



Mass Metrology

Professional Equipment
for Absolute Precision

Simplifying Progress

SARTORIUS



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 vacuum 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.

Find out more

For more information, please visit
www.sartorius.com/en/products/weighing/mass-comparators-metrology





Products for the Determination of Mass



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 **Find out more**
For more information, please visit
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The Cubis® Manual Mass Comparators

Your Full-range Mass Standards Laboratory

The manual Cubis® 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® produces results that are all naturally also ASTM-compliant.

Integrated Workflow Control

The integrated workflow control of the manual Cubis® 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. They can be integrated in existing networks and every type of data desired can be transferred to other devices.

The Cubis® 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® Manual Mass Comparators

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

- All Cubis mass comparators feature a MCA display (capacity ≤ 1 kg), MSA display (capacity > 1 kg) 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 (for MCA models the climate module is an optional accessory).
- Steps for calibration 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.
- MCM mass comparators automatically detect when the balance is skewed and provide graphic support during leveling. On the models MCM2004, MCM5004, MCM5003 and all MCA models motorized leveling is also possible.
- The Cubis® manual mass comparators 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 either USB drive (models with capacity < 2 kg) or SD card (models with capacity > 2 kg) to transfer them to the PC or other Cubis manual 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 external 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.





SHIMADZU
Model: AUW2204N
Date: 08/2018
Unit: g
100000.0
Current weight: 0.00000 g
Capacity: 220.0000 g
Max. Load: 220.0000 g

Models



Model 1	MCM6.7
Maximum capacity and electrical weighing range	6.1 g
Readability	0.1 µg
Typical repeatability	0.15 µg



Model 2	MCA36MC	MCA66MC	MCA106MC	MCA206MC
Maximum capacity and electrical weighing range	31 g	61 g	111 g	211 g
Readability	1 µg	1 µg	1 µg	1 µg
Typical repeatability	1 µg	1 µg	1.5 µg	2.5 µg



Model 3	MCA605MC	MCA1005MC	MCA1004MC
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
Typical repeatability	10 µg	15 µg	50 µg





Model 4	MCM2004	MCM5004	MCM5003	MCM10K4.2
Maximum capacity and electrical weighing range	2.5 kg	5.1 kg	5.1 kg	11 kg
Readability	0.1 mg	0.1 mg	1 mg	0.2 mg
Typical repeatability	0.05 mg	0.3 mg	0.5 mg	0.4 mg



Model 5	MCM10K4.1
Maximum capacity and electrical weighing range	10.050 g
Readability	0.1 mg
Typical repeatability	0.25 mg



Model 6	MCM10K3
Maximum capacity and electrical weighing range	11 kg
Readability	1 mg
Typical repeatability	0.8 mg



Model 7	MCM40K3	MCM60K3	MCM60K2
Maximum capacity	41 kg	64 kg	64 kg
Readability	1 mg	2 mg	10 mg
Typical repeatability	2 mg	4 mg	6 mg



Model 8	MCM32002
Maximum capacity	32 kg
Readability	10 mg
Typical repeatability	10 mg

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

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

Accessories and Service	Order Number
Climate module, without calibration certificate, 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-DAkks 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

* Not available as an option on model MCM32002

Automatic Air 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 must be performed to determine the conventional mass.

All models in the Cubis® MCM manual mass comparator family, except model MCM32002, 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.

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:

$u_t = 0.15 \text{ K}$ in the range 18°C to 27°C

Pressure:

$u_p = 1 \text{ hPa}$ in the range 800 hPa to $1,100 \text{ hPa}$

Humidity:

$u_{hr} = 1\%$, $30\% < hr < 70\%$

$u_{hr} = 2\%$, $70\% < hr < 90\%$

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




Climate module connected within the draft shield



Manual High-Capacity Mass Comparators

18 Manual High-capacity Mass Comparators
up to 3,000 kg



 **Find out more**
For more information, please visit
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Manual High-Capacity Mass Comparators

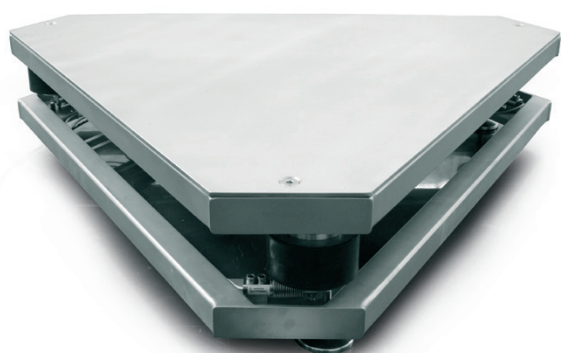
Up to 3,000 kg

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 "heavyhanded" 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

CCI Range

	MCM150K2	MCM300K2	MCM600K2
Maximum capacity	155 kg	310 kg	610 kg
Readability	10 mg	20 g	50 mg
Repeatability (typical) s*	80 mg	200 mg	500 mg

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.




CCS Range

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

Automatic Mass Comparators AMC

- 22 Model AMC1006
- 22 Model AMC10005
- 22 Model AMC20004

 Find out more
For more information, please visit
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Automatic Mass Comparators

Uncompromised Weighing Accuracy Meets High Throughput Mass Determination Processes

The AMC automatic mass comparators are designed to combine best weighing performance and high throughput calibration processes.

With up to 16 carousel positions the user is able to prepare comprehensive mass determination sequences while being in control of the process at the same time due to the integrated climate sensors.

The carousel allows for direct loading of up to four OIML and ASTM shape weights in each position enabling for comparison by substitution or dissemination.

Your Benefits

- High throughput due to up to 16 carousel positions
- Up to four weights can be loaded in each carousel position for comparison by substitution or dissemination
- Climate sensors integrated into main housing measure parameters at the exact location of mass determination
- Efficient comparison sequences due to flexible client software

Technical Specifications

Model	AMC1006	AMC10005	AMC20004
Maximum capacity	1,020 g	10,050 g	20,050 g
Readability	1 µg	10 µg	100 µg
Typical repeatability	1 µg	10 µg	300 µg
Carousel positions	16	8	8



Key Accessories

Order Code

YCW422-02

External calibration weight 20 g | E2

YCW452-02

External calibration weight 50 g | E2

YSN03C + YSN03RC

PC Software ScalesNet-M

YCM20DAKKS

DAkKS calibration certificate for climate sensors


YWT14

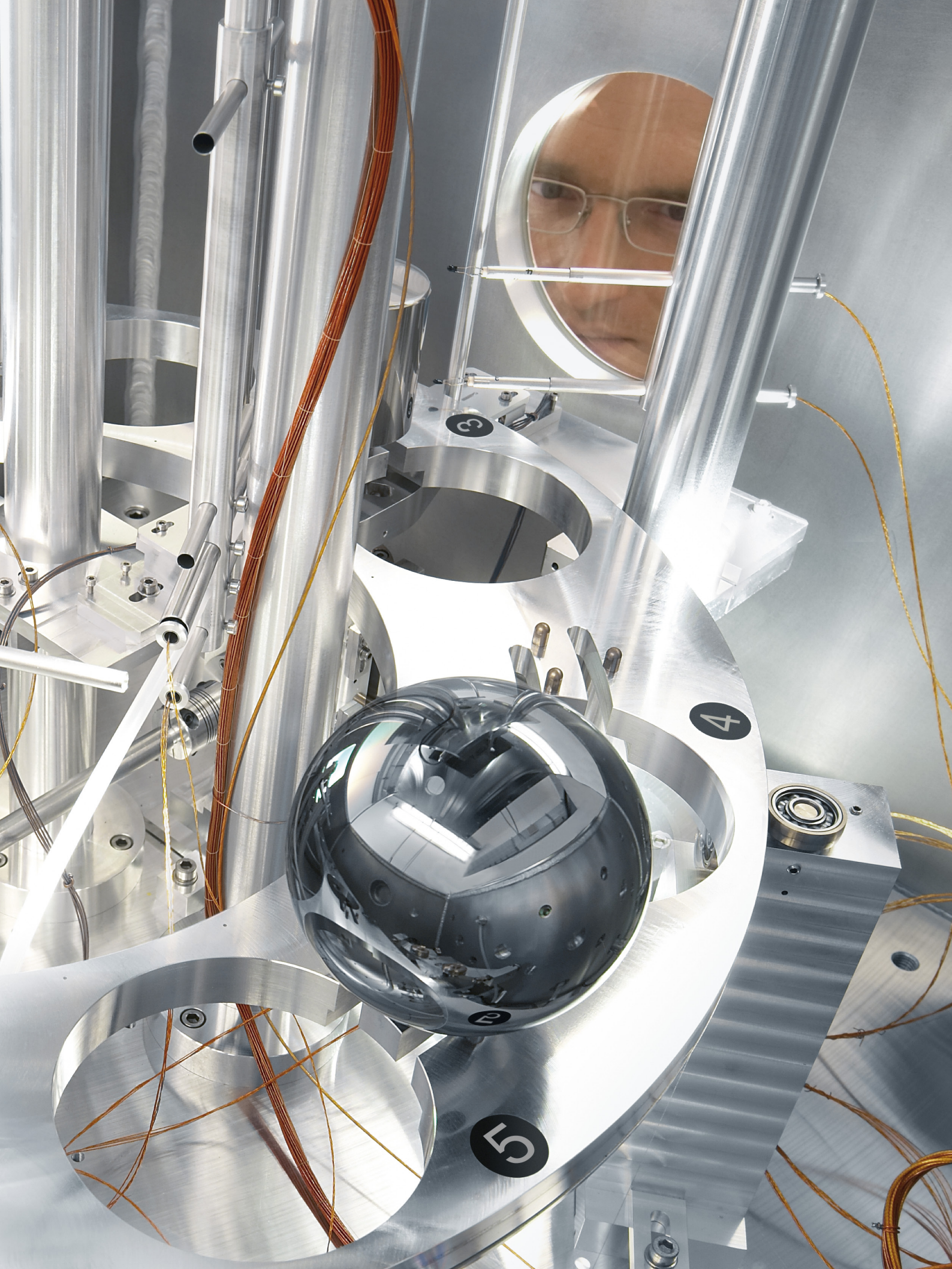
Granite weighing table for automatic mass comparators

Automatic Mass Comparators and Robots

- 32 CCL1007-C Vacuum Mass Comparator for most accurate results under optimal conditions
- 36 Robot for Fully Automated Determination of Mass from 1 mg to 1 kg



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Mass Comparator VMC1007 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 VMC1007 – 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 VMC1007 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 threepoint 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 VMC1007 can additionally be equipped with a vacuum transfer channel (YVTS02C).

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.

