

# Mass Metrology Precision Is a Matter of Having the Right Equipment



## 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. These institutes are the measure of all things.

On behalf of and in collaboration with the NMIs, Sartorius develops innovative mass comparators to the highest standards.

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

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

At this point, we would like to specially 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)
- SIOS Messtechnik GmbH
- The Technical University of Ilmenau (TUI), Germany

With the support of the next two partners in Austria, we developed the most accurate balance in the world, the CCL1007 mass comparator:

- The Austrian Bundesamt für Eich- und Vermessungswesen (BEV, The Federal Office of Metrology and Surveying)
- The Technical University of Vienna

In cooperation with our two partners below, we developed a number of robot systems and an innovative and fully automatic system for density determination:

- Häfner Gewichte GmbH
- MARO Elektronik, Bretzenheim, Germany

We worked together to develop a robot system and metrological software.



# Products for the Determination of Mass

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## Automatic Mass Comparators and Robots Determination of Mass to the Very Highest Standards

Sartorius masters the core disciplines of weighing like no other and sets new standards 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 mass comparator is protected from environmental effects by a pressure-stable aluminum chamber. In the vacuum chamber, measurements can be performed at high vacuum up to 10<sup>-6</sup> mbar. Unlike conventional stainless steel vacuum bell jars, the aluminum chamber does not cause any magnetic reactions that would affect the weighing system.

Test objects and reference weights can be introduced easily and positioned precisely through the lower loading hatch by means of an automatic loading device, without the need to open the entire vacuum chamber. The load alternator can accommodate up to eight weights. The position of the weight on the load alternator is assigned at the operating terminal. The quantity and method of mass comparisons are also entered at this terminal.

After the weight has been transferred into the interior of the vacuum chamber by a fully automatic loading device, a three-point lifting mechanism picks up this weight. This lifting mechanism determines the center of mass of the weight fully automatically and centers the weight on the load alternator.

The unique three-point holder is capable of handling both cylindrical weights and silicon spheres efficiently.

The equipment thus meets all of the requirements for the new definition of the kilogram using a silicon sphere. The scientific tests necessary to determine the Avogadro constant can therefore be performed conveniently and precisely.

The weigh cell is located in the upper section of the vacuum chamber. The weighing pan for the substitution weights is accessed via the upper loading hatch.

The motors that drive the load alternator and the weight changing device are located outside the vacuum chamber. This reduces interference caused by temperature fluctuations.

The driving force of these motors is transferred into the interior of the vacuum chamber by rotary axes and vacuum couplings. The load alternator is driven by a pulley hoist system.

All components inside the vacuum chamber are completely resistant to high vacuum and, therefore, will not outgas under 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 and thus ideally suited to high-vacuum applications.

The more than 20 vacuum flanges enable additional sensors to be introduced into the vacuum chamber, which has sufficient space to accommodate additional measuring instruments.



The vacuum chamber of the CCL1007



# The Balance for the Prototype Kilogram

## Areas of Application

- Use 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



The load alternator of the CCL1007

Technical Specifications	CCL1007
Maximum capacity	1031 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 <sup>-6</sup> – 1000 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\* The standard deviation "s" is the repeatability calculated from 6 ABBA cycles after elimination of drift. Prerequisites for accurate calculation of the standard deviation are good ambient conditions in accordance with OIML R111 for an E1 mass standards laboratory.

## Robots for Fully Automated Determination of Mass from 1 mg to 1 kg



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 for CCR10-1000 (1 mg – 10 g)

Robot systems with the latest weighing technology guarantee **highest accuracy** for the mass determination.

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.

Reference and test weights are positioned in the magazine that accommodates a high number of weights. The weighing mode is entered on the PC, the number of comparison cycles is defined and a direct 1:1 mass comparison or subdivision (dissemination of mass for class E1 weights) is initiated. The robot retrieves the weights from the magazine and starts mass comparison. Prior to mass comparison, the robot automatically combines the groups of weights required for dissemination of mass according to the weighing design.

For **efficient operation** of the robot system, the reference weight and test weight are placed on separate comb-type weight grabbers. These weight grabbers accommodate a group of up to four weights.

Groups of weights are placed on the weighing pan simultaneously, guaranteeing fast loading of the mass comparator with reference and test weights.

The 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.

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.

The robot systems are supplied with a PC and user-friendly control software.

Naturally, all Sartorius robot systems can be controlled directly by ScalesNet-M (see YSN03C on pages 18-21). This is a management software program designed to cover all requirements and to network all equipment in the mass standards laboratory.

### Technical Specifications

	CCR10	CCR1000	CCR10-1000
Application range (E1)	1 mg–10 g	10 g–1 kg	1 mg–1 kg
Maximum capacity	10.5 g	1002 g	10.5 g   1002 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	2.1 g	3.5 g   2.1 g
Magazine positions	39	23	39   23
Optional magazine positions	26-65	2-37	2-102

s\* The standard deviation "s" is the repeatability calculated from 6 ABBA cycles after elimination of drift. Prerequisites for accurate calculation of the standard deviation are good ambient conditions in accordance with OIML R111 for an E1 mass standards laboratory.

## Automatic Mass Comparators with Load Alternator

Automated weight handling provides the best repeatability.

Sartorius mass comparators with a load alternator perform fully automatic mass comparison of individual reference mass standards and groups of weights in any combination. As no additional cylindrical or stackable weights are required, loss of accuracy is prevented.

Relatively large objects, such as disk weights, buoyancy artifacts, and pressure disks, can also be easily positioned for determination of their mass.

To determine air density, we recommend our climate measurement station YCM16C (see page 13) along with the associated software.

The ScalesNet-M software enables all mass and volume comparators, automatic systems, and climate measurement stations in a mass laboratory to be networked together. The software is designed for data acquisition, automatic equipment control, data evaluation and storage, and generation of calibration certificates. ScalesNet-M covers all international requirements placed on a professional mass laboratory (see pages 18–21).



Comparison of mass standards as groups of weights using the CCE1000S-L



Subdivision weighing on CCE1000S-L | CCE1000U-L | CCE2000S-L



Comparison of a weight with a group of mass standards using the CCE50001S-L

Mass comparators with a load alternator are ideally suited for determining the mass of class E1 weights.

The generously sized weighing pan provides sufficient space for the calibration of groups of weights and large-diameter weights.

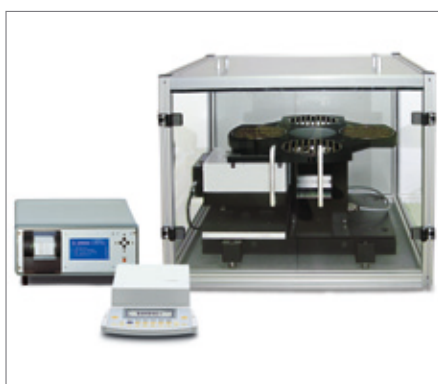
The integrated centering equipment is positioned below the weighing pan to give the user the best possible access.

These mass comparators can also be used as stand-alone instruments without a PC. Networking and PC control are possible by using external programs.



**CCE1000S-L**

Maximum capacity: 1.002 kg  
 Electrical weighing range: 2 g  
 Readability: 0.001 mg  
 Repeatability (typical), s\*: 0.001 mg



**CCE10000U-L**

Maximum capacity: 10.05 kg  
 Electrical weighing range: 60 g  
 Readability: 0.01 mg  
 Repeatability (typical), s\*: 0.02 mg



**CCE50001S-L**

Maximum capacity: 51 kg  
 Electrical weighing range: 51 kg  
 Readability: 1 mg  
 Repeatability (typical), s\*: 2 mg

**CCE10000S-L**

Maximum capacity: 10.05 kg  
 Electrical weighing range: 60 g  
 Readability: 0.1 mg  
 Repeatability (typical), s\*: 0.05 mg

**CCE20000S-L**

Maximum capacity: 20.05 kg  
 Electrical weighing range: 60 g  
 Readability: 0.1 mg  
 Repeatability (typical), s\*: 0.1 mg

s\* The standard deviation "s" is the repeatability calculated from 6 ABBA cycles after elimination of 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 Mass Comparators up to 1 kg

The CCE generation of manually-operated weighing equipment is the ultimate in manual mass comparators.

With up to 61 million weighing steps, these instruments are world class. The monolithic weigh cells that are manufactured as a single structure from a high quality aluminum alloy deliver results with outstanding repeatability.

