7 × 1.6 × 0.6 m

s* Repeatability is the standard deviation "s"; it is calculated from 5 ABA cycles, after eliminating drift.
Prerequisites for accurate calculation of the standard deviation are good ambient conditions in accordance with OIML R111 for an M1 mass standards laboratory.

Mass Comparators

With Vacuum Chamber




	CCL1007	YVP01C	YVTS01C	YVC01C
Maximum capacity	1031 g		1 kg	1 kg
Readability	0.1 µg			
Application range	1 mg – 1 kg			
Repeatability s*	0.2 µg			
Repeatability in vacuum, s*	0.1 µg			
Repeatability (typical), s*	0.1 µg			
Electronic weighing | taring range	2 g			
Linearity	1 µg			
Range sensitivity	0.2 µg – 500 mg			
Stabilization time	80 s			
Cycle time ABBA	480 s			
Pressure range	10E-6 – 1000 mbar	10E-6 – 1000 mbar	10E-6 – 1000 mbar	10E-6 – 1000 mbar
Helium leak rate	< 10E-7 (mbar*l)/s	< 10E-7 (mbar*l)/s	< 10E-7 (mbar*l)/s	< 10E-7 (mbar*l)/s
Standard Accessories				
Load alternator positions	8		1	
Interfaces	LAN | USB | RS-232			
isoCAL				
Centermatic	•			
Enclosure	•			
Control unit	•		•	
PC	•			
PC software	•			
Optional Accessories				
Turbopump Stand	YVP01C		YVP02C	YVP02C
Vacuum Transfer System	YVTS01C			
Vacuum container	YVC01C		YVC01C	
Climate station for E1	YCM16C			
PC software ScalesNet-M	YSN03C			
Calibration weight	2 g | E2 YCW322-02			
Dimensions				
Sample size (D × H)	34 – 95 × 110 mm		34 – 95 × 110 mm	34 – 95 × 110 mm
Diameter range for a silicon sphere	45 – 100 mm		45 – 100 mm	45 – 100 mm
Vacuum chamber (W × D × H)	960 × 860 × 1,260 mm		1,081 × 1,044 × 1,261 mm	
Control unit (W × D × H)	600 × 800 × 2.000 mm			
Net weight	350 kg	45 kg	200 kg	

s* Repeatability is the standard deviation "s"; it is calculated from 6 ABBA cycles, after eliminating drift.
Prerequisites for accurate calculation of the standard deviation are good ambient conditions in accordance with OIML R111 for an E1 mass standards laboratory.

Mass Comparators

Fully Automatic



	CCR10	CCR1000	CCR10-1000
Maximum capacity	10.5 g	1,021 g	1,021 g
Readability	0.1 µg	1 µg	0.1 µg | 1 µg
Application range	1 mg – 10 g	10 g – 1 kg	1 mg – 1 kg
Repeatability s*	0.5 µg	8 µg	0.5 µg | 8 µg
Repeatability at 1/2 load	0.3 µg	5 µg	0.3 µg | 5 µg
Repeatability at 1/10 load	0.2 µg	3 µg	0.2 µg | 3 µg
Repeatability (typical), s*	0.2 µg	2 µg	0.2 µg | 2 µg
Electronic weighing | taring range	3.5 g	21 g	3.5 g | 21g
Substitution weights	2 × 3.5 g	30 | 40 | 50, 2 × 100 | 300 | 400 g	2 × 3.5 | 30 | 40 | 50, 2 × 100 | 300 | 400 g
Linearity	1 µg | 3.5 g	20 µg | 21 g	1 µg | 3.5 g | 20 µg | 21 g
Corner load error	0.25 µg / mm	0 mg	0.25 µg / mm | 0 mg
Stabilization time	15 s	25 s	15 s | 25 s
Cycle time ABBA	<240 s	<400 s	<240 s | <400 s
Standard Accessories			
Load alternator positions	2	2	2 | 2
Magazine positions	39 pos.	23 pos.	39 pos. | 23 pos.
Interfaces	LAN | USB | RS-232	LAN | USB | RS-232	LAN | USB | RS-232
Centermatic	–	•	– | •
Enclosure	•	•	•
PC	•	•	•
PC software	•	•	•
Climate station	YCM16C	YCM16C	YCM16C
Optional Accessories			
PC software ScalesNet-M	YSN03C	YSN03C	YSN03C
Calibration weight	2 g | E2 YCW322-00	20 g | E2 YCW422-00	2 g | E2 YCW322-00 and 20 g | E2 YCW422-00
Extensions			
Upgrade kit	Y1000UPGRADE	Y10UPGRADE	
Reference magazine	Y10R:(26)	Y1000R:(14)	Y10R:(26) | Y1000R:(14)
2nd turning magazine	Y10M:(39)	Y1000M:(23)	Y10M:(39) | Y1000M:(23)
Dimensions			
Weighing pan dimensions (W × D)	49 × 29 mm	104 × 68 mm	49 × 29 mm | 104 × 68 mm
Sample size (D × H)	18 × 20 mm	100 × 120 mm	18 × 20 mm | 100 × 120 mm
Exterior measurements (W × D × H)	1,900 × 1,250 × 2,328 mm	1,900 × 1,250 × 2,328 mm	1,900 × 1,250 × 2,328 mm
Net weight	1,900 kg	1,900 kg	1,900 kg