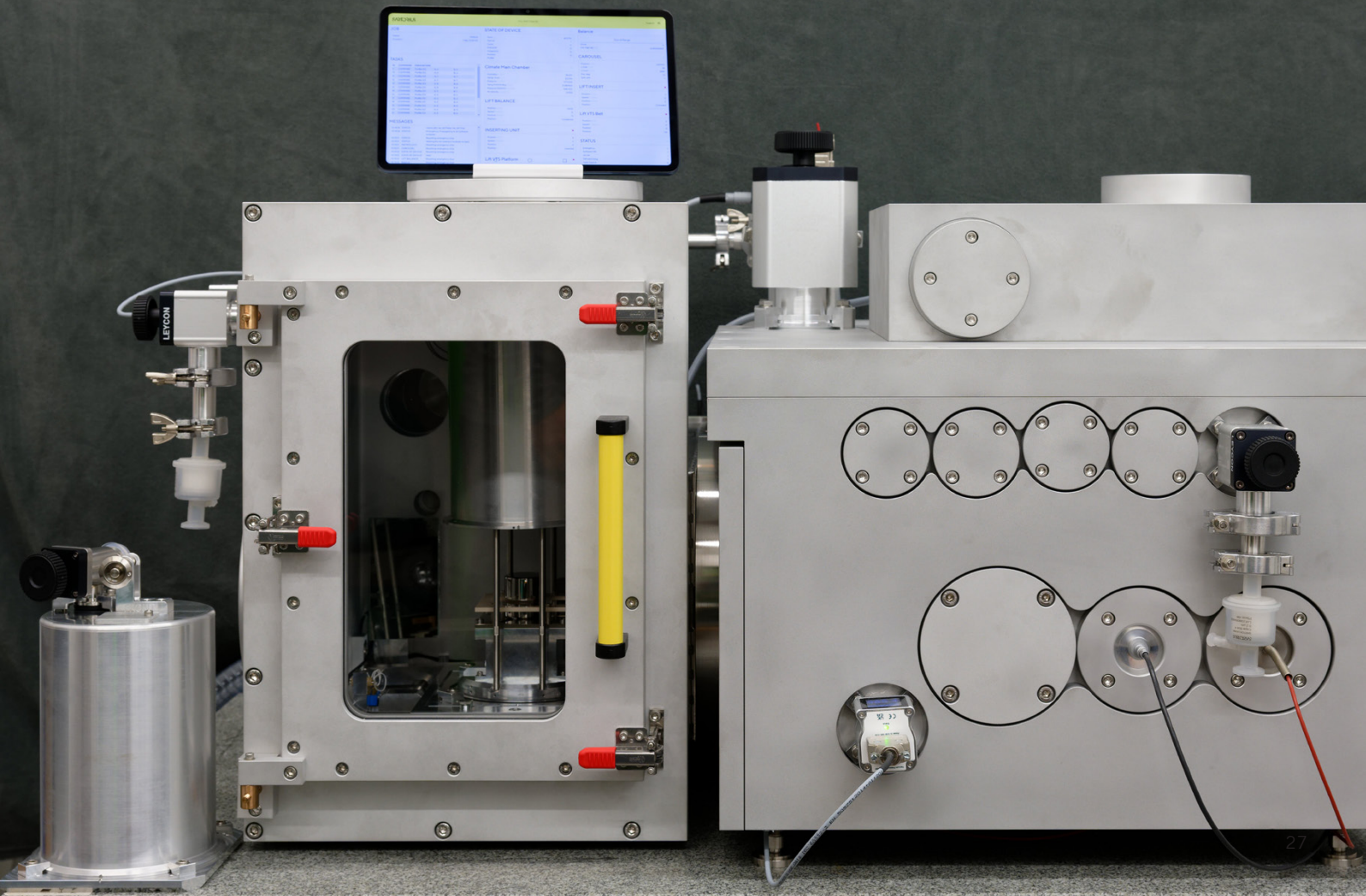
The motors that drive the load alternator and the related control device are located outside the vacuum chamber in a control unit. Ceramic axles and spatial separation prevent any energy input from these components onto the vacuum chamber. This minimizes temporal and spatial temperature gradients in 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 44) a management software program designed to cover all requirements and to network equipment in mass standards laboratories.

The VMC1007 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.

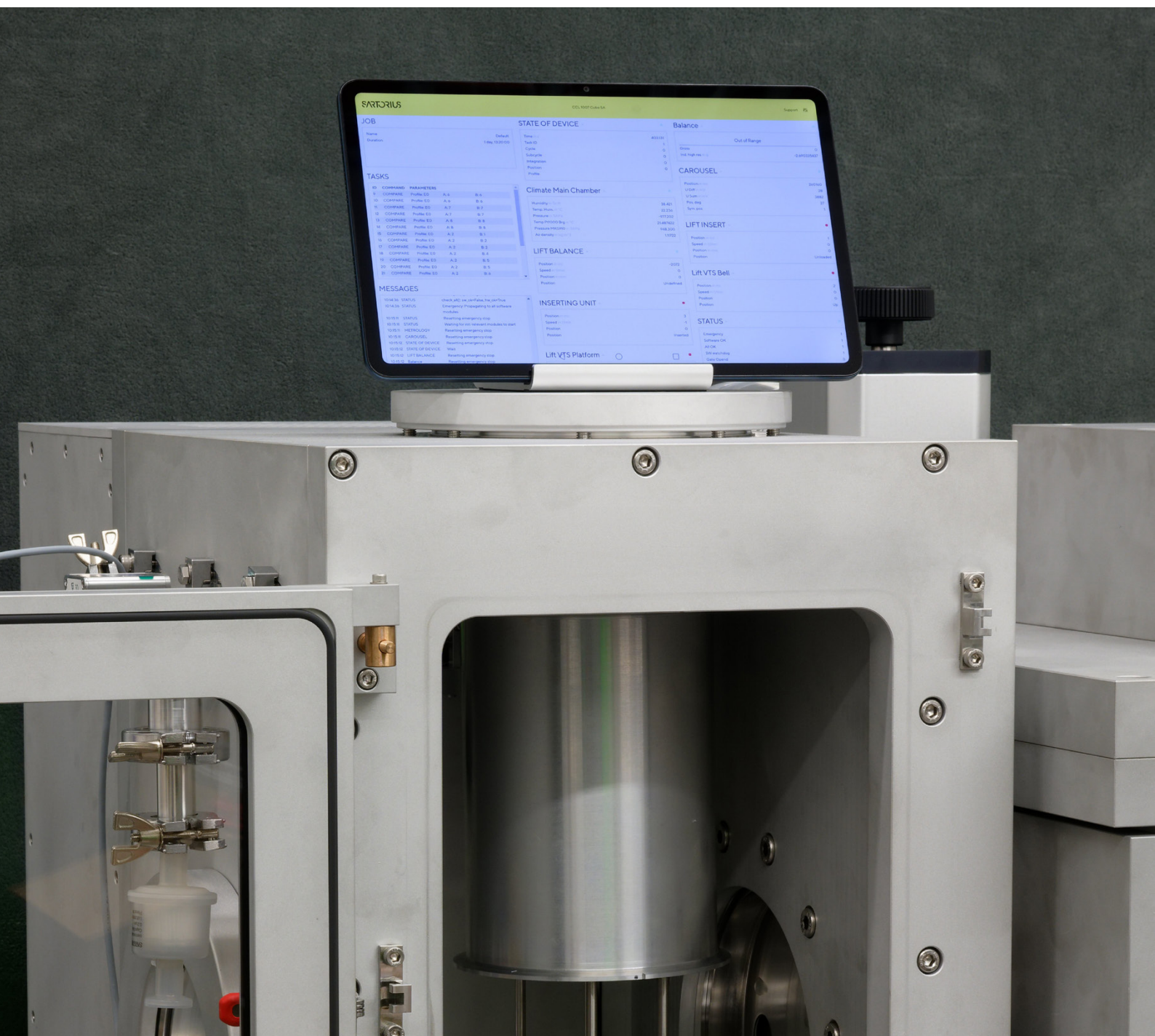


VMC1007 with vacuum transfer system VTS



Areas of Application

- As a 1 kg vacuum 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 ≤ 50 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 longterm stability of mass standards



Vacuum Transfer System

The 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


	VMC1007
Maximum capacity	1,002 g
Readability	0.1 µg
Repeatability s*	0.3 µg
Repeatability in vacuum, s*	0.2 µg
Repeatability (typical), s*	0.2 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	Ø 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.

Table-Top Robotic Mass Comparators CCR10-C

- 29 Model CCR10.7-C, range 0.1 μ g / 10 g
- 29 Model CCR6.7-C, range 0.1 μ g / 6 g
- 29 Model CCR10.6-C, range 1 μ g / 10 g
- 29 Key Accessories



 Find out more
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Table-Top Robotic Mass Comparators CCR10-C

Accurate Yet Compact and Cost Efficient Solutions for Mass Determination
And Dissemination Processes

The CCR-Compact Robotic Systems offer table-top sized automated solutions for mass determination or dissemination processes up to 10 g maximal capacity. With 120 magazine positions, these systems offer a walkaway solution allowing continuous processing of the measurements overnight or over the weekend. Designed for simultaneous management of reference and test weights the Sartorius dual robotic arm system with the patented multi and single weight handlers speeds up the processes with its most efficient motion sequences and handles the weights with highest precision and consistency. The climate sensors integrated into the weighing chamber additionally contribute to the reliability of the results. Automated weight handling at the range of 1 mg to 10 g not only eliminate the error rates of manual handling but significantly increase productivity which consequently leads to cost-savings long term.

Your Benefits

- 120 magazine positions allow overnight and weekend processing
- Dual Robotic Arm Technology guarantees the most efficient motion sequences available on the market
- Table-Top design saves prestigious laboratory space
- Robustness assure best repeatability values
- Build-in Climate Sensor directly in the weighing cells to further support measurement accuracy
- 3 Models fulfill your workflow requirements

High-throughput Allows Weekend Processing and Releases Resources

120 magazine positions enable loading of large number of weights and allow continuous processing of the measurements overnight or over the weekend. The magazine was designed to directly hold any possible weight shapes used for OIML-class and ASTM-class weights without the need of additional weight carriers or weight holders.





Unique Robotic Arm Technology for Efficient Motion Sequences

The Sartorius dual robotic arm system with the patented multi and single weight handlers was designed for simultaneous management of reference and test weights. The two single weight handlers allow simplified and fast handling of the reference and test weight directly between the magazine and the weighing cell. The dual arm system with a multi- and single weight handler is able to collect up to 4 weights and the reference weight. The 4 weights are assembled at the collect station and measured afterwards simultaneously. Therefore, there is no need of returning the weights to the magazine or in a parking position.