Reliability and speed are key features of this new class of mass comparators.

All CCE comparators up to 5 kg have a fully electronic weighing range or several overlapping weighing ranges. As a result, any weight value between 0 g and the maximum capacity can be attained.

The CCE comparators up to 1 kg have an electronic draft shield and below-balance weighing equipment.

Below-balance weighing equipment makes density determination easy. This equipment is standard on nearly all mass comparators in this product range.

In addition to the below-balance weighing equipment, Sartorius mass comparators are also available with the YDK01 density determination kit.



### CCE6

Maximum capacity and electronic weighing range: 6.1 g  
 Readability: 0.1 µg  
 Repeatability (typical), s\*: 0.15 µg



### CCE36

Maximum capacity and electronic weighing range: 31 g  
 Readability: 1 µg  
 Repeatability (typical), s\*: 1 µg



### CCE605

Maximum capacity: 610 g  
 Electrical weighing range: 610 g  
 Readability: 10 µg  
 Repeatability (typical), s\*: 15 µg

### CCE66

Maximum capacity and electronic weighing range: 61 g  
 Readability: 1 µg  
 Repeatability (typical), s\*: 1 µg

### CCE1005

Maximum capacity: 1110 g  
 Electrical weighing range: 610 g  
 Readability: 10 µg  
 Repeatability (typical), s\*: 15 µg

### CCE106

Maximum capacity: 111 g  
 Electrical weighing range: 61 g  
 Readability: 1 µg  
 Repeatability (typical), s\*: 1 µg

s\* The standard deviation "s" is the repeatability calculated from 5 ABA cycles after elimination of 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 Mass Comparators up to 20 kg

Developed for mass metrology, the integrated application software facilitates daily work routines. This software guides the user, while mass comparator takes over the timing and, at the end of the ABA or ABBA cycles, delivers the difference in mass, standard deviation and individual values.

All CCE mass comparators up to a load range of 5 kg have a built-in isoCAL motorized calibration weight.

The majority of Sartorius manual mass comparators are designed so that they do not require space-consuming centering equipment within the weighing chamber.

The complete electronics and the power supply for display and evaluation are separate from the weighing system in order to prevent heat from affecting the results.

Additional draft shields are available for all models. They reduce air movement caused by air conditioning systems and, in this way, enable excellent repeatability to be achieved even under unfavorable ambient conditions (for a list, see page 23).



### CCE1004

Maximum capacity and electronic weighing range: 1.2 kg  
 Readability: 0.1 mg  
 Repeatability (typical), s\*: 0.05 mg

### CCE2004

Maximum capacity and electronic weighing range: 2.5 kg  
 Readability: 0.1 mg  
 Repeatability (typical), s\*: 0.1 mg

### CCE5004

Maximum capacity and electronic weighing range: 5.1 kg  
 Readability: 0.2 mg  
 Repeatability (typical), s\*: 0.3 mg

### CCE5003

Maximum capacity and electronic weighing range: 5.1 kg  
 Readability: 1 mg  
 Repeatability (typical), s\*: 0.5 mg

### CCE10000S

Maximum capacity: 10.05 kg  
 Electrical weighing range: 60 g  
 Readability: 0.1 mg  
 Repeatability (typical), s\*: 0.1 mg

### CCE20000

Maximum capacity: 20.05 kg  
 Electrical weighing range: 60 g  
 Readability: 1 mg  
 Repeatability (typical), s\*: 1 mg

### CCE10K3

Maximum capacity and electronic weighing range: 11 kg  
 Readability: 1 mg  
 Repeatability (typical), s\*: 1 mg

s\* The standard deviation "s" is the repeatability calculated from 5 ABA cycles after elimination of drift.

Prerequisites for accurate calculation of the standard deviation are good ambient conditions in accordance with OIML R111 for an E1 mass standards laboratory.

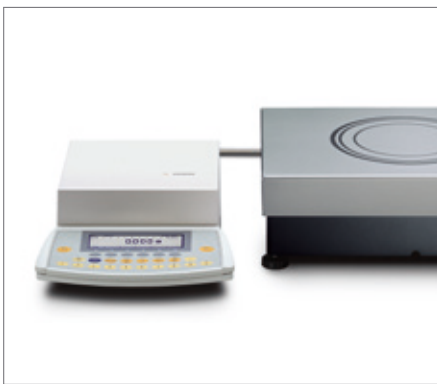
## Manual Mass Comparators up to 300 kg

All mass comparators from a load range of 40 kg have a continuous, full-resolution weighing range and large weighing pan. This makes them ideal for universal use.

If necessary for below-balance weighing, a hanger can be attached directly to the port on the weigh cell. In this way, for example, a simple, yet highly accurate density measurement setup can be achieved. The integrated software supplied for density determination on all CCE models simplifies work routines.

The single-point monolithic weigh cell based on electromagnetic force compensation directly supports a load of over 60 kg. As a result of the direct introduction of force into the weigh cell, unprecedented repeatabilities of just a few milligrams are achieved with this weighing system. Due to the direct introduction of force, the off-center loading error (eccentricity) is extremely low, and the stated specifications are also achieved without the use of a Centermatic.

Depending on the ambient conditions, the excellent repeatabilities can be increased still further by using a Centermatic and a draft shield (see page 23).



### CCE40K3

Maximum capacity: 41 kg  
 Readability: 2 mg  
 Repeatability (typical), s\*: 3 mg

### CCE60K3

Maximum capacity: 64 kg  
 Readability: 2 mg  
 Repeatability (typical), s\*: 4 mg

### CCE60K2

Maximum capacity: 64 kg  
 Readability: 10 mg  
 Repeatability (typical), s\*: 7 mg

### CCI60K2

Maximum capacity: 64 kg  
 Readability: 50 mg  
 Repeatability (typical), s\*: 100 mg

### CCI100K2

Maximum capacity: 151 kg  
 Readability: 50 mg  
 Repeatability (typical), s\*: 200 mg

### CCI300K

Maximum capacity: 303 kg  
 Readability: 1000 mg  
 Repeatability (typical), s\*: 500 mg

s\* The standard deviation "s" is the repeatability calculated from 5 ABA cycles after elimination of drift.

Prerequisites for accurate calculation of the standard deviation are good ambient conditions in accordance with OIML R111 for an E1 mass standards laboratory.

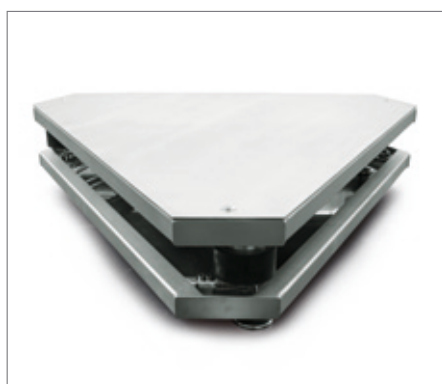
## Manual Mass Comparators up to 3000 kg

All Sartorius heavy-duty mass comparators are made of high quality stainless steel. This design eliminates the possibility of magnetic 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 guarantees 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 achieved.



### CCT1000K

Maximum capacity: 1200 kg  
 Readability: 1 g  
 Repeatability (typical), s\*: 2 g  
 Dimensions in cm LxWxH: 151x137x24

### CCT2000K

Maximum capacity: 2100 kg  
 Readability: 1 g  
 Repeatability (typical), s\*: 5 g  
 Dimensions in cm LxWxH: 192x171x23

### CCS600K

Maximum capacity: 605 kg  
 Readability: 1 g  
 Repeatability (typical), s\*: 2 g  
 Dimensions in cm LxWxH: 83x103x25

### CCS1000K

Maximum capacity: 1510 kg  
 Readability: 5 g  
 Repeatability (typical), s\*: 5 g  
 Dimensions in cm LxWxH: 83x103x25

### CCS3000K

Maximum capacity: 3010 kg  
 Readability: 10 g  
 Repeatability (typical), s\*: 10 g  
 Dimensions in cm LxWxH: 150x125x30

s\* The standard deviation "s" is the repeatability calculated from 5 ABA cycles after elimination of drift.

Prerequisites for accurate calculation of the standard deviation are good ambient conditions in accordance with OIML R111 for an M1 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 is the perfect solution for determining air density and can be used to monitor the room climate in all metrological laboratories.

