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White Paper

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Keywords:
Balance test report, manufacturer tolerances, customer tolerances, environmental conditions, warning limit, intervention limit

Testing and evaluating of balances against different tolerance requirements

What possibilities does the Sartorius balance test report offer?

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Abstract

Balance test reports can be used to test balances against pre-determined tolerances. These may be manufacturer tolerances or tolerances set by the user.

Compliance with up to four key parameters (repeatability, deviation in case of eccentric loading, adjustment accuracy and linearity) is tested and evaluated. This white paper describes the different tests and presents the test reports.

Introduction

Test equipment must work within the specified tolerance ranges to achieve successful quality assurance. For this purpose, equipment must be tested at suitable time intervals.

Since there are no normative specifications for non-automatic balances that specify a tolerance, for example depending on the resolution of the device, the manufacturer's tolerances or the user's tolerance specifications are needed when evaluating balances. For this purpose, Sartorius Service offers a unique balance test report where testing is performed against individually selected tolerances.

The goal of this information is to describe the different tests that are carried out when creating a test report as well as to present the two test reports with testing against manufacturer or customer tolerances.

Tests

The four key parameters for assessing the proper functioning of a balance in operation are repeatability, deviation in case of eccentric loading, adjustment accuracy and linearity. These tests can be performed and their results compared against the tolerance specifications when creating a balance test report. When assessing the tolerance, a simple compliance decision is made without taking measurement uncertainty into consideration.
In addition to the four tests named above, additional tests are conducted during device production, such as the temperature behaviour of every balance. These are long-term tests that cannot be repeated at the site of use and are, therefore, not taken into consideration below.

Testing repeatability
When testing repeatability, the same test load is placed on the weighing pan several times (five times at test loads < 100 kg, three times at test loads ≥ 100 kg) under the most constant measurement conditions possible. If necessary, the display is set to zero between the individual measurements by pressing the zero key. The measured values are recorded in the metrology software.

The determined test result is the standard deviation *s* of the display values. The test is performed without a tare load set up.

Determining the test load is identical to determining the test load for calibrations according to EURAMET cg-18, which means with single-range balances the test load is determined by the metrology software used so that it corresponds to at least 40 % of the maximum load. With multiple range balances, the testing only occurs in the fine partial weighing range. The test can be performed in any weighing range on multiple range balances. If possible, the test loads are chosen so that only one test weight is required at a time. For this purpose, also see our separate white paper on the topic of "Calibration directive EURAMET cg-18" (1-2). The standard deviation may not exceed the corresponding tolerance in order to pass the test.

Testing the deviation in case of eccentric loading

When testing the eccentric loading, the same test load is placed at different positions on the weighing pan. The first measurement is done in the centre and the four following are performed in the middle of the respective quadrant (see figure 1).

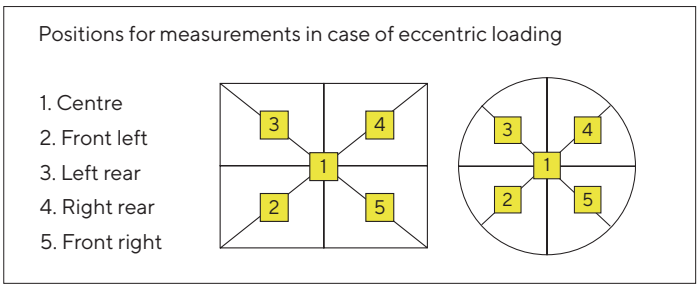


Figure 1: Positions for measurements in case of eccentric loading.

If necessary, the display is set to zero between the individual measurements by pressing the zero key. The measured values are recorded in the metrology software. The test result represents the maximum difference between the central weighing and the four weighings in the off-centre positions. The test is performed without a tare load set up.

The test load here is stipulated specific to the model. For tests against customer tolerances, the customer determines the test load. In case of multiple range balances, the eccentricity test may be performed in each weighing range.