Integrated Climate Sensor

The weighing cells of all three models have a built-in climate sensor which means that the parameters for temperature, humidity and atmospheric pressure are measured at the exact location of the mass determination, therefore guaranteeing the most accurate correction for air buoyancy.



Error Free Weight Sorting

The weight sorting plate designed specially for these systems allows an easy and error free processing of the large number of weights. Each row and column is labelled and is identically to the labeling on the weight magazine. Additionally, each row is removable which further support an intuitive and efficient weight handling.



Variability to Adjusts to Your Workflows





Three different variants not only cover mass dissemination requirements from National Metrology Institutes and Legal Metrology Labs accredited to Class E1, but offer attractive high-throughput solutions for calibration laboratories typically accredited to E2 or F1.



Technical Specifications

Models	CCR10.7-C	CCR10.6-C	CCR6.7C
Capacity	10 g	10 g	6 g
Readability	0.1 µg	1.0 µg	0.1 µg
Repeatability Typical	0.2 µg	0.5 µg	0.2 µg
Magazine Positions	120	120	120
Robotic Arm Technology	Dual Arm System	Dual Arm System	Dual Arm System
Weight Handlers	1 Multi & 1 Single	2 × Single	1 Multi & 1 Single
Dimensions (W × D × H mm)	1200 × 800 × 760	1200 × 800 × 760	1200 × 800 × 760

Key Accessories

Order Code	Description
YWT12	 <p>Weighing Table made of granite, weight: 680 kg, dimensions (W × D × H mm) 800 × 1200 × 800</p>
YWT13	 <p>Weighing Table made of granite and steel, weight: 330 kg, dimensions (W × D × H mm) 800 × 1200 × 800</p>
YCM20MC-Tower	 <p>Climate tower monitors the influencing variables of the environment (temperature, pressure, and humidity)</p>
YCM20DAKKS	DakKS calibration certificate for climate sensors
YAW10CCR-C	 <p>Weight sorting plate with removable trays for easy and error free processing of the large number of weights. Each row and column is labelled and is identical to the labelling on the weight magazine.</p>
YSN03C YSN03NC YSN03RC	PC Software ScalesNet-M
YCW322-02	2 g Class E2 with DAkKS calibration certificate for model CCR10.7-C
YCW412-02	10 g Class E2 with DAkKS calibration certificate for model CCR10.6-C
YCW352-0	5 g Class E2 with DAkKS calibration certificate for model CCR6.7-C



Find out more
Brochure: CCR-Compact Robotic Systems



Find out more
White Paper: Accurate and High Throughput
Mass Determination with Table-Top Robotic Systems



Find out more
Datasheet: Table-Top Robotic Mass Comparators

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. An additional PC workplace is thus not needed. The CCR robot systems are equipped as standard with YCM20MC climate modules, which means that all climate parameters relevant for a mass comparison are available.

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



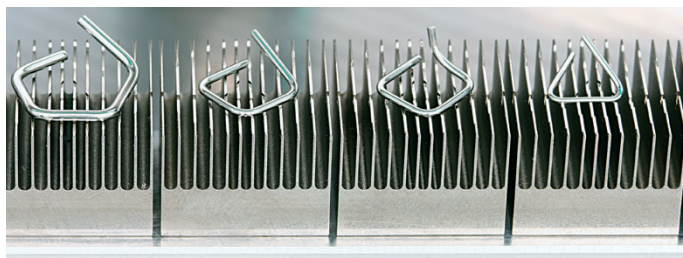
Comb-type weight grabber with 4 weights



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



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



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 rotating magazines for the next measurements while running your current measurement procedure, you no longer have to sit through protracted waiting periods to acclimatize your weights.

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 44) 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 To

To allow the robot system to work quickly, the test weight and reference weight are placed on separate comb-type weight handlers. These weight handlers 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 handlers 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

Technical Specifications

	CCR10	CCR1000	CCR10-1000
	1 mg - 10 g	10 g - 1 kg	1 mg - 1 kg
Maximum capacity	10.5 g	1,016 g	10.5 g 1,016 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	26 g	3.5 g 26 g
Magazine positions	39	23	39 23
Optional magazine positions	26 - 65	13 - 36	13 - 101


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

- 40 Climate Station & Data Logger
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for Professionally Calibrating Weights
- 48 Weights and Weight Sets

 **Find out more**
For more information, please visit
www.sartorius.com

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

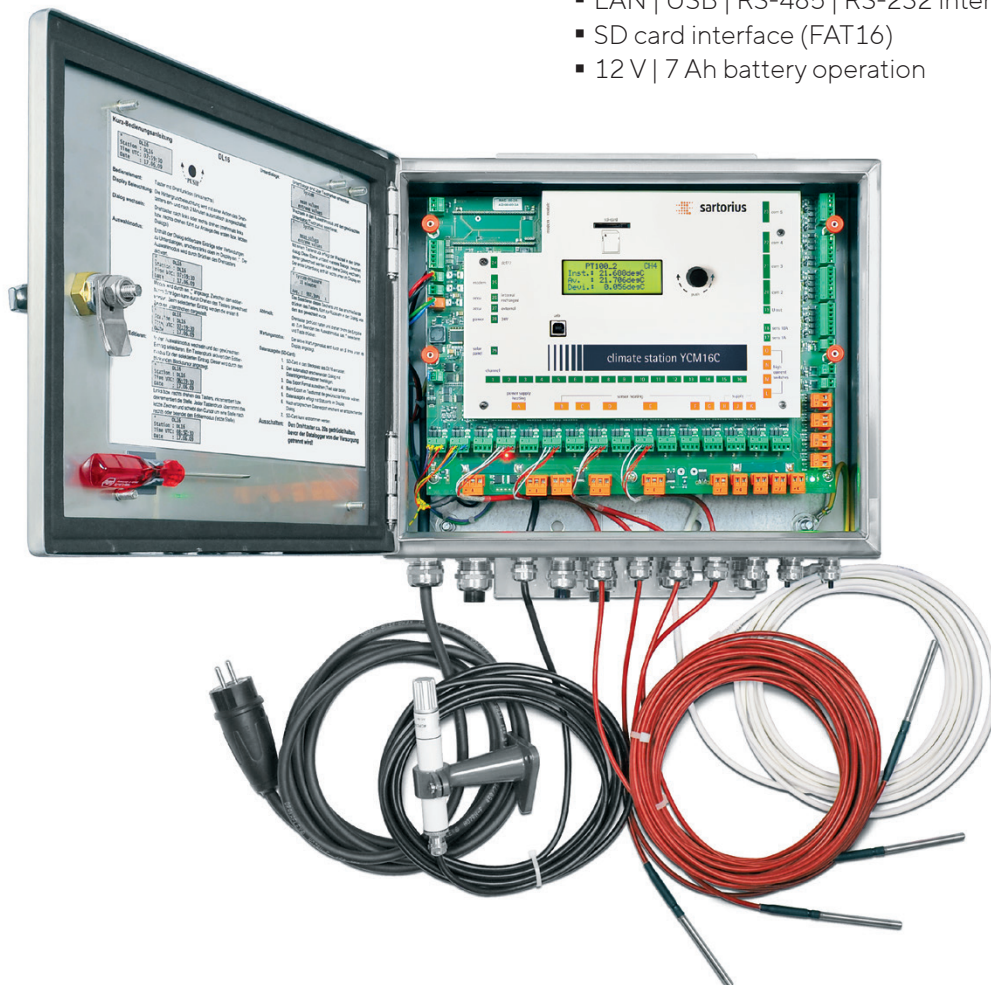
The climate station can be combined with ScalesNet-M software to make air buoyancy corrections in order to achieve an extremely high degree of accuracy when determining mass.

Easy to Use

It can be operated directly using the touch key or from your desk using networkbased 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



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

Optional Accessories

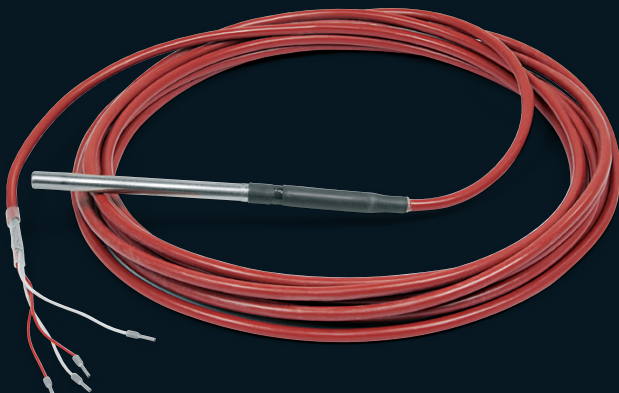
	Order number
Air temperature sensor 1/3 DIN	YCM16T
Air temperature sensor 1/10 DIN	YCM20T
Air humidity temperature sensor	YCM16H
Air pressure sensor	YCM16P
ScalesNet-M software	YSN03C



Calibrated air humidity | temperature sensor YCM16H | YCM16T



Calibrated air pressure sensor YCM16P



Air temperature sensor YCM20T

Volume & Density Determination

Volume Comparators 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.

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.



Volume comparator VD1005



Application

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

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.