### Monitoring Accuracy Classes

As is required for calibration laboratories, the YCM16C provides room monitoring for all of the accuracy classes given in accordance with OIML R111 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.

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 No.
ScalesNet-M software	YSN03C
PC 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



### 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



Air humidity/temperature sensor YCM16H | YCM16T



Air pressure sensor YCM16P



Air temperature sensor YCM20T

# Susceptometer – A Complete Solution for Testing the Magnetic Properties of Weights

It is recommended to test the magnetic properties of weights using the OIML R111. This confirms that the requirements placed on weights no longer only apply to geometric quantities, material density, weight, or surface qualities. In fact, many scientific evaluations support the demand that both the susceptibility and magnetization of weights be considered.



Susceptometer YSZ01C|YSZ02C

## Susceptometer Method

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

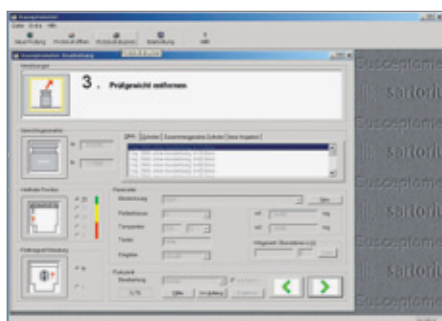
This method measures the interaction between a permanent magnet and the weight to be tested using a high-resolution balance as a weight force. The desired magnetic properties of the weight can be calculated on the basis of the known properties of the test magnet, the distance of the weight from the test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

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 software that comes standard with the susceptometer is exceptionally easy to use and enables data to be automatically transferred from the unit. It also supports the user through all required 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.



Application Software

## Technical Specifications

Susceptometer	YSZ01C	YSZ02C										
Readability of the susceptometer	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: <table border="1"> <tr> <td><math>Z_1 = 18</math></td> <td><math>Z_2 = 20</math></td> <td><math>Z_3 = 27</math></td> <td><math>Z_4 = 35</math></td> <td><math>Z_5 = 43</math></td> </tr> <tr> <td>2700</td> <td>2000</td> <td>800</td> <td>360</td> <td>200</td> </tr> </table>		$Z_1 = 18$	$Z_2 = 20$	$Z_3 = 27$	$Z_4 = 35$	$Z_5 = 43$	2700	2000	800	360	200
$Z_1 = 18$	$Z_2 = 20$	$Z_3 = 27$	$Z_4 = 35$	$Z_5 = 43$								
2700	2000	800	360	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 for Susceptometers



### YSZ01RMC

3 reference magnets in a wooden case for Sartorius susceptometer YSZ01C and YSZ02C



### YSZ01RSC

Susceptibility standard, as reference, in a wooden case for Sartorius Susceptometer YSZ01C and YSZ02C, with PTB susceptibility certificate

## Permeability Indicator



YAW61 with optional knob weight

The Sartorius permeability indicator is easy to use 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 " $\chi$ " is the result of the relationship between the relative magnetic permeability and the magnetic susceptibility ( $\mu_r = 1 + \chi$ ).

$\chi$  = magnetic susceptibility  
 $\mu_r$  = 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 and 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.

### YAW61 Technical Specifications

Balance beams with a permanent magnet in the case, including permeability reference standards [ $\mu_r$ ]

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 and Density Determination up to 1 kg

Density determination is often required in metrology and industry. The most accurate method for determining the density of solid objects in accordance with OIML R111 is hydrostatic mass comparison in liquid. In this procedure, a volume reference of known mass and volume is compared in liquid of known density with a test object of known mass. The volume or density of the test weights is calculated from the different buoyancies of the weights in the liquid.

Sartorius has integrated this OIML R111 method into a fully automatic volume comparator.

Sartorius offers two fully automatic systems for density determination for weights in the range from 1 g to 1 kg: models VD1005 and VL1005.

Both volume comparators have a nine-position load alternator in a liquid bath. Model VD1005 also has a second nine-position load alternator for substitution weights in air. The load alternators operate synchronously in that a position in air is assigned for each position in liquid. 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, a built-in PC with user-friendly software takes over fully automatic control of the volume comparator and evaluation of density measurement.

### Technical Specifications

#### VD1005|VL1005

Density uncertainty*	1 kg/m <sup>3</sup>
Volume uncertainty*	0.00015 cm <sup>3</sup>
Weight diameter	6...100 mm
Maximum sphere diameter	95 mm

### Application

Density determination of weights in accordance with OIML R111, Class E1	1 g...1 kg
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### Comparator Technical Specifications

Maximum capacity	1110 g
Readability	10 µg
Repeatability, s*	≤ 40 µg
Repeatability (typical), s*	≤ 20 µg
Weighing range, electronic	305 g
Tare range (subtractive)	305 g

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



Volume Comparator VD1005|VL1005 (VD 2×9 load alternator positions)



Dual load alternator VD1005

s\* The standard deviation "s" is the repeatability calculated from 6 ABBA cycles after elimination of 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

YVT01C	Thermostat
YWT20C	Table for VD1005 and VL1005
YDR1000SIC	1 kg silicon sphere with PTB density certificate
YCS31-612-09	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



1 kg silicon sphere YDR1000SIC



E1 set of weights YCS31-612-09, stackable



Table for volume comparator YWT20C



Thermostat YVT01C

## Density Determination up to 50 kg

Sartorius offers the YP50K Pycnometer for determining the volume of weights in the range from 2 kg to 50 kg.

In combination with the CCE60K3 and a PC, the pycnometer is a reliable solution for determination of volume.

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.



Sartorius Pycnometer YP50K

## ScalesNet-M – Individual Software Solution for Professionally Calibrating of 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 the professional software for effective mass calibration.



### Individual

This is thanks to the new, modular ScalesNet-M concept. ScalesNet-M can be adapted to the highly diversified needs of our customers and supplemented at any time.

### Mass Calibration

Mass calibration with ScalesNet-M 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.

Sartorius, which is open to connecting all comparators from any manufacturer and flexible in incorporating existing climate measurement stations, 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.

### Benefits of ScalesNet-M

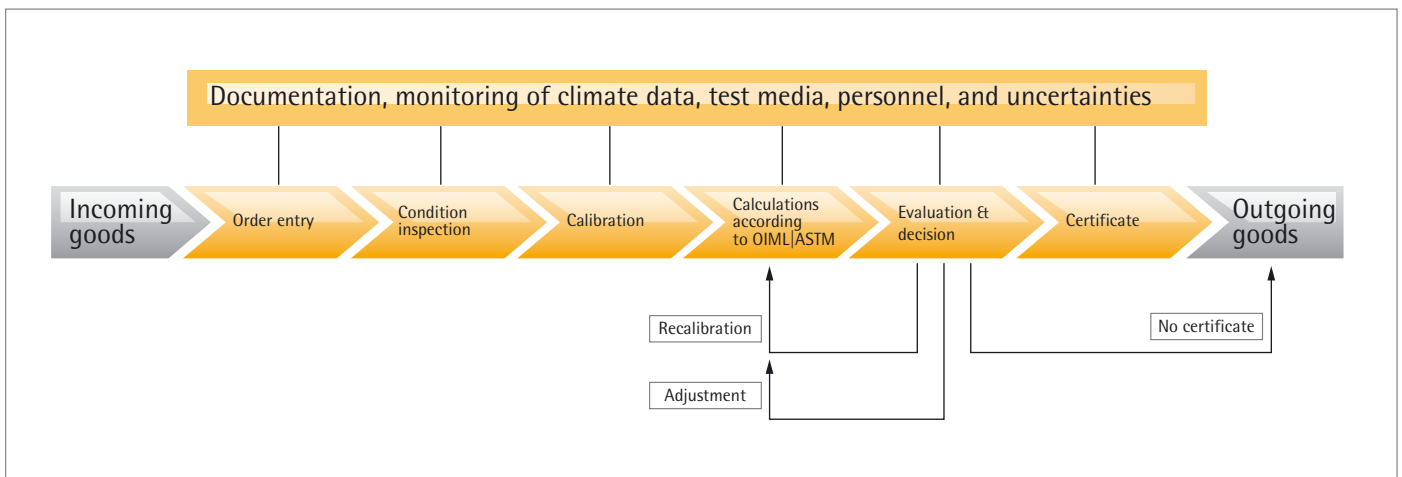
- Safe weight calibration
- Efficient measurement laboratory management
- Calculating and evaluating according to international guidelines such as OIML | ASTM
- Basis for an accredited measurement laboratory according to DIN EN ISO/IEC 17025
- Transparent documentation and archiving of all process-relevant 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
- Individual service package



### ScalesNet-M 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



## ScalesNet-M Module



### YSN03C

#### Basic module

Sartorius basic software module for highly accurate mass determination.