Note: When selecting tolerances for the deviation in case of an eccentric loading, the fact that these are proportional to the test load as a first approximation must be taken into consideration – in other words, if the maximum deviation for an eccentric loading is to be 3 mg, for example, for a test load of 100 g, then this value may not simply be adopted for another test load, but rather must be doubled for 200 g, for example.

The test result may not exceed the specified tolerance in order to pass the test.

Testing the adjustment accuracy

During this test, the weighing value displayed by the balance is compared with the known weight value of a test weight. No separate measurement is performed for this test. Instead, the measured value with the greatest deviation from the repeatability measurement is used. The specified test result is the difference between the indicated value and the conventional mass of the test load (for test weights from 10 kg and above, difference to the nominal value of the test load).

The specified value may not exceed the corresponding tolerance in order to pass the test.

The adjustment status of the balance is noted in the test report. If the balance does not comply with the specified tolerance, there may be different causes for this, depending on the adjustment status:

1. The balance was not adjusted by the service technician before testing (typical case in the context of an incoming inspection)
   - A negative result indicates that the balance is not correctly adjusted. The cause may either be that adjustments | tests are not carried out frequently enough on the user side (also see here the separate white paper “Test intervals and tolerances” (3)). Another reason may be that the adjustment weight used by the customer is faulty and the balance was therefore incorrectly adjusted (see here the separate white paper “Correct handling of test weights” (4)).
2. The balance was adjusted internally before the test (typically done before an outgoing inspection)
   - A negative result indicates that the internal adjustment weight has not been correctly determined. In this case, the service technician should re-determine the internal adjustment weight during device maintenance and then repeat the test. However, the balance may also have a defect.
3. The balance was externally adjusted by the service technician before the test.
   - A negative result may indicate that there is a defect on the balance, for example that there is frictional contact or the weighing system is damaged.

Testing linearity
Linearity describes the proportionality between the applied loads and the displayed values across the entire weighing range of the balance. A straight line is virtually placed as an optimal characteristic curve between the first test point (zero) and the last (near max. load), which serves as a reference. If necessary, the display is set to zero by pressing the zero key to record the individual test points. The measured values are recorded in the metrology software. The test result is the amount of the maximum deviation of the test points from this optimal characteristic curve.

When testing linearity, two different test methods are used depending on the balance' scale interval:
Balances with a lower resolution (the guide value is balances with less than a million measuring steps) are tested according to the procedure **"Testing with known weights"**. During this test method, four different test loads are applied to the weighing pan in succession. The test loads are determined here identically to when determining the test load for calibrations according to EURAMET cg-18 and correspond approximately to 0.25 Max; 0.5 Max; 0.75 Max and Max.

Balances with a higher resolution are tested according to the method **"Testing with unknown weights"** (also known as the "tare load method" or "graduated method"). During this test method, the same test load is applied to the weighing pan four times, whereby different tare loads (zero, approx. 0.25 Max, approx. 0.5 Max and approx. 0.75 Max) are applied to the balance during the measurements so that the entire weighing range is covered. The test load and tare loads are specified by the metrology software depending on the balance's maximum load. The test load approximately corresponds to 0.25 Max. By always comparing the same test load at different positions of the load range, the uncertainty of the mass of the test weight is eliminated so that it is possible to determine the linearity behaviour of the balance more precisely with this method.

With multi interval balances, the linearity is determined once over the entire weighing range. For multi range balances the test is performed separately for each weighing range. For both of these types of balances, we generally recommend the "Testing with unknown weights" method.

The specified value may not exceed the corresponding tolerance in order to pass the test.