s* Repeatability is the standard deviation "s"; it is calculated from 6 ABBA cycles, after eliminating drift.
Prerequisites for accurate calculation of the standard deviation are good ambient conditions in accordance with OIML R111 for an E1 mass standards laboratory.

Devices for Determination of Volume, Density, Susceptibility and Magnetism




	VD1005	YP50K	YSZ02C	YSZ01C
Maximum capacity	1,110 g	50 kg	50 kg	50 kg
Readability	10 µg		1 µg	10 µg
Application range	1 g – 1 kg	2 kg – 50 kg	2 g – 50 kg	2 g – 50 kg
Repeatability s*	40 µg		8 µg	20 µg
Repeatability (typical), s*	20 µg		5 µg	10 µg
Electronic weighing | taring range	305 g		10 g	10 g
Linearity	0.12 mg		0.05 mg	0.1 mg
Stabilization time	20 s		15 s	15 s
Uncertainty of density	1 kg/m^3	< 10 kg/m^3		
Uncertainty of volume	0.00015 cm^3	0.6 – 1.5 cm^3		
Standard Accessories				
Load alternator positions	2 × 9			
Interfaces	LAN | USB | RS-232		RS-232	RS-232
Draft shield	•		•	•
Enclosure	•			
Control unit	•			
PC	•			
PC software	•	•	•	•
Air temperature sensor	1			
Humidity sensor	1			
Air pressure sensor	1			
Fluid temperature sensor	2	1		
Test certificate	BEV	BEV	Sartorius	Sartorius
PC connection cable			•	•
Climate station	•			
Optional Accessories				
Calibration weight	200 g | E2 YCW522-00		10 g | E2 YCW412-00	10 g | E2 YCW412-00
Weighing table	YWT20C		YWT03	YWT03
Crane with chain hoist		YLD01C	YLD01C	YLD01C
Gripper for weights with handle		YLD02C	YLD02C	YLD02C
1 kg PTB reference susceptibility			YSZ01RSC	YSZ01RSC
Magnet calibration kit for susceptometer			YSZ01RMC	YSZ01RMC
Thermostat	YVT01C			
Density reference (Si)	200 | 500 | 1,000 g			
Density reference, set of weights 1 g – 1 kg	YCS31-612-09			

s* Repeatability is the standard deviation "s"; it is calculated from 6 ABBA cycles, after eliminating drift.
Prerequisites for accurate calculation of the standard deviation are good ambient conditions in accordance with OIML R111 for an E1 mass standards laboratory.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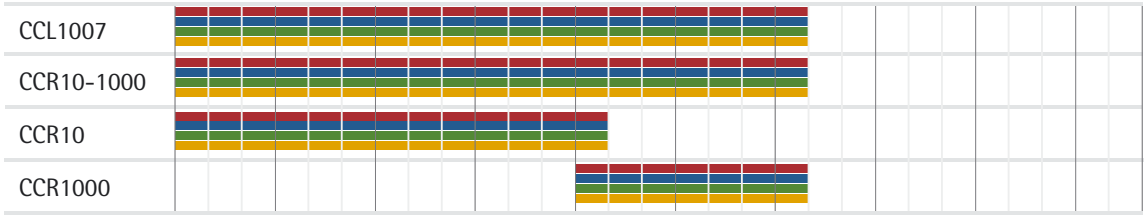
Calculations and Areas of Application