## Module 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.



### YSN03BC

#### Module for manual comparators

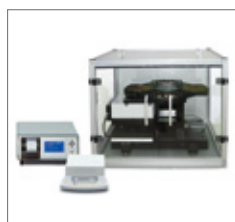
PC license for connecting up to five additional scales or manual mass comparators for simultaneous use.



### YSN03PC

#### ScalesDesk module

Administrator license for the simultaneous use of an additional administrator.



### 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 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.



### 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.



## Equipment Supplied

The YSN03C basic package contains 1 CD and one dongle with the following licenses:

- 1× ScalesServer, SQL database
- 1× ScalesMass, laboratory calibration
- 1× ScalesDesk, administration
- 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, Accept, 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 on the PC
- PC connection cable for comparators

## Reports

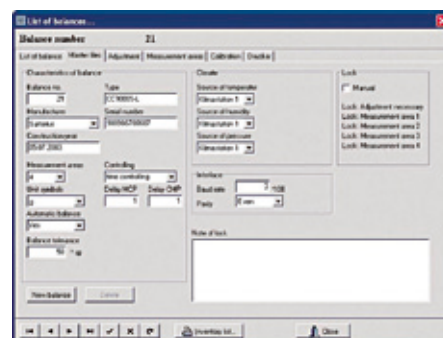
- DAkS calibration certificates
- Calibration report
- Inventory lists
- Device lists
- Six comparison log
- Dissemination log

## 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 Software

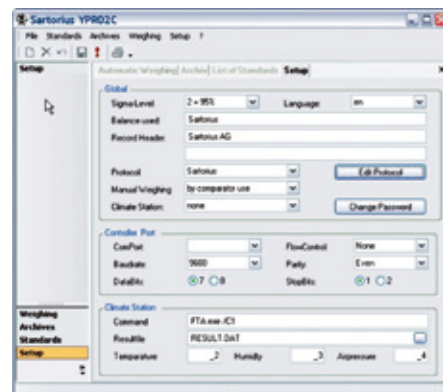
## EasyMassCal – Compact Software Solution for Determination of Mass

EasyMassCal application software is designed for highly accurate online determination of mass using Sartorius manual mass comparators and for controlling automatic comparisons of mass in conjunction with Sartorius automatic mass comparators. It runs on Microsoft Windows® XP or higher.

The software facilitates the determination of the difference between two masses and the determination of absolute or apparent mass (conventional mass value), taking buoyancy errors into account. The program automatically implements buoyancy corrections after manual entry of the climate data or automatic acquisition of climate data using the climate station YCM16C. The climate data will be collected and stored on the PC. The time at which the mass comparison takes place and the maximum uncertainty for automatic mass comparison are selectable.

The standard software contains a database for reference and test weights, and facilitates online calculation of the standard deviation and mass difference and the uncertainties at either the sigma 1, sigma 2, or sigma 3 level.

The number of ABBA (NPPN) cycles can be selected in the range from 01–99.



Software EasyMassCal YPRO2C

## 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 1000 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 3-digit marking in accordance with the international OIML-R111 recommendations. Sartorius weights are therefore uniquely identifiable for their entire life cycles.



Set of reference weights



Glass bell jar with lower base

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 high-quality 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 in shape, material, and markings.

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

### DAkkS certificate

Sartorius reference weights are DAkkS calibrated; certificates are supplied free of charge\*. 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. These weights help support your quality management and quality assurance systems, and fulfill 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](http://www.sartorius.com).

### Excerpt from Our Weight and Accessories Range

Weight sets	Order No. E1	Order No. DAkkS calibrated E1	Order No. DAkkS calibrated E2
1 mg – 5 g	YCS011-351-00*	YCS011-351-02*	YCS011-352-00*
1 mg – 100 g	YCS011-511-00*	YCS011-511-02*	YCS011-512-00*
1 mg – 200 g	YCS011-521-00*	YCS011-521-02*	YCS011-522-00*
1 mg – 1 kg	YCS011-611-00*	YCS011-611-02*	YCS011-612-00*
1 mg – 5 kg	YCS011-651-00*	YCS011-651-02*	YCS011-652-00*
1 g – 1 kg	YCS31-611-00*	YCS31-611-02*	YCS31-612-00*
1 g – 5 kg	YCS31-651-00*	YCS31-651-02*	YCS31-652-00*
1 g – 10 kg	YCS31-711-00*	YCS31-711-02*	YCS31-712-00*

### Glass bell jar with support plate

	Order No.
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

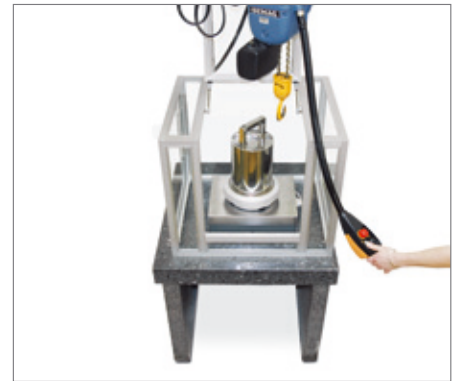
### Lifting devices

	Nominal value	Order No.
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

\* weights with DKD certificate in Sartorius's name for classes E2, F1, F2 up to 50 kg

## Equipment

<b>Weighing table</b>	<b>Order No.</b>
Weighing table made from synthetic stone (L × W × H) 900 × 600 × 760 mm	YWT03
Weighing table made from volume comparator (W × D × H) 1500 × 800 × 600 mm	YWT20C
<b>Draft shield</b>	
For CCE6	YDS20C
For CCE1004   CCE2004   CCE5004   CCE5003   CCE36   CCE66   CCE106   CCE605   CCE1005   CCE10K3	YDS24C
For CCE10000S-L   CCE10000U-L   CCE20000S-L	YDS01C
For CCE40K3   CCE60K3   CCE60K2	YDS05C
For CCI60K2	YDS62C
For CCI100K2   CCI300K	YDS64C
<b>Density references</b>	
1000 g silicon sphere	YDR1000SIC
500 g silicon sphere	YDR500SIC
200 g silicon sphere	YDR200SIC
1000 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 for volume comparators	YCS31-612-09
<b>Special weighing pans</b>	
Weighing pan with set of weighing plates for weighing mass combinations for CC1000S-L	YWP04C
Centering pan for CCE40K3   CCE60K3   CCE60K2	YWP03C
<b>Printers</b>	
Data printer, with real-time clock for printing out date and time, and for statistical evaluation of weight values	YDP20-OCE
<b>Switches</b>	
Foot switch with T-connector	YFS01
Hand switch with T-connector	YHS02
<b>Density Determination</b>	
Hook for below-balance weighing for CC30002   CC50002   CCE40K3   CCE60K3   CCE60K2	69EA0040
Density Kit for CCE36   CCE66   CCE106   CCE605   CCE1005	YDK01LP



Weighing table with optional accessories



Draft shield



1 kg silicon sphere YDR1000SIC

## Summary and Product Recommendations

### Calculating Uncertainties in Accordance with OIML R111

The diagrams on the next two pages show the suitability of Sartorius comparators for different weight error classes at a 95% level of confidence (k=2). The uncertainty of the mass determination is calculated using the following formula:

$$u_c(m_i) = \sqrt{u_w^2(\overline{\Delta m}) + u^2(m_{cr}) + u_b^2 + u_{ba}^2}$$

(OIML R111-1, formula C.6.5-2)

A possible division of the uncertainties given in the formula is the basis for the following diagrams of the international recommendations for OIML and ASTM. The share of the uncertainty of the weighing process  $u_w$  is taken to be 80% of other overall uncertainty and all others each 1/3, although the overall uncertainty is  $u_c(m_i) = 1/3$  MPE.