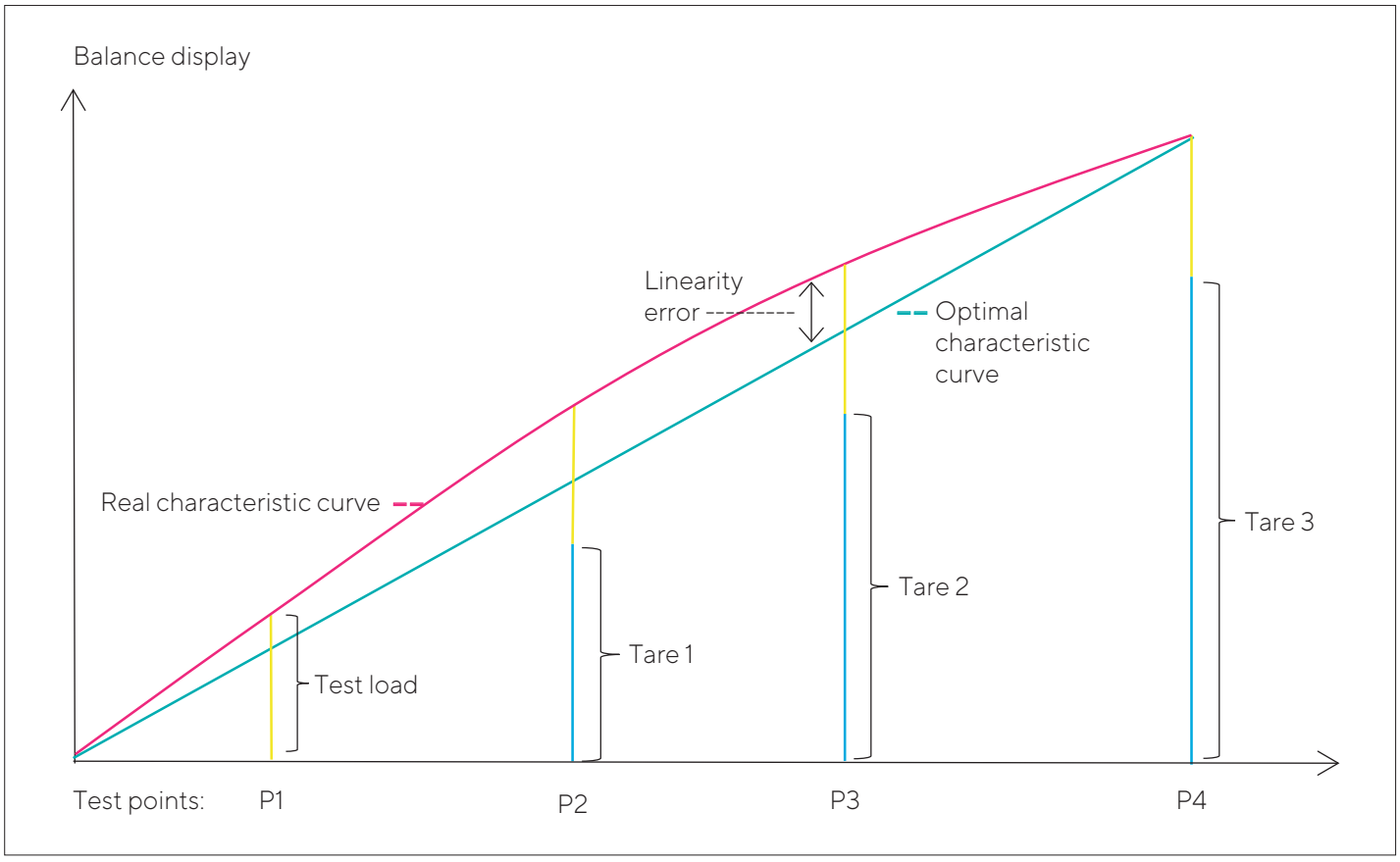


Figure 2: Linearity test according to the "Testing with unknown weights" method.

The balance test report against Sartorius tolerance requirements

Manufacturer tolerances are tolerance specifications of the device manufacturer, which devices must reliably comply with during the final inspection in production. The manufacturer's tolerances are reflected in the device specification, i.e. in the device data sheet. The test is performed under ideal conditions.

The performance capability of balances is influenced to a high degree by the installation conditions, i.e. by physical effects and the ambient conditions at the site of installation (see also our separate white paper "Reliable weighing results" (4)). The manufacturer's tolerance specifications can therefore not be complied with under all installation conditions.