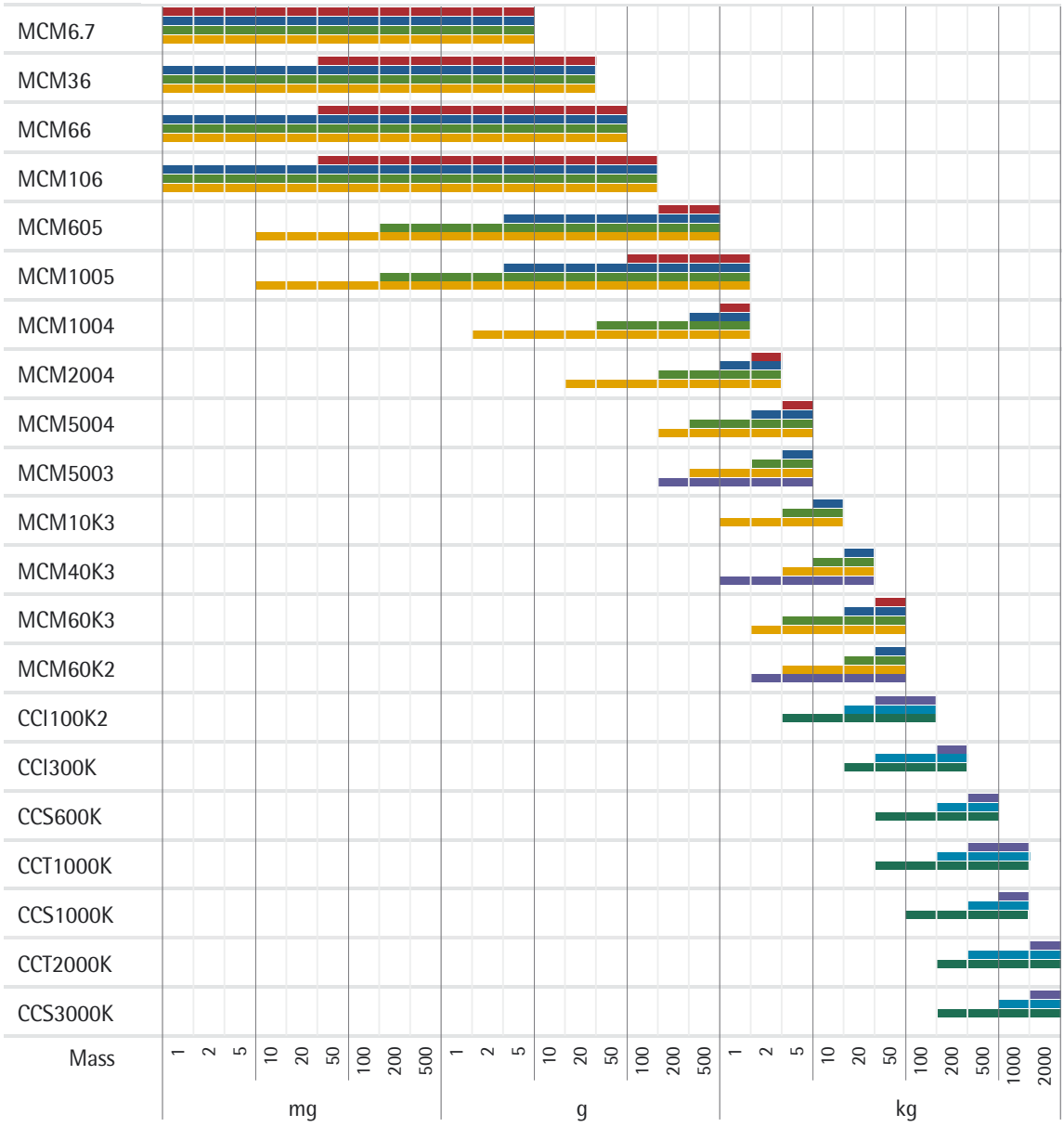
Areas of Application

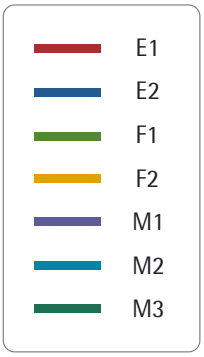
In Accordance with OIML R111-1:2004

Robots and Automatic Mass Comparators



Manual Mass Comparators

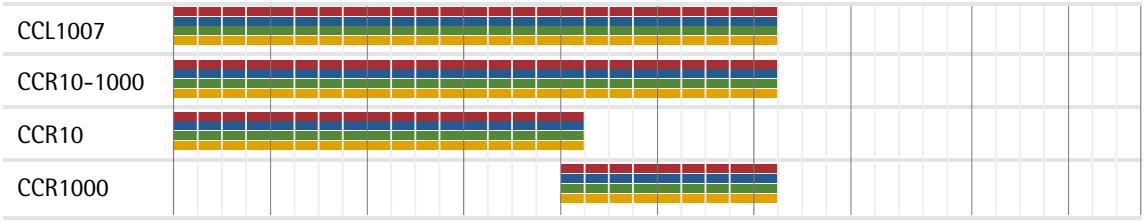




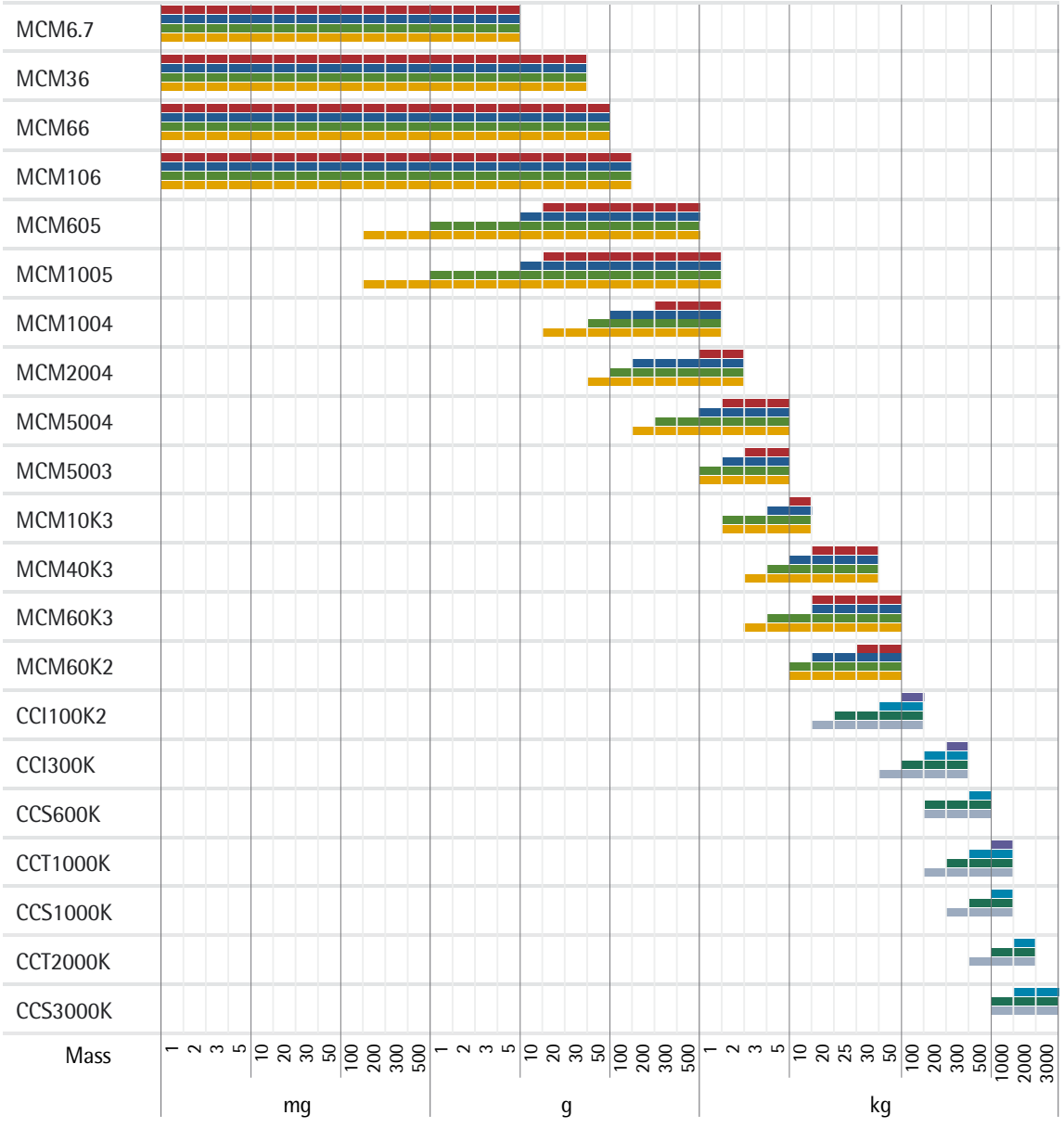
Areas of Application

In Accordance with ASTM E617-13

Robots and Automatic Mass Comparators



Manual Mass Comparators



Calculating Uncertainties

In Accordance with OIML R111

The figures "Areas of Application in Accordance with OIML R111-1 and ASTM E617-13" present an overview of the suitability of Sartorius mass comparators for mass comparisons in the various accuracy classes with a 95% confidence level ($k = 2$).
The following explains the basic principles for determining these ranges.

The expanded uncertainty of the conventional mass of the test weight is produced from:

$$U(m_{ct}) = k \times u_c(m_{ct})$$ [1, Formula C.6.5-3]

Each weight must fulfill this condition

$$U(m_{ct}) \leq \frac{1}{3}\text{MPE}$$ cf. [1, Formula C.5.2-1, Tab. 1]

(MPE: Maximum Permissible Error)

The combined uncertainty of the test weight is produced from:

$$u_c(m_{ct}) = \sqrt{u_w^2(\overline{\Delta m_c}) + u^2(m_{cr}) + u_b^2 + u_{ba}^2}$$ [1, Formula C.6.5-1],

from the standard uncertainty of the weighing process:

$$u_w(\overline{\Delta m_c}) = s(\Delta m_c)/\sqrt{n}$$ [1, Formula C.6.1-1],

from the standard uncertainty of the reference weight:

$$u(m_{cr}) = \sqrt{(U/k)^2 + u_{inst.}^2(m_{cr})}$$ [1, Formula C.6.2-1],

from the standard uncertainty of the air buoyancy correction with ρ

$\rho_{al} = \rho_0$: cf. [1, Formula C.6.3-1], [3, Formula 34.67]

$$u_b = m_{cr}\sqrt{[(\rho_r - \rho_t)/(\rho_r \times \rho_t)\, u(\rho_a)]^2 + (\rho_a - \rho_0)^2(u(\rho_t)^2/\rho_t^4 + u(\rho_r)^2/\rho_r^4)}$$

and the combined standard uncertainty of the balance:

$$u_{ba} = \sqrt{u_s^2 + u_d^2 + u_E^2 + u_{ma}^2}$$ [1, Formula C.6.4-5].

This comprises the standard uncertainty due to the sensitivity of the comparator:

$$u_s = |\overline{\Delta m_c}|\sqrt{u^2(m_s)/m_s^2 + u^2(\Delta I_s)/\Delta I_s^2}$$ [1, Formula C.6.4-1], and|or simplified

$$u_s \approx |\overline{\Delta m_c}|\, u(m_s)/m_s \approx 5 \times 10^{-4}|\overline{\Delta m_c}|$$ cf. [3, Sections 3.4.6.2-3.4.6.3],

from the standard uncertainty of the display resolution:

$$u_{\mathrm{d}} = d\sqrt{2}/(2\sqrt{3})$$ [1, Formula C.6.4-2],

from the standard uncertainty due to eccentricity:

$$u_{\mathrm{E}} = 0$$ cf. [1, Section C.6.4.4.1]

and the standard uncertainty due to magnetism:

$$u_{\mathrm{ma}} = 0$$ cf. [1, Section C.6.4.5]