MPE = Maximum Permissible Error

$$u_c(m_i) \geq \sqrt{u_w^2 \left( \frac{4}{5} (u_c) \right)^2 + u^2(m_{cr}) \left( \frac{1}{3} (u_c) \right)^2 + u_b^2 \left( \frac{1}{3} (u_c) \right)^2 + u_{ba}^2 \left( \frac{1}{3} (u_c) \right)^2} > u_c(m_i) \geq \sqrt{u_w^2(0,64u_c) + u(m_{cr})(0,1\bar{1}u_c) + u_b(0,1\bar{1}u_c) + u_{ba}(0,1\bar{1}u_c)} = 0,985(u_c)$$

with  $U(m_i) = k \times u_c(m_i)$  and when k=2, then:  $U(m_i) = 2u(m_i) = \frac{1}{3} MPE$

$$u_w(\overline{\Delta m}) = \frac{MPE}{2} \times \frac{1}{3} \times 80\% = \frac{MPE}{7,5} \quad \text{therefore:} \quad u_w(\overline{\Delta m}) = \frac{s(\overline{\Delta m})}{\sqrt{n}} \leq \frac{MPE}{7,5}$$

Table as basis for the recommendations

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

$$s_{max}(\overline{\Delta m}) = \frac{MPE \sqrt{n}}{7,5} \quad \frac{MPE}{3,36} \quad \frac{MPE}{4,33} \quad \frac{MPE}{5,3} \quad \frac{MPE}{7,5} \quad \frac{MPE}{7,5} \quad \frac{MPE}{7,5} \quad \frac{MPE}{7,5}$$

In individual cases it must be proven that the given uncertainties have been adhered to. The given overall uncertainty limits are to be ensured.

The following example calculation of a calibration of 20 kg E2 with specific uncertainty shares proves the suitability of a comparator for an accuracy class.

Comparator: CCE60K3, s = 6 mg | d = 2 mg  
 Test weight:  $m_{ct} = 20 \text{ kg} | \text{E2}$   
 Reference weight:  $m_{cr} = 20 \text{ kg} + 5 \text{ mg} | \text{E1 with DAkkS certificate}$

Key figures:  $MPE = 30 \text{ mg} (20 \text{ kg} | \text{E2})$        $u_t = 0.5 \text{ K}$       for  $t = 20 \text{ }^\circ\text{C}$   
 $u(m_{cr}) = 1.5 \text{ mg} (k = 2)$        $u_{hr} = 2\%$       for  $hr = 50\%$   
 $u_c = 5 \text{ mg}$        $u_p = 100 \text{ Pa}$       for  $p = 970 \text{ hPa}$       }  $u_b = 0.365 \text{ mg}$

$$u_{ba} = \sqrt{u_s^2 + u_d^2 + u_E^2 + u_{ma}^2} = \sqrt{(2 \text{ mg})^2 + \left( \frac{1 \text{ mg}}{\sqrt{3}} \times \sqrt{2} \right)^2 + (2 \text{ mg})^2 + (1 \text{ mg})^2} = 3,11 \text{ mg}$$

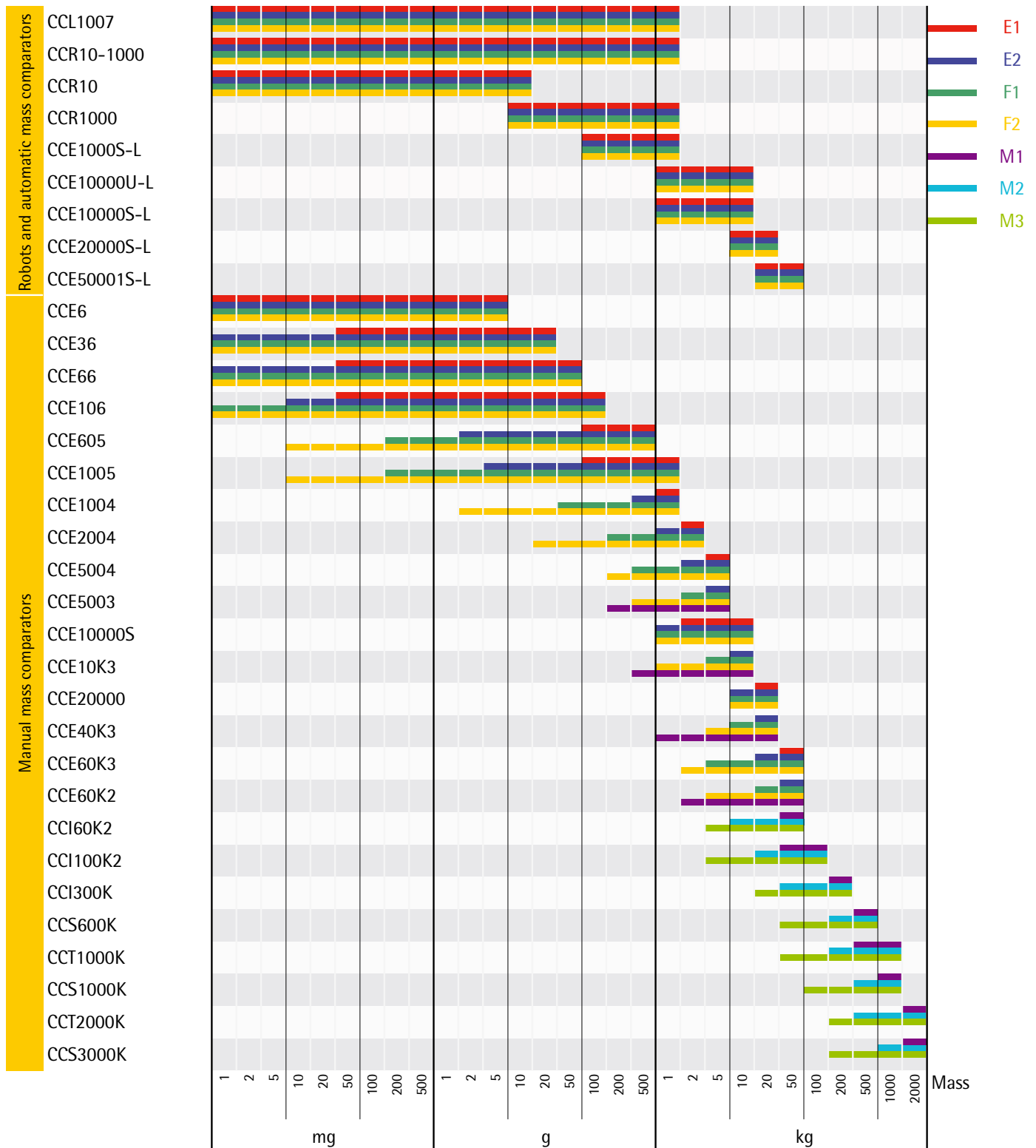
$$u_c(m_i) = \sqrt{u_w^2(\overline{\Delta m}_c) + u^2(m_{cr}) + u_b^2 + u_{ba}^2}$$

$$u_c(m_i) = \sqrt{\left( \frac{6 \text{ mg}}{\sqrt{3}} \right)^2 + 1,5^2 \text{ mg}^2 + 0,365^2 \text{ mg}^2 + 0,311^2 \text{ mg}^2} = 4,90 \text{ mg}$$

$$U_c(m_i) = 2 \times u_c(m_i) = 9,80 \text{ mg} \leq \frac{1}{3} MPE = 10 \text{ mg}$$