This is why the installation conditions are assessed when creating a balance test report against the manufacturer's tolerances. The installation location is evaluated according to three criteria that have a particularly strong influence: Vibration, air movement and environmental stability.
There is a separate estimation | evaluation of the installation conditions for each criterion, which results in three classes:
Class A: Very suitable condition
Class B: Conditionally suitable conditions
Class C: Less suitable | poor conditions

When assessing **vibration,** the installation location is first taken into consideration. Vibrations are oscillations from the environment, which are transmitted to the installation location. These may, for example, be caused by larger machines or even streets nearby. Since vibrations cannot be easily quantified, actions that reduce or favour the transmission of vibrations are assessed when evaluating vibration. Special weighing tables, which reduce the transmission of ambient vibrations, are considered class A installation locations, permanently installed laboratory tables are considered class B, and moving tables are considered class C installation locations.

When evaluating **air movement,** the spatial conditions present that favour or reduce air movement are considered. An installation location away from windows, doors and outlets of air conditioning systems is considered a class A installation location. Installation locations with normal air movement are considered class B, and installation locations with significant air movement (e.g. situated directly on highly-frequented paths or in fume cupboards) are considered class C.

When evaluating **environmental stability,** consideration is given to whether measures have been taken at the installation location to prevent temperature fluctuations. For example, a climate-controlled room is considered a class A installation location. A room with windows that can be opened is considered class B, and installations, for example, in an open workshop or an installation location with direct exposure to sunlight are considered class C.

As every evaluation criterion can have a similarly strong negative effect, the worst-rated criterion is always used when summarizing the installation location evaluation. For example, the installation location of a balance on a weighing table (A) located in the corner of a room with little air movement (A) but not in a climate-controlled room (B) is considered a class B installation location overall. Due to the environmental stability influences present, the conditions here are considered conditionally suitable. An influence on the balance's performance capability must be assumed here.

Sartorius manufacturer tolerances only apply at installation locations with optimal conditions (class A). For installation locations with poorer conditions, tolerances are multiplied by a factor of 1.5 (class B) or a factor of 2 (class C).

When examined closely, different environmental conditions do not have the same influence on all tests and models. For example, the repeatability of a device is heavily dependent on the installation, while its linearity is not directly affected. However, the factors of 1.5 and 2 named above for all parameters make it easy and manageable to evaluate balances depending on the influences at the site of installation.

The balance test report against customer tolerance requirements

Customer tolerances are tolerance specifications that users stipulate for devices, for example, depending on the device location and the criticality of the weighing application.

With the balance test report, every test can be performed against two tolerance values (known as the warning limit and the action / intervention limit).

The warning limit is typically tighter than the action / intervention limit. If tolerances of the warning limit are not reached, the device is in a safe working range. If the warning limit for one or more tolerance values is exceeded, special attention may be required; for example, this may result in shortened test cycles. If the action / intervention limit for one or more tolerance values is exceeded, the device should be locked and, for example, returned to the safe working range through appropriate adjustments, optimization of the installation location or repair.

Since customer tolerances must be reliably met for the respective balance or weighing application at the installation location, there is no evaluation of the environmental conditions at the installation location for tests against customer tolerances. Possible influences of the installation location must have already been taken into consideration as a part of the respective customer tolerances.

For an individual determination of tolerances, we refer to our separate white paper “Test intervals and tolerances” (3).

The first page of the balance test report

1 The overview specifies whether the tests are performed against Sartorius tolerance requirements or against user’s tolerance requirements.