Thermostat YVT01C

Optional Accessories for Density Determination

	Order number
1 kg silicon sphere see below	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



1 kg silicon sphere YDR1000SIC



E1 set of weights YCS31-612-09, stackable

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 multi-lingual, linguistically accurate calibration certificates
- Verifiable software
- Customizable service package

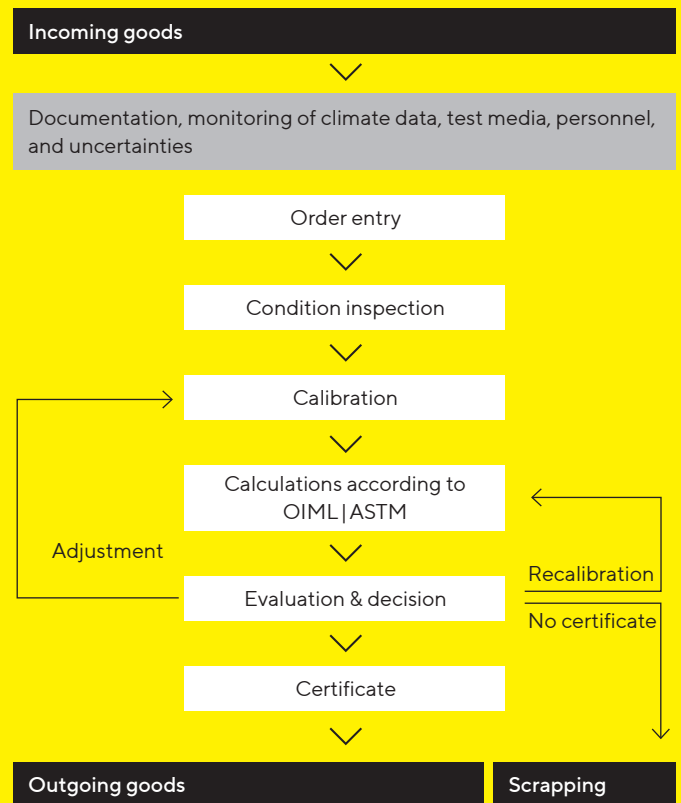


Features

- 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 or JSON 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. Freely designable customer certificates in 2 languages
- 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



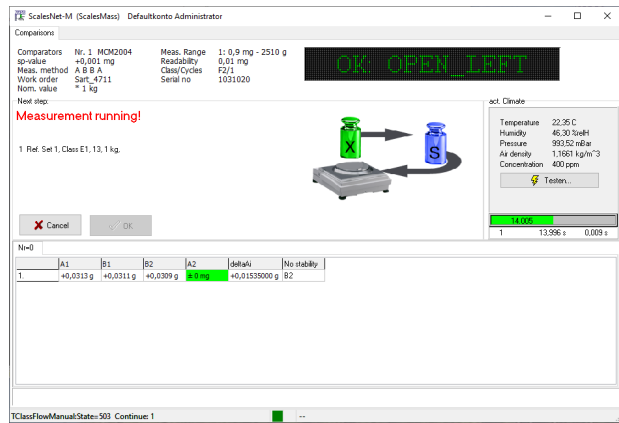
Equipment Supplied

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 F1, F2, M1, M2, M3
- ASTM 2, 3, 4, 5, 6, 7, NIST Handbooks F

System Requirements

- PC or laptop with a resolution of at least 1024 × 768, with current Windows® version and internet access for remote maintenance
- Local administrator rights during installation for all PCs | Laptops Microsoft WORD
- PC connection cable for comparators



Software ScalesNet-M

Reports

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

Languages

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

User Management

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



ScalesNet-M Module

YSN03C – Comprehensive Module

Sartorius software module for highly accurate mass determination.

Modules for Supplementing the ScalesNet-M Software



YSN03NC

Network module

PC license for connecting to local networks.



YSN03CC –

Module for a climate measuring station

PC license for connecting an additional climate measuring station.



YSN03LC

ScalesMass module

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



YSN03BC – Module for manual comparators

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



YSN03PC

ScalesDesk module

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



YSN03AC –

Module for automatic mass comparators

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



YSN03DC

ScalesPrinter module

PC license for connecting an additional printer.



YSN03MC – Module for the mass comparison

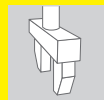
PC license for mass comparison for E1 weight classes and for calibrating weights of all accuracy classes in accordance with OIML R111 and ASTM E617.



YSN03EC

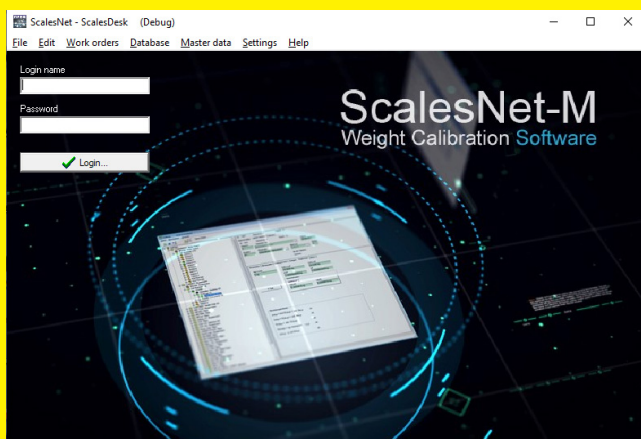
Class E module

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.

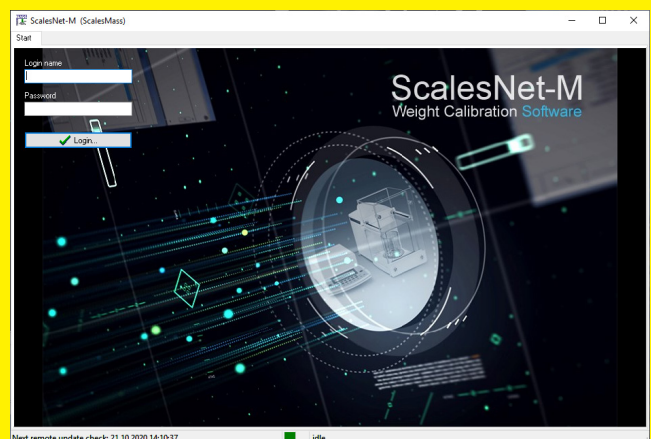


YSN03RC – Robot module

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.



ScalesNet-M, YSN03PC Administration Module



ScalesNet-M, YSN03LC Balance Communication Module

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.

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



Set of reference weights



Glass bell jar with lower base

 Find out more
For more information, please visit
www.sartorius.com

Accessories

Handles for lifting weights	Nominal value	Order number
Weight fork	for 500 g	YAW41
Weight fork	for 1 kg	YAW42
Weight fork	for 2 kg	YAW43
Handles for lifting weights	for 5 kg	YAW50
Handles for lifting weights	for 10 kg	YAW51
Handles for lifting weights	for 20 kg	YAW52
Handles for lifting weights	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 x W x H) 900 x 600 x 760 mm	YWT03
Weighing table for Table-Top Robots, made of granite, weight 680 kg, dimensions (W x D x H) 800 x 1200 x 800 mm	YWT12
Weighing table for Table-Top Robots, made of granite and steel, weight 330 kg, dimensions (W x D x H) 800 x 1200 x 800 mm	YWT13
Weighing table for Table-Top Robots, made of granite and steel, weight 540 kg, dimensions (W x D x H) 1000 x 1000 x 500 mm	YWT14

Weight Sorting Plate	Order number
Weight sorting plate designed for Table-Top Robots. The removable trays and the identical labelling to the 120 positions in the magazine ensure easy and error free processing of the large number of weights.	YAW10CCR-C

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
Adapter for silicon spheres	YSHSI01



Draft shield	Order number
For MCM6.7	YDS20C
For MCM1004 MCM2004 MCM5004 MCM5003 MCM36 MCM66 MCM106 MCM206 MCM605 MCM1005 MCA36MC MCA66MC MCA106MC MCA206MC MCA1004MC MCA1005MC	YDS24C
For MCM40K3 MCM60K3 MCM60K2 MCM10K3	YDS05C
For CCI60K2	YDS62C

Density references	Order number
1,000 g silicon sphere	YDR1000SIC
500 g silicon sphere	YDR500SIC
200 g silicon sphere	YDR200SIC
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
Thermo transfer and thermo direct printer for GxP printing on standard paper and self-adhesive labels	YDP30

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

Density determination	Order number
Below-balance weighing equipment for MCM40K3 MCM60K3 MCM60K2 CCE30002 CCE50002	69EA0040
Density kit for MCM36 MCM66 MCM106 MCM605 MCM1005	YDK01LP



Weighing table with optional accessories



Draft shield

Detailed Technical Specifications

- 54 Cubis® MCM Mass Comparators up to 1 kg
- 56 Cubis® MCM Mass Comparators 2 kg to 10 kg
- 57 Cubis® MCM Mass Comparators 40 kg to 60 kg
- 58 Manual Mass Comparators 100 kg – 300 kg
- 59 Manual Mass Comparators 600 kg – 3,000 kg
- 60 Automatic Mass Comparators
- 61 Table-Top Robotic Mass Comparators
- 63 Floor-Standing Robotic Mass Comparators
- 64 Mass Comparator with Vacuum Chamber
- 65 Devices for Determination of Volume, Density, Susceptibility and Magnetism





Cubis® MCM Manual Mass Comparators

Up to 1 kg



Comparator	MCM6.7	MCA36MC	MCA66MC	MCA106MC	MCA206MC
Order number with calibrated climate sensors with DAkkS certificate	MCM6.7-DAkkS				
Design	1	2	2	2	2
Maximum capacity	6.1 g	32 g	61 g	111 g	211 g
Readability	0.1 µg	1 µg	1 µg	1 µg	1 µg
Application range	0 – 6 g	0 – 32 g	0 – 61 g	0 – 111 g	0 – 211 g
Repeatability s					
Typical	0.15 µg	1 µg	1 µg	1.5 µg	2.5 µg
At nominal load (5 × ABA)	0.3 µg (5 g)	2 µg (20 g)	2 µg (50 g)	2 µg (100 g)	4 µg (200 g)
At low load (5 × ABA)	0.2 µg (2 g)	0.7 µg (2 g)	0.7 µg (2 g)	1.5 µg (10 g)	3 µg (100 g)
Electronic weighing taring range	6.1 g	32 g	61 g	111 g	111 g
Substitution weights				100 g	
Linearity	1 µg	6 µg	8 µg	8 µg	10 µg
Eccentric load deviation	0.25 µg/mm	0.64 µg/mm	0.8 µg/mm	1.6 µg/mm	3.2 µg/mm
Stabilization time	10 s	3.5 s	3.5 s	3.5 s	3.5 s
Standard Accessories					
Data interfaces	RS-232C, USB, Ethernet, SD card (optional RS-232C, PS2, Bluetooth*)	Ethernet, USB-A, USB-B and USB-C	Ethernet, USB-A, USB-B and USB-C	Ethernet, USB-A, USB-B and USB-C	Ethernet, USB-A, USB-B and USB-C
Draft shield	■	■	■	■	■
Additional application programs	Weighing, unit conversion, individual identifiers, density determination, statistics				
Below-balance weighing equipment	■	■	■	■	■
Climate sensors	Integrated into draft shield	Integrable into draft shield (optional)	Integrable into draft shield (optional)	Integrable into draft shield (optional)	Integrable into draft shield (optional)
Optional Accessories					
All calibrations weights with DakkS certificate	5 g E2 YCW352-02	20 g E2 YCW422-02	50 g E2 YCW452-02	100 g E2 YCW512-02	100 g E2 YCW512-02
Climate module	YCM20MC				
Calibrated climate module	YCM20MC-DAkkS				
2nd Draft shield	YDS20C	YDS24C	YDS24C	YDS24C	YDS24C
Weighing table	YWT03	YWT03	YWT03	YWT03	YWT03
Dimensions					
Weighing pan size	Ø 16 mm	Ø 50 mm	Ø 50 mm	Ø 50 mm	Ø 50 mm
Maximum object size (D×H)	16 × 70 mm	50 × 115 mm	50 × 115 mm	50 × 120 mm	50 × 120 mm
Weigh cell (W×D×H)	122 × 343 × 141 mm	240 × 501 × 301 mm	240 × 501 × 301 mm	240 × 501 × 301 mm	240 × 501 × 301 mm
Electronics unit (W×D×H)	239 × 320 × 56 mm				