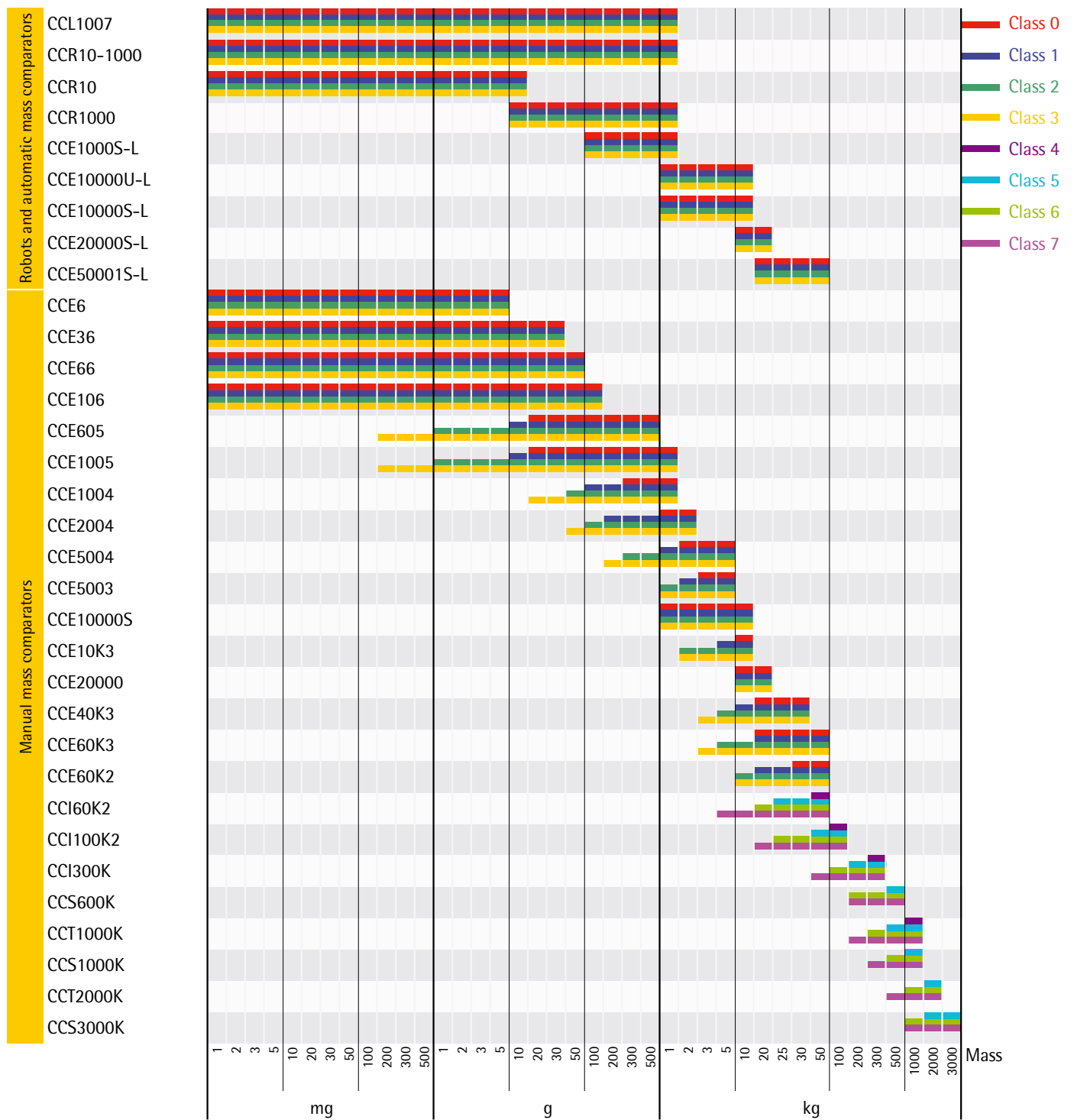


# Application Ranges in Accordance with OIML R111-1





# Application Ranges in Accordance with ASTM E617



## Technical Specifications

### Mass Comparator with Vacuum Chamber



	CC1007	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			
ScalesNet-M PC software	YSN03C			
Calibration weight	2 g   E2 YCW322-00			

#### 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)	960×860×1260 mm		1081×1044×1261 mm	
Control unit (W×D×H)	600×800×2000 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.

## Technical Specifications

### Fully Automatic Mass Comparator



	CCR10	CCR1000	CCR10-1000
Maximum capacity	10.5 g	1002 g	1002 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	2.1 g	3.5 g   2.1 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 / 2 g	1 µg / 3.5 g   20 µg / 2 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

ScalesNet-M PC software	YSN03C	YSN03C	YSN03C
Calibration weight	2 g   E2 YCW322-00	2 g   E2 YCW322-00	2 g   E2 YCW322-00

#### Expansions

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)	1900 × 1250 × 2328 mm	1900 × 1250 × 2328 mm	1900 × 1250 × 2328 mm
Net weight	1900 kg	1900 kg	1900 kg

s\* Repeatability is the standard deviation "s"; it is calculated from 6 ABBA cycles, after eliminating drift.

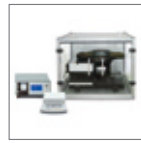
Prerequisites for accurate calculation of the standard deviation are good ambient conditions in accordance with OIML R111 for an E1 mass standards laboratory.

## Technical Specifications

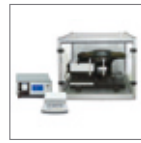
### Mass Comparator with Load Alternator



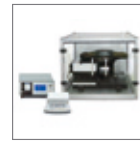
CCE1000S-L



CCE1000U-L



CCE1000S-L



CCE2000S-L



CCE5000S-L

	CCE1000S-L	CCE1000U-L	CCE1000S-L	CCE2000S-L	CCE5000S-L
Maximum capacity	1.02 kg	10.05 kg	10.05 kg	20.05 kg	51 kg
Readability	1 µg	0.01 mg	0.1 mg	0.1 mg	1 mg
Application range	100–1000 g	1 2 3 5 6 10 kg	1 2 3 5 6 10 kg	10 20 kg	20 kg – 50 kg
Repeatability s*	2 µg	0.05 mg	0.1 mg	0.3 mg	3 mg
Repeatability at 1/2 load					2 mg
Repeatability (typical), s*	1 µg	0.02 mg	0.05 mg	0.1 mg	2 mg
Electronic weighing   taring range	21 g	60 g	60 g	60 g	51 kg
Substitution weights	100 100 300 400 g	4 1 2 1 1 kg	4 1 2 1 1 kg	10 kg	
Linearity	20 µg/21 g	0.3 mg/60 g	0.3 mg/60 g	3 mg/60 g	50 mg
Corner load error	0 µg	0 mg	0 mg	0 mg	0 mg
Range sensitivity	1 µg/10 mg	0.03 mg/1 g	0.1 mg/1 g	0.2 mg/1 g	5 mg/50 g
Stabilization time	25 s	20 s	10 s	10 s	10 s
Cycle time ABBA	240 s	240 s	240 s	240 s	720 s

#### Standard Accessories

Load alternator positions	4	4	4	4	2
Touch screen display	×	×	×	×	×
Interfaces	RS-232	RS-232	RS-232	RS-232	RS-232
Centermatic	×	×	×	×	×
Draft shield	×	×	×	×	×
Control unit	×	×	×	×	×
Printers	×	×	×	×	×
PC connection cable	×	×	×	×	×

#### Optional Accessories

ScalesNet-M PC software	YSN03C	YSN03C	YSN03C	YSN03C	YSN03C
Climate station for E1	YCM16C	YCM16C	YCM16C	YCM16C	YCM16C
Calibration weight	20 g E2 YCW422-00	50 g E2 YCW452-00	50 g E2 YCW452-00	50 g E2 YCW452-00	50 kg E2 YCW752-00
Weighing table	YWT03				
Crane with chain hoist				YLD01C	YLD01C
Gripper for weights with handle				YLD02C	YLD02C
Lifting device for 50 kg					YAW53

#### Dimensions

Weighing pan diameter	9 mm	200 mm	200 mm	200 mm	70 mm
Sample size (D×H)	70×130 mm	320×300 mm	320×300 mm	320×300 mm	120–330×300 mm
Load alternator (W×D×H)	230×365×510 mm	790×720×430 mm	790×720×430 mm	790×720×430 mm	1500×670×915 mm
Electronics unit (W×D×H)	254×320×106 mm	254×320×106 mm	254×320×106 mm	254×320×106 mm	254×320×106 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.