Calculation of the air density from the climate parameters temperature, air pressure and humidity produces the standard uncertainty of the air density according to [1, Formula C.6.3-3]:

$$u(\rho_{\mathrm{a}}) = \sqrt{u_{\mathrm{F}}^2 + \left(\partial\rho_{\mathrm{a}}/\partial p \; u_p\right)^2 + (\partial\rho_{\mathrm{a}}/\partial t \; u_t)^2 + (\partial\rho_{\mathrm{a}}/\partial hr \; u_{hr})^2}$$

with the standard uncertainty of formula:

$$u_{\mathrm{F}} = \; 2 \times 10^{-4}\rho_{\mathrm{a}}$$ cf. [1, Section E.3]

and the sensitivity coefficient:

$$\partial\rho_{\mathrm{a}}/\partial p \approx +1 \times 10^{-5}\mathrm{Pa}^{-1}$$
$$\partial\rho_{\mathrm{a}}/\partial t \approx -4 \times 10^{-3}\mathrm{K}^{-1}$$
$$\partial\rho_{\mathrm{a}}/\partial hr \approx -9 \times 10^{-3}, \text{ mit } 0 \leq hr \leq 1$$

cf. [4, Section 2.2]

To verify the suitability of mass comparators for the various accuracy classes, uncertainty shares must be included in the uncertainty budget. It is good practice for a user to clearly apply the following:

$$u_{\mathrm{w}}(\overline{\Delta m_{\mathrm{c}}}) \leq \frac{4}{5}u_{\mathrm{c}}(m_{\mathrm{ct}}) \quad \text{und} \quad u(m_{\mathrm{cr}}) = u_{\mathrm{b}} = u_{\mathrm{ba}} \leq \frac{1}{3}u_{\mathrm{c}}(m_{\mathrm{ct}})$$

If these individual requirements are observed, the combined uncertainty is always less than the required uncertainty limit.
This requirement for the standard uncertainty of the weighing process $u_{\mathrm{w}}(\overline{\Delta m_{\mathrm{c}}})$ results in a similar requirement for the repeatability s of the mass comparator.

$$u_{\mathrm{w}}(\overline{\Delta m_{\mathrm{c}}}) = \; s(\Delta m_{\mathrm{c}})/\sqrt{n} \leq \frac{4}{5}u_{\mathrm{c}}(m_{\mathrm{ct}}) = \frac{2}{5}U(m_{\mathrm{ct}}) = \frac{2}{15}\mathrm{MPE}, \text{ d.h. } s(\Delta m_{\mathrm{c}}) \leq \frac{2}{15}\mathrm{MPE}\sqrt{n}$$

The necessary number of weighing cycles can be found in the OIML and|or ASTM for the respective accuracy class. The calculations in the diagrams for the suitability of mass comparators for the various accuracy classes are based on the respective number of ABA cycles indicated in the table.

Example

In the following, the generation of an uncertainty budget is illustrated using the example of a calibration of a 20-kg weight of accuracy class E2 ($n = 3$) on mass comparator MCM60K3. This example equally illustrates the suitability of the mass comparator for the corresponding accuracy class.