Order number with uncalibrated climate sensors	MCA605MC	MCA1005MC	MCA1004MC
Order number with calibrated climate sensors with DAkkS certificate			
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			
Typical	10 µg	15 µg	0.05 mg
At nominal load (5 × ABA)	20 µg (500 g)	20 µg (1000 g)	0.07 mg (1000 g)
At low load (5 × ABA)	10 µg (50 g)	15 µg (100 g)	0.05 mg (100 g)
Electronic weighing taring range	610 g	610 g	610 g
Substitution weights		500 g	500 g
Linearity	100 µg	100 µg (600 g)	0.15 mg (600 g)
Corner load error	8.9 µg/mm	11.1 µg/mm	13.3 µg/mm
Stabilization time	3.5 s	3.5 s	3.5 s
Standard Accessories			
Data interfaces	Ethernet, USB-A, USB-B and USB-C		
Draft shield	■	■	■
Additional application programs	Weighing, unit conversion, individual identifiers, density determination, statistics		
Below-balance weighing equipment	■	■	■
Climate sensors	Integrable into draft shield (optional)		
Optional Accessories			
Calibration weight	500 g E2 YCW552-02	500 g E2 YCW552-02	500 g E2 YCW552-02
Climate module	YCM20MC		
Calibrated climate module	YCM20MC-DAkkS		
2nd Draft shield	YDS24C	YDS24C	YDS24C
Weighing table	YWT03	YWT03	YWT03
Dimensions			
Weighing pan size	Ø 90 mm	Ø 90 mm	Ø 90 mm
Maximum object size (D × H)	90 × 115 mm	90 × 115 mm	90 × 115 mm
Weigh cell (W × D × H)	240 × 501 × 301 mm	240 × 501 × 301 mm	240 × 501 × 301 mm
Electronics unit (W × D × H)			

Cubis® MCM Manual Mass Comparators

2 kg - 10 kg



Order number with uncalibrated climate sensors	MCM2004	MCM5004	MCM5003
Order number with calibrated climate sensors with DAkkS certificate	MCM2004-DAkkS	MCM5004-DAkkS	MCM5003-DAkkS
Design	4	4	4
Maximum capacity	2,500 g	5,100 g	5,100 g
Readability	0.1 mg	0.1 mg	1 mg
Application range	0 – 2,500 g	0 – 5,100 g	0 – 5,100 g
Repeatability s			
Typical	0.05 mg	0.3 mg	0.5 mg
At nominal load (5 × ABA)	0.1 mg (2000 g)	0.5 mg (5000 kg)	0.8 mg (5000 kg)
At low load (5 × ABA)	0.07 mg (200 g)	0.3 mg (500 g)	0.5 mg (500 g)
Electronic weighing taring range	2,500 g	5,100 g	5,100 g
Linearity	1 mg	2 mg	3 mg
Corner load error	30 µg/mm	151 µg/mm	300 µg/mm
Stabilization time	3 s	3 s	3 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	2 kg E2 YCW622-02	5 kg E2 YCW652-02	5 kg E2 YCW652-02
Climate module	YCM20MC		
Calibrated climate module	YCM20MC-DAkkS		
2nd Draft shield	YDS24C	YDS24C	YDS24C
Weighing table	YWT03	YWT03	YWT03
Lifting device for 10 kg			
Dimensions			
Weighing pan size (W × D)	136 × 136 mm	136 × 136 mm	136 × 136 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
Electronics unit (W × D × H)	239 × 320 × 56 mm	239 × 320 × 56 mm	239 × 320 × 56 mm



	MCM10K4.2	MCM10K4.1	MCM10K3
Order number with uncalibrated climate sensors	MCM10K4.2	MCM10K4.1	MCM10K3
Order number with calibrated climate sensors with DAkkS certificate	MCM10K4.2-DAKKS		MCM10K3-DAKKS
Design	4	5	6
Maximum capacity	11 kg	10,050 g	11 kg
Readability	0.2 mg	0.1 mg	1 mg
Application range	0 - 11 kg	1 2 3 5 6 10 kg	0 - 11 kg
Repeatability s			
Typical	0.4 mg	0.1 mg	0.8 mg
At nominal load (5 × ABA)	0.5 mg (10 kg)	0.25 mg (10 kg)	1 mg (10 kg)
At low load (5 × ABA)	0.4 mg (1 kg)		0.8 mg (1 kg)
Electronic weighing taring range	11 kg	60 g	11 kg
Linearity	6 mg	0.3 mg (60 g)	6 mg
Corner load error	0.5 mg/mm	0 mg (Centermatic pan)	0.5 mg/mm
Stabilization time	3 s	10 s	3 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	■		Remote tower connected to mass comparator
Optional Accessories			
Calibration weight	10 kg E2 YCW712-02	50 g E2 YCW452-02	10 kg E2 YCW712-02
Climate module		n/a	
Calibrated climate module		n/a	
2nd Draft shield	YDS05C	YWT03	YDS05C
Weighing table	YWT03	YAW51	YWT03
Lifting device for 10 kg	YAW51		YAW51
Dimensions			
Weighing pan size (W×D)	136 × 136 mm	200 × 200 mm	200 × 200 mm
Maximum object size (D×H)	130 × 200 mm	200 × 300 mm	
Weigh cell (W×D×H)	240 × 276 × 373 mm	230 × 365 × 470 mm	240 × 276 × 102 mm
Electronics unit (W×D×H)	239 × 320 × 56 mm	230 × 320 × 56 mm	239 × 320 × 56 mm

40 kg - 60 kg



Order number with uncalibrated climate sensors	MCM32002	MCM40K3	MCM60K3	MCM60K2
Order number with calibrated climate sensors with DAkkS certificate	n/a	MCM40K3-DAkkS	MCM60K3-DAkkS	MCM60K2-DAkkS
Design	7	8	8	8
Maximum capacity	32 kg	41 kg	64 kg	64 kg
Readability	10 mg	1 mg	2 mg	10 mg
Application range	10 - 30 kg	0 - 41 kg	0 - 64 kg	0 - 64 kg
Repeatability s				
Typical	10 mg	2 mg	4 mg	6 mg
At nominal load (5 × ABA)	15 mg (20 kg)	3 mg (20 kg)	6 mg (50 kg)	10 mg (50 kg)
At low load (5 × ABA)	-	2 mg (5 kg)	4 mg (5 kg)	
Electronic weighing taring range	32 kg	41 kg	64 kg	64 kg
Linearity	50 mg	20 mg	40 mg	50 mg
Corner load error	2 mg/mm	3.5 mg/mm	3.5 mg/mm	3.5 mg/mm
Stabilization time	5 s	5 s	5 s	5 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	with opt. accessories 69EA0040
Climate sensors	no	Remote tower connected to mass comparator		
Optional Accessories				
Calibration weight	20 kg E2 YCW722-02	20 kg E2 YCW722-02	50 kg E2 YCW752-02	50 kg E2 YCW752-02
Climate module	n/a	YCM20MC		
Calibrated climate module	n/a	YCM20MC-DAkkS		
Optional external draft shield	YDS05C YDS03C	YDS05C YDS03C	YDS05C YDS03C	YDS05C YDS03C
Lifting device for 10 kg	YAW51	YAW51	YAW51	YAW51
Lifting device for 20 kg	YAW52	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)	Ø 230 mm	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	400 × 326 × 126 mm
Electronics unit (W × D × H)	239 × 320 × 56 mm	239 × 320 × 56 mm	239 × 320 × 56 mm	239 × 320 × 56 mm

Manual High-Capacity Mass Comparators

100 kg - 300 kg

Order number with uncalibrated climate sensors	MCM150K2	MCM300K2
Order number with calibrated climate sensors with DAkkS certificate	MCM150K2-DAKKS	MCM300K2-DAKKS
Design	9	9
Maximum capacity	155 kg	310 kg
Readability	10 mg	20 mg
Application range	0 - 155 kg	0 - 310 kg
Repeatability s*		
Repeatability at low load (5 x ABA)	40 mg	80 mg
Repeatability at nominal load (5 x ABA)	80 mg (100 kg)	200 mg (200 kg)
Electronic weighing taring range	155 kg	310 kg
Linearity	2 g	4 g
Corner load error	12 mg/mm	24 mg/mm
Stabilization time	10 s	10 s
Standard Accessories		
Interfaces	■	■
Draft shield	■	■
Application programs	■	■
Below-balance weighing equipment		
PC connection cable		
Optional Accessories		
Calibration weight	100 kg F2 YCW814-02	200 kg F2 YCW824-02
PC software ScalesNet-M	YCM20MC	YCM20MC
Climate station for E1	YCM20MC-DAKKS	YCM20MC-DAKKS
2nd draft shield		YDS64C
Lifting device for 10 kg	YAW-51	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 mm	800×600 mm
Weigh cell (W×D×H)	800×600×135 mm	800×600×135 mm
Electronics unit (W×D×H)	239×320×56 mm	239×320×56 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.

600 kg - 3,000 kg



Order number with uncalibrated climate sensors	CCS600K	MCM600K2	CCT1000K	CCS1000K	CCT2000K	CCS3000K
Order number with calibrated climate sensors with DAkkS certificate		MCM600K2-DAKKS				
Maximum capacity	605 kg	610 kg	1,200 kg	1,510 kg	2,100 kg	3,010 kg
Readability	1 g	50 mg	1 g	5 g	1 g	10 g
Application range	0 – 605 kg	0 – 610 kg	0 – 1,200 kg	0 – 1,510 kg	0 – 2,100 kg	0 – 3,010 kg
Repeatability at low load (5 x ABA)	2.5 g	200 mg	3 g	6 g	8 g	12 g
Repeatability at nominal load (5 x ABA)	2 g	500 mg (500 kg)	2 g	5 g	5 g	10 g
Electronic weighing taring range	605 kg	610 kg	1,200 kg	1,510 kg	2,100 kg	3,010 kg
Linearity	30 g	10 g	25 g	200 g	30 g	500 g
Corner load error	0.2 g/mm	40 mg/mm	0.3 g/mm	0.6 g/mm	0.7 g/mm	1 g/mm
Stabilization time	20 s	10 s	30 s	20 s	30 s	20 s
Standard Accessories						
Interfaces	2x RS-232C	■	2x RS-232C	2x RS-232C	2x RS-232C	2x RS-232C
Draft shield	■	■	■	■	■	■
Application programs		■				
PC connection cable	■		■	■	■	■
Optional Accessories						
Calibration weight	500 kg F2 YCW854-02	500 kg F2 YCW854-02	1000 kg M1 YCW9157-02	1000 kg M1 YCW9157-02	1000 kg M1 YCW9157-02	1000 kg M1 YCW9157-02
PC software ScalesNet-M	YSN03C	YCM20MC	YSN03C	YSN03C	YSN03C	YSN03C
Climate station for E1	YCM16C	YCM20MC-DAKKS	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
Dimensions						
Weighing pan dimensions (W×D)	830×1,030×250 mm	800×600 mm	1,510×1,370×240 mm	830×1,030×250 mm	1,920×1,710×230 mm	1,000×1,250×300 mm
Weigh cell (W×D×H)		800×600×135 mm				
Electronics unit (W×D×H)	303×195×90 mm	239×320×56 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

* 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.