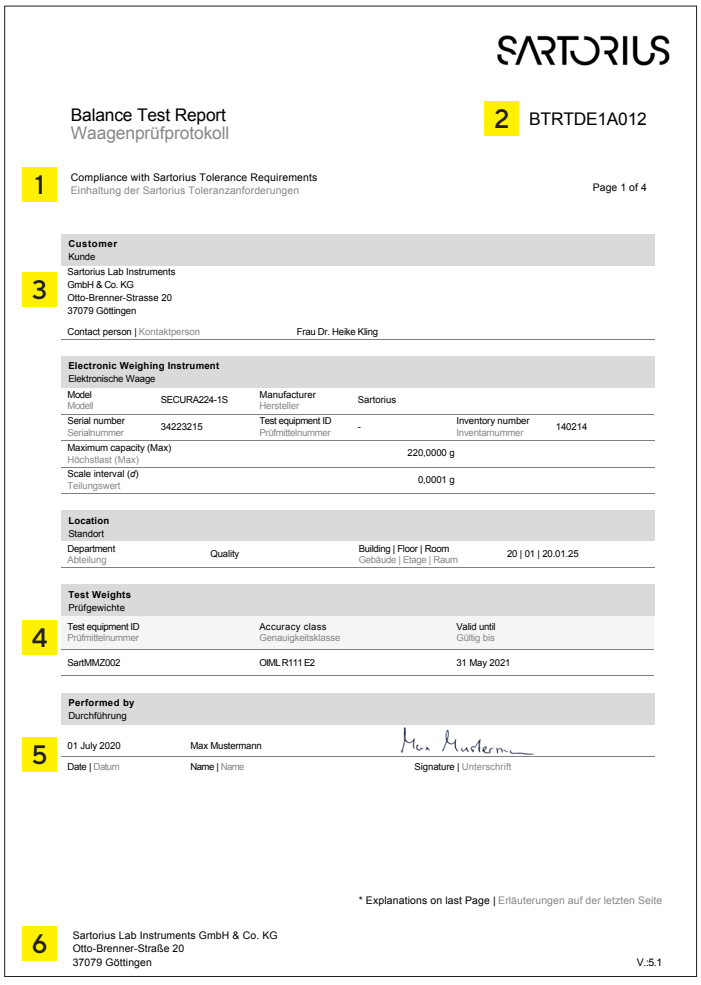
2 The report number can be used to clearly identify any balance test report. The report number is automatically assigned.

3 Basic data:
The customer data, the test item, including the metrological data, as well as the location of the balance are listed. The balance test report only applies at the listed location. Since the installation conditions at other locations are different, a test report must be created again after changing location.

4 This section lists the weights used and their calibration validity. Sartorius uses weights of the classes E2, F1 and M1 according to the classification defined in OIML recommendation R111 when testing balances.

5 The test data, as well as the name and signature of the Sartorius technician who performed the test, are listed here.

6 The Sartorius organisation that was responsible for creating the test report is listed in the footer.



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Balance Test Report
Waagenprüfprotokoll

2 BTRTDE1A012

1 Compliance with Sartorius Tolerance Requirements
Einhaltung der Sartorius Toleranzanforderungen

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Customer
Kunde

3 Sartorius Lab Instruments
GmbH & Co. KG
Otto-Brenner-Strasse 20
37079 Göttingen

Contact person | Kontaktperson: Frau Dr. Heike Kling

Electronic Weighing Instrument
Elektronische Waage

Model / Modell	SECURA224-1S	Manufacturer / Hersteller	Sartorius		
Serial number / Serialnummer	34223215	Test equipment ID / Prüfmittelnummer	-	Inventory number / Inventarnummer	140214
Maximum capacity (Max) / Höchstlast (Max)	220,0000 g				
Scale interval (d) / Teilungswert	0,0001 g				

Location
Standort

Department / Abteilung	Quality	Building | Floor | Room / Gebäude | Etage | Raum	20 | 01 | 20.01.25

Test Weights
Prüfgewichte

4

Test equipment ID / Prüfmittelnummer	Accuracy class / Genauigkeitsklasse	Valid until / Gültig bis
SartMMZ002	OIML R111 E2	31 May 2021

Performed by
Durchführung

5

01 July 2020	Max Mustermann	Max Mustermann
Date | Datum	Name | Name	Signature | Unterschrift

* Explanations on last Page | Erläuterungen auf der letzten Seite

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Figure 3: The first page of the balance test report.