## Technical Specifications

### Mass Comparators up to 600 g



	<b>CCE6</b>	<b>CCE36</b>	<b>CCE66</b>	<b>CCE106</b>	<b>CCE605</b>
Maximum capacity	6.1 g	31 g	61 g	111 g	610 g
Readability	0.1 µg	1 µg	1 µg	1 µg	0.01 mg
Application range	0-6 g	0-30 g	0-60 g	0-111 g	0-610 g
Repeatability s*	0.3 µg	1.5 µg	2 µg	2 µg	20 µg
Repeatability at 1/2 load	0.2 µg				15 µg
Repeatability at 1/10 load		1 µg	1 µg	1 µg	10 µg
Repeatability (typical), s*	0.15 µg	1 µg	1 µg	1 µg	15 µg
Electronic weighing   taring range	6.1 g	31 g	61 g	61 g	610 g
Substitution weights				50 g	
Linearity	1 µg	6 µg	10 µg	10 µg	100 µg
Corner load error	0.25 µg/mm	1 µg/mm	2 µg/mm	2 µg/mm	10 µg/mm
Range sensitivity	0.2 µg/5 mg	2 µg/10 mg	2 µg/10 mg	2 µg/10 mg	10 µg/1 g
Stabilization time	10 s	15 s	15 s	15 s	10 s

#### Standard Accessories

	<b>CCE6</b>	<b>CCE36</b>	<b>CCE66</b>	<b>CCE106</b>	<b>CCE605</b>
Interfaces	2 × RS-232C	2 × RS-232C	2 × RS-232C	2 × RS-232C	2 × RS-232C
isoCAL	×	×	×	×	×
Draft shield	×	×	×	×	×
Application programs	×	×	×	×	×
Under-scale weighing port	×	×	×	×	×
Test certificate	Sartorius	Sartorius	Sartorius	Sartorius	Sartorius
PC connection cable	×	×	×	×	×

#### Optional Accessories

	<b>CCE6</b>	<b>CCE36</b>	<b>CCE66</b>	<b>CCE106</b>	<b>CCE605</b>
Calibration weight	5 g E2 YCW352-00	20 g E2 YCW422-00	50 g E2 YCW452-00	50 g E2 YCW452-00	500 g E2 YCW552-00
ScalesNet-M PC software	YSN03C	YSN03C	YSN03C	YSN03C	YSN03C
Climate station for E1	YCM16C	YCM16C	YCM16C	YCM16C	YCM16C
2nd draft shield	YDS20C	YDS24C	YDS24C	YDS24C	YDS24C
Weighing table	YWT03	YWT03	YWT03	YWT03	YWT03
PC software for mass determination	YPR02C	YPR02C	YPR02C	YPR02C	YPR02C
SartoCollect PC software	YSC02	YSC02	YSC02	YSC02	YSC02

#### Dimensions

	<b>CCE6</b>	<b>CCE36</b>	<b>CCE66</b>	<b>CCE106</b>	<b>CCE605</b>
Weighing pan diameter	16 mm	30 mm	30 mm	50 mm	90 mm
Sample size (D×H)	16×70 mm	30×120 mm	30×120 mm	50×40 mm	135×140 mm
Load cell (W×D×H)	122×315×122 mm	220×440×305 mm	220×440×305 mm	219×408×318 mm	220×440×305 mm
Electronics unit (W×D×H)	254×320×106 mm	254×320×106 mm	254×320×106 mm	254×320×106 mm	254×320×106 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.

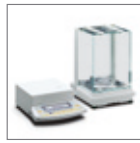


## Technical Specifications

### Mass Comparators 1 kg to 5 kg



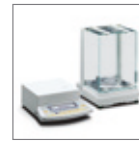
**CCE1005**



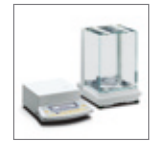
**CCE1004**



**CCE2004**



**CCE5004**



**CCE5003**

	CCE1005	CCE1004	CCE2004	CCE5004	CCE5003
Maximum capacity	1110 g	1200 g	2500 g	5100 g	5100 g
Readability	0.01 mg	0.1 mg	0.1 mg	0.2 mg	1 mg
Application range	0-1110 g	0-1200 g	0-2500 g	0-5100 g	0-5100 g
Repeatability s*	30 µg	0.1 mg	0.2 mg	0.5 mg	1 mg
Repeatability at 1/2 load	20 µg				
Repeatability at 1/10 load	10 µg	0.05 mg	0.1 mg	0.3 mg	
Repeatability (typical), s*	15 µg	0.05 mg	0.1 mg	0.3 mg	0.5 mg
Electronic weighing   taring range	610 g	1200 g	2500 g	5100 g	5100 g
Substitution weights	500 g				
Linearity	100 µg/600 g	1 mg	1 mg	3 mg	5 mg
Corner load error	15 µg / mm	30 µg / mm	30 µg / mm	151 µg / mm	300 µg / mm
Range sensitivity	10 µg/2 g	0.1 mg/2 g	0.1 mg/2 g	0.5 mg/10 g	1 mg/10 g
Stabilization time	15 s	10 s	10 s	10 s	10 s

#### Standard Accessories

	CCE1005	CCE1004	CCE2004	CCE5004	CCE5003
Interfaces	2 × RS-232C	2 × RS-232C	2 × RS-232C	2 × RS-232C	2 × RS-232C
isoCAL	×	×	×	×	×
Draft shield	×	×	×	×	×
Application programs	×	×	×	×	×
Under-scale weighing port	×	×	×	×	×
Test certificate	Sartorius	Sartorius	Sartorius	Sartorius	Sartorius
PC connection cable	×	×	×	×	×

#### Optional Accessories

	CCE1005	CCE1004	CCE2004	CCE5004	CCE5003
Calibration weight	500 g E2 YCW552-00	1 kg E2 YCW612-00	2 kg E2 YCW622-00	5 kg E2 YCW652-00	5 kg E2 YCW652-00
ScalesNet-M PC software	YSN03C	YSN03C	YSN03C	YSN03C	YSN03C
Climate station for E1	YCM16C	YCM16C	YCM16C	YCM16C	YCM16C
2nd draft shield	YDS24C	YDS24C	YDS24C	YDS24C	YDS24C
Weighing table	YWT03	YWT03	YWT03	YWT03	YWT03
PC software for mass determination	YPR02C	YPR02C	YPR02C	YPR02C	YPR02C
SartoCollect PC software	YSC02	YSC02	YSC02	YSC02	YSC02

#### Dimensions

	CCE1005	CCE1004	CCE2004	CCE5004	CCE5003
Weighing pan diameter	90 mm	130 mm	130 mm	130 mm	130 mm
Sample size (D × H)	135 × 140 mm	130 × 200 mm	130 × 200 mm	130 × 200 mm	130 × 200 mm
Load cell (W × D × H)	220 × 440 × 305 mm	240 × 260 × 355 mm	240 × 260 × 355 mm	240 × 260 × 355 mm	240 × 260 × 355 mm
Electronics unit (W × D × H)	254 × 320 × 106 mm	254 × 320 × 106 mm	254 × 320 × 106 mm	254 × 320 × 106 mm	254 × 320 × 106 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.

## Technical Specifications

### Mass Comparators 10 kg to 40 kg



**CCE10000S**



**CCE10000**



**CCE10K3**



**CCE20000**



**CCE40K3**

	CCE10000S	CCE10000	CCE10K3	CCE20000	CCE40K3
Maximum capacity	10.05 kg	10.05 kg	11 kg	20.05 kg	41 kg
Readability	0.1 mg	1 mg	1 mg	1 mg	2 mg
Application range	1 2 3 5 6 10 kg	1 2 3 5 6 10 kg	0-11 kg	10 20 kg	0-41 kg
Repeatability s*	0.25 mg	1 mg	2 mg	2.5 mg	5 mg
Repeatability at 1/2 load		0.7 mg			
Repeatability (typical), s*	0.1 mg	0.5 mg	1 mg	1 mg	3 mg
Electronic weighing   taring range	60 g	60 g	11 kg	60 g	41 kg
Substitution weights	1 2 2 4 kg	1 2 2 4 kg		10 kg	
Linearity	0.3 mg/60 g	0.3 mg/60 g	10 mg	3 mg/60 g	50 mg
Corner load error	0 mg	0 mg	0.5 mg / mm	0 mg	3.5 mg / mm
Range sensitivity	0.1 mg/1 g	0.1 mg/1 g	2 mg/10 g	1 mg/1 g	10 mg/100 g
Stabilization time	10 s	10 s	10 s	10 s	10 s

#### Standard Accessories

	CCE10000S	CCE10000	CCE10K3	CCE20000	CCE40K3
Interfaces	2 × RS-232C	2 × RS-232C	2 × RS-232C	2 × RS-232C	2 × RS-232C
Centermatic	×	×			
Draft shield	×	×	×	×	
Application programs	×	×	×	×	×
Under-scale weighing port	×	×	×	×	×
Test certificate	Sartorius	Sartorius	Sartorius	Sartorius	Sartorius
PC connection cable	×	×	×	×	×