Automatic Mass Comparators

Up to 20 kg

Technical Specifications

Model	AMC1006	AMC10005	AMC20004
Maximum capacity	1,020 g	10,050 g	20,050 g
Readability	1 µg	10 µg	100 µg
Repeatability at low load*	2 µg	20 µg	100 µg
Repeatability at nominal load	5 µg	30 µg	150 µg
Electronic weighing and taring range	21 g	61 g	61 g
Substitution weight (internal)	10 20 50 100 200 500 1,000 g	4,000 1,000 2,000 1,000 1,000 g	10 kg
Linearity	20 µg/21 g	300 µg/61 g	3 mg/60 g
Off-center loading error	0 µg (Centermatic pan)	0 µg (Centermatic pan)	0 µg (Centermatic pan)
Stabilization time	35 s	25 s	25 s
Carousel positions	16	8	8
Enclosure	✓	✓	✓
Interfaces	Ethernet	Ethernet	Ethernet
Ambient Conditions			
Permissible operating temperature range	17 - 27 °C	17 - 27 °C	17 - 27 °C
Recommended operating temperature	22 °C	22 °C	22 °C
Temperature fluctuation	0.3 °C/h 0.5 °C/12 h	0.3 °C/h 0.5 °C/12 h	0.3 °C/h 0.5 °C/12 h
Max. air movement	< 0.2 m/s	< 0.2 m/s	< 0.2 m/s
Humidity range	40 - 60 %	40 - 60 %	40 - 60 %
Humidity fluctuation	5 % / 4 h	5 % / 4 h	5 % / 4 h
Power supply	100 - 240V AC / 50 - 60 Hz	100 - 240V AC / 50 - 60 Hz	100 - 240V AC / 50 - 60 Hz
Dimensions			
Sample size (D x H)	100 x 120 mm	160 x 250 mm	
Gross weight	180 kg	180 kg	180 kg
Net weight	100 kg	100 kg	100 kg
Dimensions (W x D x H)	923 x 835 x 706 mm	923 x 835 x 706 mm	923 x 835 x 706 mm
Optional Accessories			
External Calibration weight	20 g E2 YCW422-02	50 g E2 YCW452-02	
PC Software SclesNet-M	YSN03C + YSN03RC (+ YSN03MC optional)	YSN03C + YSN03RC (+ YSN03MC optional)	YSN03C + YSN03RC (+ YSN03MC optional)
DAkKS-Certificate for Climate Module	YCM20DAKKS	YCM20DAKKS	YCM20DAKKS
Weighing Table	YWT14	YWT14	YWT14
Adapter for silicon sphere	YSHI01	YSHI01	YSHI01

* Based on 6 x ABBA cycles

Table-Top Robotic Mass Comparators

Up to 10 g



Technical Specifications

Model	CCR10.7-C	CCR10.6-C	CCR6.7-C
Maximum capacity	10.5 g	10.1 g	6.1 g
Application range	1 mg - 10 g	1 mg - 10 g	1 mg - 6 g
Readability	0.1 µg	1 µg	0.1 µg
Repeatability typical	0.2 µg	0.5 µg	0.2 µg
Rep. under standard conditions E ¹	0.5 µg	0.7 µg	0.3 µg
Repeatability, at > 1 - 6 g	0.3 µg		
Repeatability, at 0 - 1 g	0.15 µg		0.15 µg
Rep. under standard conditions F ²	1.5 µg	2 µg	1.5 µg
Electronic weighing range & taring range	3.5 g	10.1 g	6.1 g
Substitution weights	2 × 3.5 g	-	-
Linearity	1 µg 3.5 g	4 µg	1 µg
Off-center loading error	0.25 µg / mm	0.5 µg / mm	0.25 µg / mm
Stabilisation time	15 s	10 s	15 s

¹ Standard conditions E: ABA measured in a laboratory under E1 conditions, on a decoupled weighing stone, no drafts from above

² Standard conditions F: ABA measured in a laboratory under at least F1 conditions, on a non-decoupled weighing table, air conditioned and minimal drafts from above

Important: The stated specifications and technical data apply only under good ambient conditions. Disruptive factors at the place of installation, such as strong drafts (especially from air conditioning equipment), excessive vibrations, physical effects of the items being weighed (e.g. magnetic fields or electrostatic charges), or ambient conditions outside the allowable tolerances, may adversely affect on the specifications.

Models

Model	CCR10.7-C	CCR10.6-C	CCR6.7-C
Type	4-axis robot	4-axis robot	4-axis robot
Robotic Arm Technology	Dual Arm System	Dual Arm System	Dual Arm System
Weight Handlers	1 Multi × 1 Single	2 × Single	1 Multi × 1 Single
Magazine positions	120	120	120
Interfaces	LAN	LAN	LAN
Draft shield	▪	▪	▪
Enclosure	▪	▪	▪
Laptop PC	-	-	-
PC software	▪	▪	▪
Climate sensor integrated in the weighing chamber to measure humidity, air pressure & air temperature	▪	▪	▪
Test certificate	Sartorius	Sartorius	Sartorius

Ambient Conditions

Model	CCR10.7-C	CCR10.6-C	CCR6.7-C
Permissible operating temperature range	17–27°C	17–27°C	17–27°C
Recommended operating temperature	22°C	22°C	22°C
Temperature fluctuation	0.3°C/h 0.5°C/12h	0.3°C/h 0.5°C/12h	0.3°C/h 0.5°C/12h
Max. air movement	< 0.2m/s	< 0.2m/s	< 0.2m/s
Humidity range	40–60%	40–60%	40–60%
Humidity fluctuation	5%/4h	5%/4h	5%/4h
Power supply	100–240V AC / 50–60Hz	100–240V AC / 50–60Hz	100–240V AC / 50–60Hz

Dimensions

Model	CCR10.7-C	CCR10.6-C	CCR6.7-C
Weighing pan dimensions (W×D)	49×29 mm	49×29 mm	49×29 mm
Sample size (D×H)	18×20 mm	18×20 mm	18×20 mm
External dimensions W×D×H	1,200×800×760 mm	1,200×800×760 mm	1,200×800×760 mm
Gross weight	265 kg	265 kg	265 kg
Net weight	190 kg	190 kg	190 kg
Number of packages	1	1	1
Pallet	1400×980×1400 mm	1400×980×1400 mm	1400×980×1400 mm
Optimal height for setup	800 mm	800 mm	800 mm

Optional Accessories

Model	CCR10.7-C	CCR10.6-C	CCR6.7-C
External Calibration weight	2g E2 YCW322-02	10g E2 YCW412-02	5g E2 YCW352-02
PC Software ScalesNet-M	YSN03C + YSN03RC (+ YSN03MC optional)	YSN03C + YSN03RC	YSN03C + YSN03RC (+ YSN03MC optional)
Weight sorting plate	YAW10CCR-C	YAW10CCR-C	YAW10CCR-C
External climate Sensor	YCM20MC-Tower	YCM20MC-Tower	YCM20MC-Tower
DakkS calibration certificate for climate sensors	YCM20DAKKS	YCM20DAKKS	YCM20DAKKS
Weighing Table premium	YWT12	YWT12	YWT12
Weighing Table budget	YWT13	YWT13	YWT13

Floor-Standing Robotic Mass Comparators

Up to 1 kg



	CCR10	CCR1000	CCR10-1000
Maximum capacity	10.5 g	1,016 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 21 g
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
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 module	YCM20MC	YCM20MC	YCM20MC
Optional Accessories			
PC software ScalesNet-M	YSN03C	YSN03C	YSN03C
Calibration weight	2 g E2 YCW322-02-DAkks	20 g E2 YCW422-02-DAkks	2 g E2 YCW322-02-DAkks and 20 g E2 YCW422-02-DAkks
Extensions			
Upgrade kit	Y1000UPGRADE	Y10UPGRADE	
Reference magazine	Y10R:(26)	Y1000R:(13)	Y10R:(26) Y1000R:(13)
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.

Mass Comparators

With Vacuum Chamber

	VMC1007	YVP03C and YVP04C	YVTS02C	YVC02C
Maximum capacity	1,002 g		1 kg	1 kg
Readability	0.1 µg			
Application range	1 mg – 1 kg			
Repeatability s*	0.3 µg			
Repeatability in vacuum, s*	0.2 µg			
Repeatability (typical), s*	0.2 µg			
Electronic weighing taring range	2 g			
Linearity	1 µg			
Range sensitivity	0.2 µg – 500 mg			
Stabilization time	50 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				
YVP03C				
Pump				
Turbopump	YVP04C		YVP04C	YVP02C
Vacuum Transfer System	YVTS01C			
Vacuum container	YVC01C		YVC01C	
PC software ScalesNet-M	YSN03C			
Calibration weight	2 g E2 YCW322-02			
Dimensions				
Sample size (D × H)	22 – 95 × 100 mm		22 – 95 × 100 mm	22 – 95 × 100 mm
Diameter range for a silicon sphere	45 – 95 mm		45 – 95 mm	45 – 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.

Devices for Determination of Volume and Density



	VD1005
Maximum capacity	1,110 g
Readability	10 µg
Application range	1 g - 1 kg
Repeatability s*	40 µg
Repeatability (typical), s*	20 µg
Electronic weighing taring range	305 g
Linearity	0.12 mg
Stabilization time	20 s
Uncertainty of density	1 kg/m ³
Uncertainty of volume	0.00015 cm ³
Standard Accessories	
Load alternator positions	2 × 9
Interfaces	LAN USB 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
Test certificate	BEV
PC connection cable	
Climate station	■
Optional Accessories	
Calibration weight	200 g E2 YCW522-00
Weighing table	YWT20C
Crane with chain hoist	
Gripper for weights with handle	
1 kg PTB reference susceptibility	
Magnet calibration kit for susceptometer	
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.