The second page of the balance test report

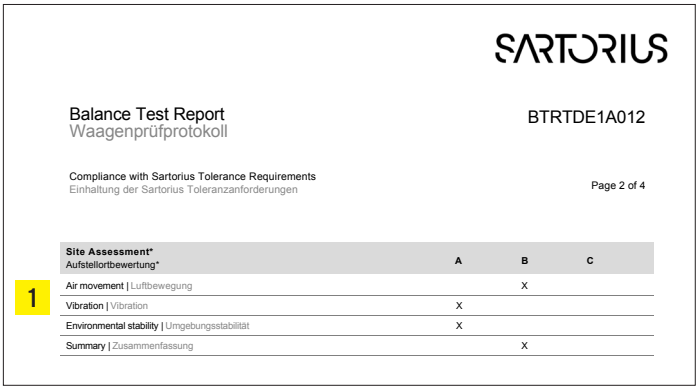
1 The installation location is only evaluated in the balance test report to ensure compliance with Sartorius tolerance requirements. The evaluation given in the summary will be used to check compliance with the tolerance requirements.

2 The measurement conditions at the installation location are specified in the test report. The adjustment status is listed, among other things. The information about the linearity test method is also important (see above).

3 The test results are listed separately for each test and each area. Only the test result is listed, not the individual measurement results.

4 The right area shows the result of the test against the respective tolerance requirement. An evaluation is always performed if a tolerance requirement is specified. If no tolerance requirement is specified, N/A for "not applicable" is noted in the test report.

5 The final result is stated. The test result is then only evaluated as "passed" if every single test has been passed. As soon as the tolerance of one individual test has not been met, the entire evaluation is also documented as "failed".
When testing against Sartorius tolerance requirements, the evaluation is performed here while taking the installation location evaluation into consideration – the example includes an evaluation against the tolerance requirements at a class B installation location.
Test reports checking compliance with customer tolerances evaluate against the tolerances of the intervention limit.



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Waagenprüfprotokoll

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Compliance with Sartorius Tolerance Requirements
Einhaltung der Sartorius Toleranzanforderungen

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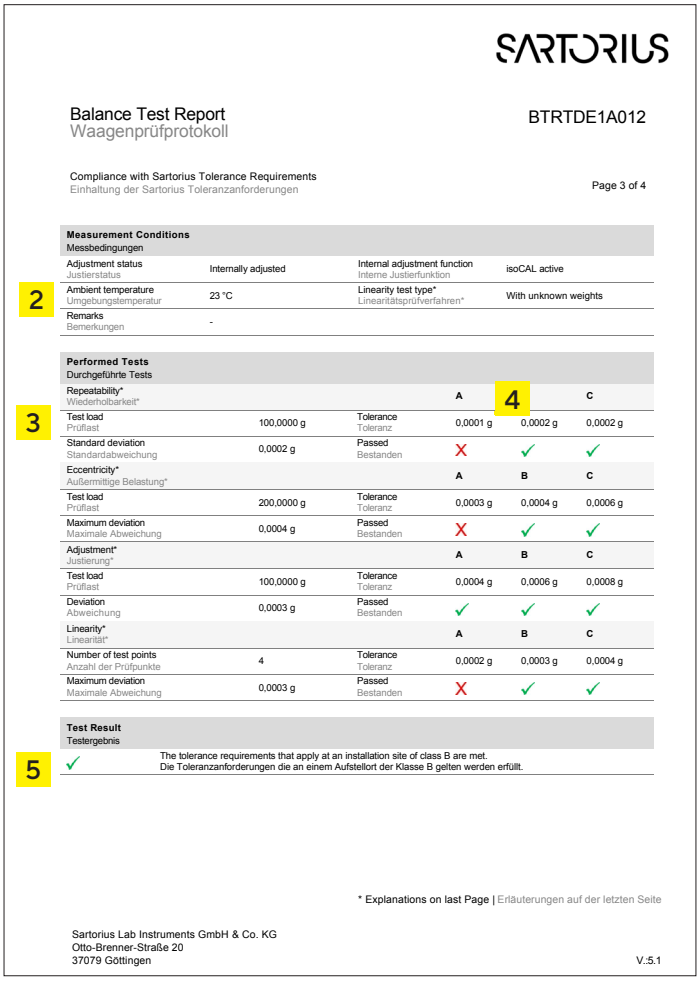
1