#### Optional Accessories

	CCE10000S	CCE10000	CCE10K3	CCE20000	CCE40K3
Calibration weight	50 g E2 YCW452-00	50 g E2 YCW452-00	10 kg E2 YCW712-00	50 g E2 YCW452-00	20 kg E2 YCW722-00
ScalesNet-M PC software	YSN03C	YSN03C	YSN03C	YSN03C	YSN03C
Climate station for E1	YCM16C	YCM16C	YCM16C	YCM16C	YCM16C
2nd draft shield			YDS24C		YDS05C YDS03C
Weighing table	YWT03	YWT03	YWT03	YWT03	
Lifting device for 10 kg	YAW51	YAW51	YAW51	YAW51	YAW51
Lifting device for 20 kg				YAW52	YAW52
PC software for mass determination	YPR02C	YPR02C	YPR02C	YPR02C	YPR02C
SartoCollect PC software	YSC02	YSC02	YSC02	YSC02	YSC02

#### Dimensions

	CCE10000S	CCE10000	CCE10K3	CCE20000	CCE40K3
Weighing pan diameter	200 mm	200 mm		200 mm	
Weighing pan dimensions (W×D)			350×240 mm		400×300 mm
Sample size (D×H)	200×300 mm	200×300 mm		200×300 mm	
Load cell (W×D×H)	230×365×470 mm	230×365×470 mm	350×240×133 mm	230×365×470 mm	400×300×120 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.

## Technical Specifications

### Mass Comparators 60 kg to 300 kg



	<b>CCE60K3</b>	<b>CCE60K2</b>	<b>CCI60K2</b>	<b>CCI100K2</b>	<b>CCI300K</b>
Maximum capacity	64 kg	64 kg	64 kg	151 kg	303 kg
Readability	2 mg	10 mg	0.05 g	0.05 g	1 g
Application range	0-64 kg	0-64 kg	0-64 kg	0-151 kg	0-303 kg
Repeatability s*	6 mg	10 mg	0.15 g	0.3 g	1 g
Repeatability at 1/10 load	4 mg				
Repeatability (typical), s*	4 mg	7 mg	0.1 g	0.2 g	0.5 g
Electronic weighing   taring range	64 kg	64 kg	64 kg	151 kg	303 kg
Linearity	70 mg	70 mg	2 g	2 g	10 g
Corner load error	3.5 mg / mm	3.5 mg / mm	20 mg / mm	25 mg / mm	50 mg / mm
Range sensitivity	20 mg/100 g	20 mg/100 g	0.3 g/1 kg	0.3 g/1 kg	2 g/1 kg
Stabilization time	10 s	10 s	10 s	10 s	10 s

#### Standard Accessories

Interfaces	2 × RS-232C	2 × RS-232C	2 × RS-232C	2 × RS-232C	2 × RS-232C
isoCAL			×	×	×
Draft shield				×	
Application programs	×	×			
Under-scale weighing port	×	×			
Test certificate	Sartorius	Sartorius	Sartorius	Sartorius	Sartorius
PC connection cable	×	×	×	×	×

#### Optional Accessories

Calibration weight	50 kg E2 YCW752-00	50 kg E2 YCW752-00	50 kg F1 YCW753-00	50 kg F1 YCW753-00	100 kg F1 YCW813-02
ScalesNet-M PC software	YSN03C	YSN03C	YSN03C	YSN03C	YSN03C
Climate station for E1	YCM16C	YCM16C	YCM16C	YCM16C	YCM16C
2nd draft shield	YDS05C YDS03C	YDS05C YDS03C	YDS62C		YDS64C
Lifting device for 10 kg	YAW51	YAW51	YAW51	YAW51	YAW51
Lifting device for 20 kg	YAW52	YAW52	YAW52	YAW52	YAW52
Lifting device for 50 kg	YAW53	YAW53	YAW53	YAW53	YAW53
Crane with chain hoist	YLD01C	YLD01C	YLD01C	YLD01C	YLD01C
Gripper for weights with handle	YLD02C	YLD02C	YLD02C	YLD02C	YLD02C
Floor-mounted column, stainless steel			YDH03CIS	YDH03CIS	YDH03CIS

#### Dimensions

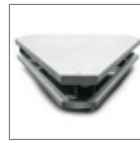
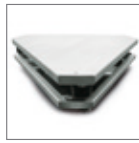
Weighing pan dimensions (W × D)			560 × 450 × 95 mm	800 × 600 × 135 mm	800 × 600 × 135 mm
Weigh cell (W × D × H)	400 × 300 × 120 mm	400 × 300 × 120 mm			
Electronics unit (W × D × H)	254 × 320 × 106 mm	254 × 320 × 106 mm	303 × 195 × 90 mm	303 × 195 × 90 mm	303 × 195 × 90 mm

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.

## Technical Specifications

### Mass Comparators 600 kg to 3000 kg



	CCS600K	CCT1000K	CCS1000K	CCT2000K	CCS3000K
Maximum capacity	605 kg	1200 kg	1510 kg	2100 kg	3010 kg
Readability	1 g	1 g	5 g	1 g	10 g
Application range	0-605 kg	0-1200 kg	0-1510 kg	0-2100 kg	0-3010 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	1200 kg	1510 kg	2100 kg	3010 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	×	×	×	×	×
Test certificate	Sartorius	Sartorius	Sartorius	Sartorius	Sartorius
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
ScalesNet-M PC software	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
SartoCollect PC software	YSC02	YSC02	YSC02	YSC02	YSC02

#### Dimensions

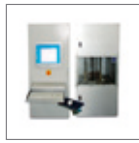
Weighing pan dimensions (W × D)	830 × 1030 × 250 mm	1510 × 1370 × 240 mm	830 × 1030 × 250 mm	1920 × 1710 × 230 mm	1000 × 1250 × 300 mm
Electronics unit (W × D × H)	303 × 195 × 90 mm	303 × 195 × 90 mm	303 × 195 × 90 mm	303 × 195 × 90 mm	303 × 195 × 90 mm
Electronics unit (W × D × H)	303 × 195 × 90 mm	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.

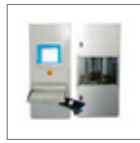
Prerequisites for accurate calculation of the standard deviation are good ambient conditions in accordance with OIML R111 for an M1 mass standards laboratory.

## Technical Specifications

### Determination of Volume, Density, Susceptibility, and Magnetism



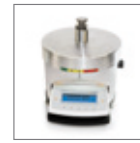
**VD1005**



**VL1005**



**YP50K**



**YSZ02C**



**YSZ01C**

Maximum capacity	1110 g	1110 g	50 kg	50 kg	50 kg
Readability	10 µg	10 µg		1 µg	10 µg
Application range	1 g-1 kg	1 g-1 kg	2 kg-50 kg	2 g-50 kg	2 g-50 kg
Repeatability s*	40 µg	40 µg		8 µg	20 µg
Repeatability (typical), s*	20 µg	20 µg		5 µg	10 µg
Electronic weighing   taring range	305 g	305 g		10 g	10 g
Linearity	0.12 mg	0.12 mg		0.05 mg	0.1 mg
Range sensitivity	20 µg / g	20 µg / g		10 µg/1 g	20 µg/1 g
Stabilization time	20 s	20 s		15 s	15 s
Uncertainty of density	1 kg/m <sup>3</sup>	1 kg/m <sup>3</sup>	< 10 kg/m <sup>3</sup>		
Uncertainty of volume	0.00015 cm <sup>3</sup>	0.00015 cm <sup>3</sup>	0.6 - 1.5 cm <sup>3</sup>		

#### Standard Accessories

Load alternator positions	2 × 9	9			
Interfaces	LAN USB RS-232	LAN USB RS-232		RS-232	RS-232
Draft shield	×	×		×	×
Enclosure	×	×			
Control unit	×	×			
PC	×	×			
PC software	×	×	×	×	×
Air temperature sensor	1	1			
Humidity sensor	1	1			
Air pressure sensor	1	1			
Fluid temperature sensor	2	2	1		
Test certificate	BEV	BEV	BEV	Sartorius	Sartorius
PC connection cable				×	×
Climate station	×	×			

#### Optional Accessories

Calibration weight	200 g E2 YCW522-00	200 g E2 YCW522-00		10 g E2 YCW412-00	10 g E2 YCW412-00
Weighing table	YWT20C	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	YVT01C			
Density reference (Si)	200 500 1000g	200 500 1000g			
Density reference, set of weights 1 g - 1 kg	YCS31-612-09	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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