Mass comparator:	MCM60K3 with calibrated internal climate module YCM20MC
Repeatability:	$s = 6\ \mathrm{mg}$
Digital scale interval:	$d = 2\ \mathrm{mg}$
Permissible error limit:	MPE = 30 mg (20 kg, accuracy class E2)
Reference weight:	Accuracy class E1, with DAkkS certificate Conventional mass: $m_{\mathrm{cr}} = 20\ \mathrm{kg} - 12\ \mathrm{mg}$ Expanded uncertainty : $U(m_{\mathrm{cr}}) = 3\ \mathrm{mg}, \quad k = 2$ Density: $\rho_{\mathrm{r}} = 8012.7\ \mathrm{kg\,m^{-3}}, \quad u(\rho_{\mathrm{r}}) = 1.25\ \mathrm{kg\,m^{-3}}$
Test weight:	Conventional mass: $m_{\mathrm{ct}} = 20\ \mathrm{kg} + 42\ \mathrm{mg}$
Density:	$\rho_{\mathrm{t}} = 7950\ \mathrm{kg\,m^{-3}},\ u(\rho_{\mathrm{t}}) = 70\ \mathrm{kg\,m^{-3}}$ [1, Tab. B.7, Stainless steel]
Ambient conditions:	Measured values of the internal climate module Temperature: $t = 20\ °\mathrm{C}, \quad u_t = 0.15\ \mathrm{K}$ Pressure: $p = 970\ \mathrm{hPa}, \quad u_p = 1\ \mathrm{hPa}$ Humidity: $hr = 50\ \%, \quad u_{hr} = 1\ \%$
Air density:	$\rho_{\mathrm{a}} = 1.148\ \mathrm{kg\,m^{-3}}, u(\rho_{\mathrm{a}}) = 0.001\ \mathrm{kg\,m^{-3}}$ (calculated by application software on the mass comparator)
Uncertainties:	$u_{\mathrm{w}}(\overline{\Delta m_{\mathrm{c}}}) = 6\ \mathrm{mg}/\sqrt{3} = 3.46\ \mathrm{mg}$ $u(m_{\mathrm{cr}}) = 3\ \mathrm{mg}/2 = 1.50\ \mathrm{mg}$, with $u_{\mathrm{inst.}}(m_{\mathrm{cr}}) = 0$ $u_{\mathrm{b}} = 1.15\ \mathrm{mg}$ $u_{\mathrm{ba}} = 0.82\ \mathrm{mg}$, with $u_{\mathrm{s}} = 5 \times 10^{-4} \times 54\ \mathrm{mg} = 0.03\ \mathrm{mg}$ $u_{\mathrm{d}} = 2\ \mathrm{mg} \times \sqrt{2}/(2\sqrt{3}) = 0.82\ \mathrm{mg}$ $u_{\mathrm{E}} = 0\ \mathrm{mg}$ (already contained in u_{w}) $u_{\mathrm{ma}} = 0\ \mathrm{mg}$ (since weight is OIML-compliant)

$$u_{\mathrm{c}}(m_{\mathrm{ct}}) = \sqrt{(3.46\ \mathrm{mg})^2 + (1.50\ \mathrm{mg})^2 + (1.15\ \mathrm{mg})^2 + (0.82\ \mathrm{mg})^2} = 4.03\ \mathrm{mg}$$

$$\boldsymbol{U(m_{\mathrm{ct}}) = 2 \times 4.03\ \mathrm{mg} = 8.05\ \mathrm{mg} \leq \frac{1}{3} 30\ \mathrm{mg} = 10\ \mathrm{mg}}$$

The following example calculation is used to prove that the expanded uncertainty of the conventional mass of the test weight is less than 1/3 of the permissible error limit. This means the calibration undertaken with the mass comparator used is compliant with OIML R111-1.

References

[1] OIML R111-1, Weights of classes E1, E2, F1, F2, M1, M1–2, M2, M2–3 and M3, Part 1: Metrological and technical requirements, Edition 2004 (E)

[2] ASTM E617-13, Standard Specification for Laboratory Weights and Precision Mass Standards, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States, 2013

[3] Kochsiek, M., Gläser, M., "Comprehensive Mass Metrology", Wiley-VCH Verlag Berlin (2000), Sec.3.4, "Mass determination with balances" (Roman Schwartz)

[4] Picard, A., Davis, R.S., Gläser, M., Fujii, K., "Revised formula for the density of moist air (CIPM-2007)", Metrologia 45 (2008) 149–155

[5] GUM 1995, Guide to the expression of uncertainty in measurement, JCGM 100:2008, 2008

Table: Number of ABA weighing cycles

OIML class	E1	E2	F1	F2	M1	M2	M3
ASTM class	0	1 | 2	3 | 4	5	6	7	F
Cycles n	5	3	2	1	1	1	1
$s_{\max}(\Delta m_c) = \frac{2}{15}\mathrm{MPE}\sqrt{n}$	0.30 MPE	0.23 MPE	0.19 MPE	0.13 MPE	0.13 MPE	0.13 MPE	0.13 MPE

In individual cases, it must be proven that the preset limit values of the expanded uncertainty of the conventional mass of the test weight comply.

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