Calculations and Areas of Application

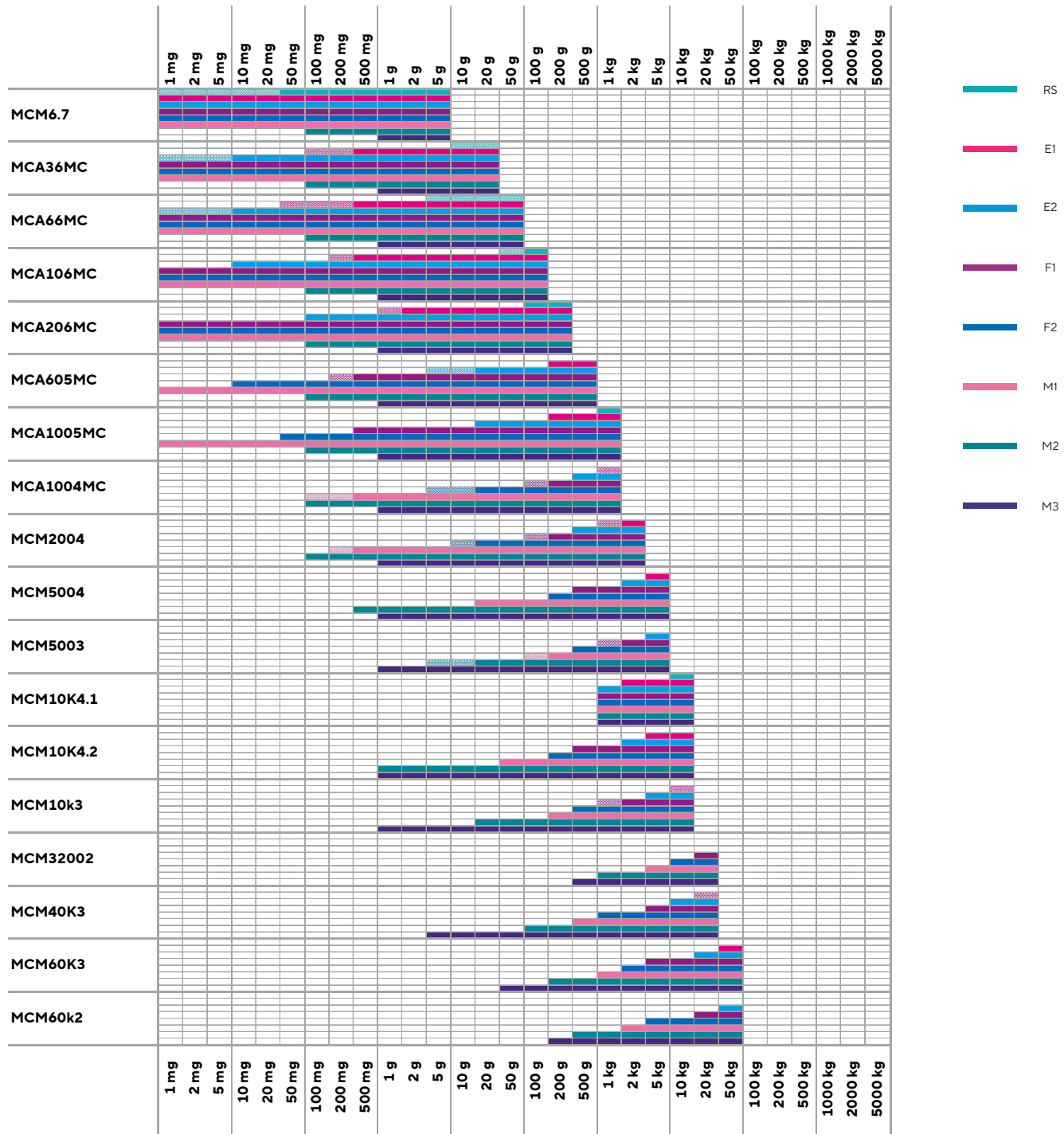
- 68 Areas of Application in Accordance with OIML R111-1:2004
- 70 Areas of Application in Accordance with ASTM E617
- 72 Calculating Uncertainties in Accordance with OIML R111

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Areas of Application

In Accordance with OIML R111-1:2004

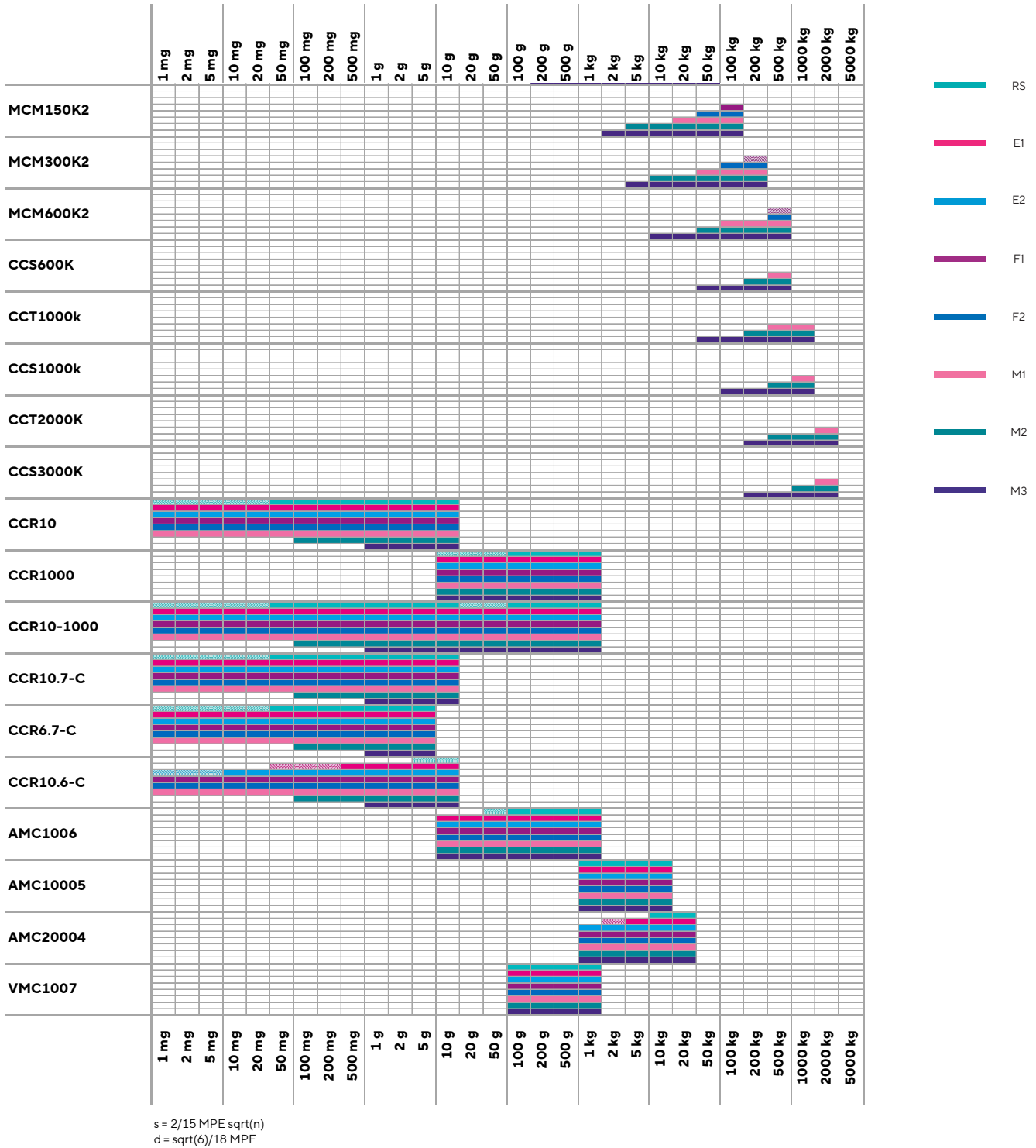
Recommended Application Range according to OIML R111



$s = 2/15 \text{ MPE} \sqrt{n}$
 $d = \sqrt{6}/18 \text{ MPE}$

RS: Reference Standard with 1/5 uncertainty contribution of the E1 Class tolerance limit

Recommended Application Range according to OIML R111

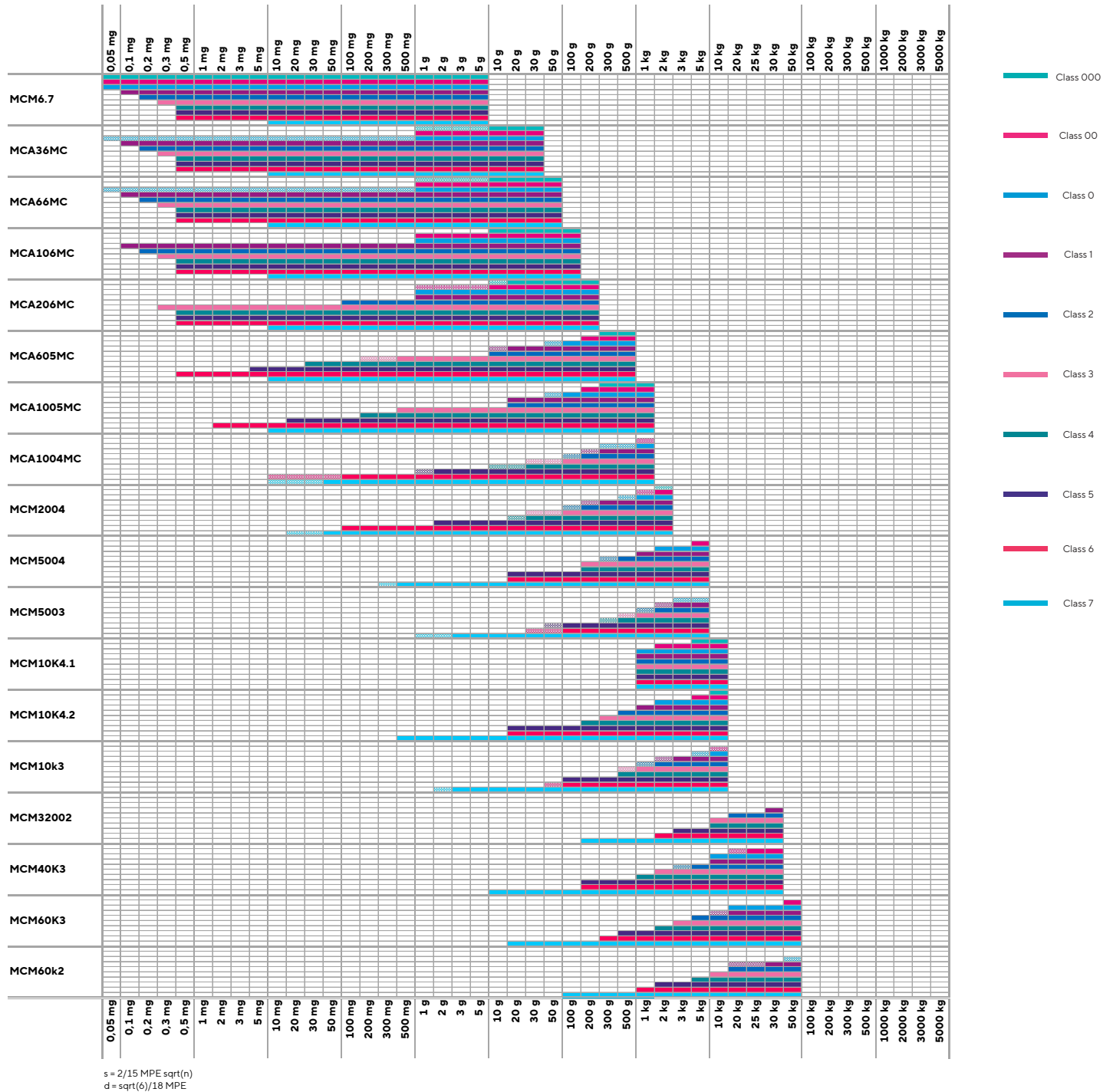


RS: Reference Standard with 1/5 uncertainty contribution of the E1 Class tolerance limit