Site Assessment* Aufstellortbewertung*	A	B	C
Air movement | Luftbewegung		X	
Vibration | Vibration	X		
Environmental stability | Umgebungsstabilität	X		
Summary | Zusammenfassung		X	

Figure 4: Evaluation of the installation location in the test report for compliance with Sartorius tolerance requirements.



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Balance Test Report
Waagenprüfprotokoll

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Compliance with Sartorius Tolerance Requirements
Einhaltung der Sartorius Toleranzanforderungen

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Measurement Conditions Messbedingungen			
Adjustment status Justierstatus	Internally adjusted	Internal adjustment function Interne Justierfunktion	isoCAL active
Ambient temperature Umgebungstemperatur	23 °C	Linearity test type* Linearitätsprüfverfahren*	With unknown weights
Remarks Bemerkungen	-		

3 4

Performed Tests Durchgeführte Tests					
Repeatability* Wiederholbarkeit*			A		C
Test load Prüflast	100,0000 g	Tolerance Toleranz	0,0001 g	0,0002 g	0,0002 g
Standard deviation Standardabweichung	0,0002 g	Passed Bestanden	X	✓	✓
Eccentricity* Außermittige Belastung*			A	B	C
Test load Prüflast	200,0000 g	Tolerance Toleranz	0,0003 g	0,0004 g	0,0006 g
Maximum deviation Maximale Abweichung	0,0004 g	Passed Bestanden	X	✓	✓
Adjustment* Justierung*			A	B	C
Test load Prüflast	100,0000 g	Tolerance Toleranz	0,0004 g	0,0006 g	0,0008 g
Deviation Abweichung	0,0003 g	Passed Bestanden	✓	✓	✓
Linearity* Linearität*			A	B	C
Number of test points Anzahl der Prüfpunkte	4	Tolerance Toleranz	0,0002 g	0,0003 g	0,0004 g
Maximum deviation Maximale Abweichung	0,0003 g	Passed Bestanden	X	✓	✓

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Test Result Testergebnis	
✓	The tolerance requirements that apply at an installation site of class B are met. Die Toleranzanforderungen die an einem Aufstellort der Klasse B gelten werden erfüllt.

* Explanations on last Page | Erläuterungen auf der letzten Seite

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Figure 5: Results page of the balance test report with testing for compliance with Sartorius tolerance requirements at a class B installation location.

Literature

1. Sartorius white paper:
   The calibration certificate according to EURAMET cg-18 (understanding calibration certificates and applying results in practice), 2020 (planned).
2. Sartorius white paper:
   Calibration guideline EURAMET cg-18 for electronic, non-automatic balances (specifications, options and implementation of the guideline by Sartorius), 2020 (planned).
3. Sartorius white paper:
   Test intervals and tolerances (how test intervals and tolerances are practically defined in a risk-based manner), 2020 (planned).
4. Sartorius white paper:
   Dealing with test weights (sensible selection and correct handling of weights), 2020 (planned).

Sartorius recommendation

- Determine which tolerances your balances shall comply with. It is always recommended to determine tolerances that are based on the criticality of the weighing task, i.e. to test devices against customer tolerances.
- Select tolerances so that they can also be met during subsequent tests.
- Determine the frequency of the review. This should also be oriented on the criticality of the weighing task.

This white paper is part of the white paper bundle "Best Practice Guide: Lab Weighing". To be able to dynamically add updates and corrections and at the same time giving users as clear a reference as possible, for example in their QM documentation, versions are provided.

Version history

Version	Date	Changes
1.0	October 2020	First version

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