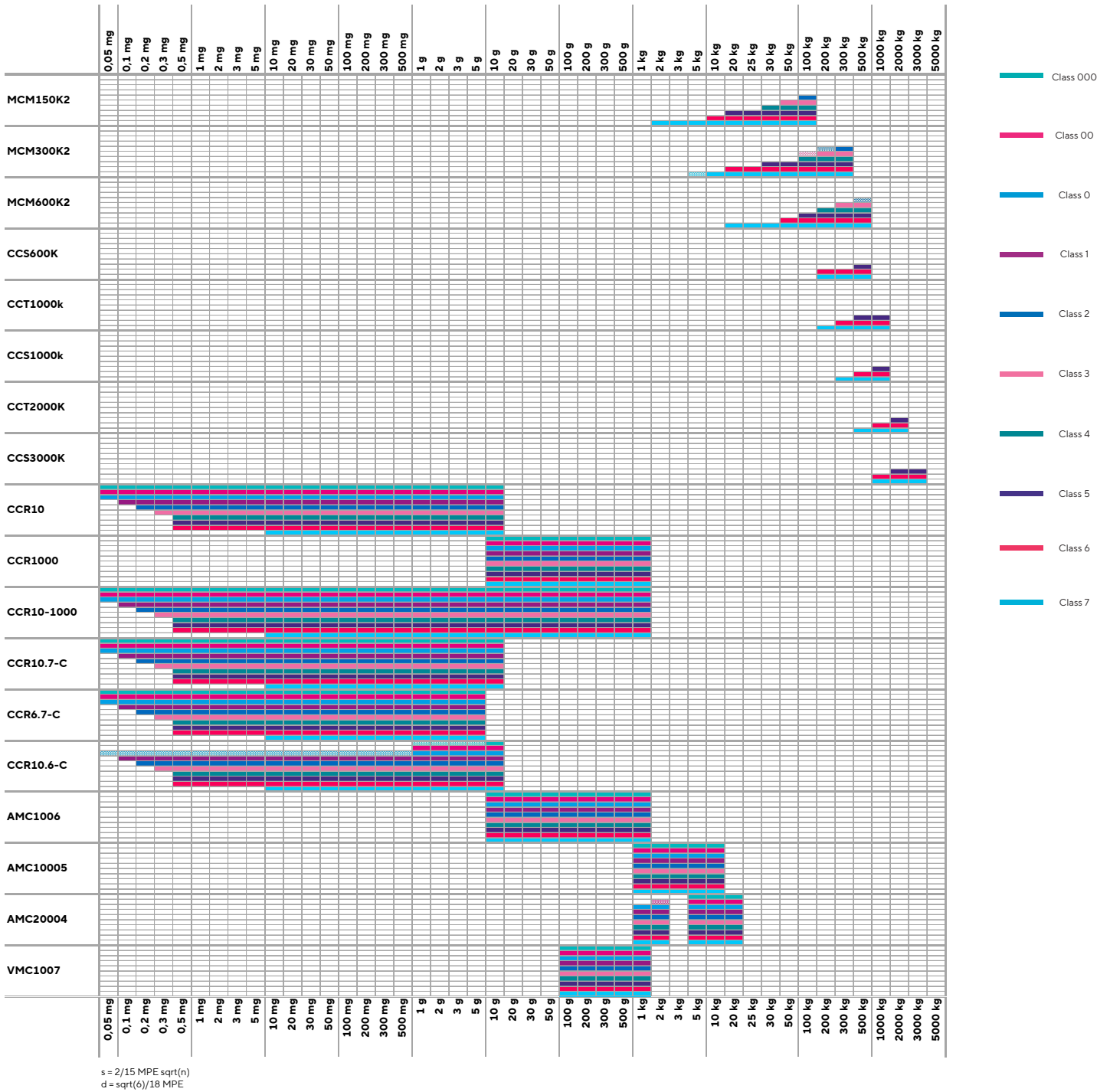
Areas of Application

In Accordance with ASTM E617

Recommended Application Range according to ASTM E617



Recommended Application Range according to ASTM E617



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:

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

Each weight must fulfill this condition

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

(MPE: Maximum Permissible Error)

The combined uncertainty of the test weight is produced from:

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

from the standard uncertainty of the weighing process:

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

from the standard uncertainty of the reference weight:

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

from the standard uncertainty of the air buoyancy correction with

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

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

and the combined standard uncertainty of the balance:

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

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

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

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

from the standard uncertainty of the display resolution:

$$u_d = d\sqrt{2}/(2\sqrt{3})$$

[1, Formula C.6.4-2],

from the standard uncertainty due to eccentricity:

$$u_E = 0$$

cf. [1, Section C.6.4.4.1]

and the standard uncertainty due to magnetism:

$$u_{ma} = 0$$

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]:

$$u(\rho_a) = \sqrt{u_T^2 + (\partial\rho_a/\partial p u_p)^2 + (\partial\rho_a/\partial t u_t)^2 + (\partial\rho_a/\partial hr u_{hr})^2}$$

with the standard uncertainty of formula:

$$u_F = 2 \times 10^{-4} \rho_a$$

cf. [1, Section E.3]

and the sensitivity coefficient:

$$\begin{aligned} \partial\rho_a/\partial p &\approx +1 \times 10^{-5} \text{Pa}^{-1} \\ \partial\rho_a/\partial t &\approx -4 \times 10^{-3} \text{K}^{-1} \\ \partial\rho_a/\partial hr &\approx -9 \times 10^{-3}, \text{ with } 0 \leq hr \leq 1 \end{aligned}$$

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:

$$u_w(\overline{\Delta m_c}) \leq \frac{4}{5} u_c(m_{ct}) \quad \text{and} \quad u(m_{cr}) = u_b = u_{ba} \leq \frac{1}{3} u_c(m_{ct})$$

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 $u_w(\overline{\Delta m_c})$ results in a similar requirement for the repeatability s of the mass comparator.

$$u_w(\overline{\Delta m_c}) = s(\Delta m_c)/\sqrt{n} \leq \frac{4}{5} u_c(m_{ct}) = \frac{2}{5} U(m_{ct}) = \frac{2}{15} \text{MPE}, \text{ i.e. } s(\Delta m_c) \leq \frac{2}{15} \text{MPE}\sqrt{n}$$

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: $s = 6 \text{ mg}$

Digital scale interval: $d = 2 \text{ mg}$

Permissible error limit: MPE = 30 mg (20 kg, accuracy class E2)

Reference weight: Accuracy class E1, with DAkkS certificate

Conventional mass: $m_{cr} = 20 \text{ kg} - 5 \text{ mg}$

Expanded uncertainty: $U(m_{cr}) = 3 \text{ mg}$, $k = 2$

Density: $\rho_r = 8012.7 \text{ kg m}^{-3}$, $u(\rho_r) = 1.25 \text{ kg m}^{-3}$

Test weight: Conventional mass: $m_{ct} = 20 \text{ kg} + 15 \text{ mg}$

Density: $\rho_t = 7950 \text{ kg m}^{-3}$, $u(\rho_t) = 70 \text{ kg m}^{-3}$ [1, Tab. B.7, Stainless steel]

Ambient conditions: Measured values of the internal climate module

Temperature: $t = 20 \text{ }^\circ\text{C}$, $u_t = 0.15 \text{ K}$

Pressure: $p = 970 \text{ hPa}$, $u_p = 1 \text{ hPa}$

Humidity: $hr = 50 \%$, $u_{hr} = 1 \%$

Air density: $\rho_a = 1.148 \text{ kg m}^{-3}$, $u(\rho_a) = 0.001 \text{ kg m}^{-3}$
(calculated by application software on the mass comparator)

Uncertainties:

$$u_w(\overline{\Delta m_c}) = 6 \text{ mg}/\sqrt{3} = 3.46 \text{ mg}$$

$$u(m_{cr}) = 3 \text{ mg}/2 = 1.50 \text{ mg}, \text{ with } u_{\text{inst.}}(m_{cr}) = 0$$

$$u_b = 1.15 \text{ mg}$$

$$u_{ba} = 0.82 \text{ mg}, \text{ with}$$

$$u_s = 5 \times 10^{-4} \times 20 \text{ mg} = 0.01 \text{ mg}$$

$$u_d = 2 \text{ mg} \times \sqrt{2}/(2\sqrt{3}) = 0.82 \text{ mg}$$

$$u_E = 0 \text{ mg} \text{ (already contained in } u_w)$$

$$u_{ma} = 0 \text{ mg} \text{ (since weight is OIML-compliant)}$$

$$u_c(m_{ct}) = \sqrt{(3.46 \text{ mg})^2 + (1.50 \text{ mg})^2 + (1.15 \text{ mg})^2 + (0.82 \text{ mg})^2} = 4.03 \text{ mg}$$

$$U(m_{ct}) = 2 \times 4.03 \text{ mg} = \mathbf{8.06 \text{ mg}} \leq \frac{1}{3} 30 \text{ mg} = \mathbf{10 \text{ mg}}$$

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	000, 00, 0	1	2 3	4 5	6 7		
Cycles n	5	3	2	1	1	1	1
$s_{\max}(\Delta m_c) = \frac{2}{15} \text{MPE} \sqrt{n}$	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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